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Some Safe Treatments for Controlling Postharvest Diseases of Mango (*Mangifera indica* L.) Fruits

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This study was conducted to reveal the spread and disease severity of mango decayed after harvesting on the most commercial verities (Keitt, Kent and Tommy Atkins). Disease survey was studied on mango fruits collected from the fields of two localities: Ismaillia and Nobaria district. In addition of diseased samples were collected after harvesting and marketing from El-Aboor and 6th October markets. Varietal susceptibility was studied under laboratory conditions. Three attempts were carried out as save treatments to control the disease using chitosan, citral; two bioagents *Pseudomonaes fluorescens* and *Candida tennis* as well as hot water. Shelf life, fruit contents of total soluble solids (TSS), titratable acidity (TA) and vitamin C were also taken into consideration.

The results revealed that the most dominant fungi attacking mango fruits during field growth, harvesting and marketing were *Colletotrichum gloeospirioides* Pass. and *Botryodiplodia theobromae* Pat., which caused infection of 65.0 and 43.23%, respectively. In concern with varietal susceptibility all the tested cultivars were liable to the infection by the disease without any resistant.

All of the tries treatments succeeded to control the decay on the mango fruits along the period after harvesting and increased the shelf life of the fruit when stored at temperature 22±2°C. Chitosan applied with 8.0g/l to coat the treated fruits gave a very high efficient against the disease .In the same category citral (as a volatile oil from the exocarpe of fresh citrus fruit) which exhibited strong toxicity towards several fungal pathogens when applied at 8.0g/l. Meanwhile, the bioagent *P. fluorescens* was more effective than *C. tennis*, but still not efficient as chitosan and citral. Hot water treatment was very effective to control fruit decay with longer to shelf life as well as chitosan and citral.

The study revealed no marked differences of the treatments on the fruit quality, *i.e.* total soluble solids (TSS) and titratable acidity (TA), except a slight high in vitamin C in all cultivars.

Keywords: Biological control, *Botryodiplodia theobromae*, *Candida tennis*, *Colletotrichum gloeospirioides*, mango, postharvest diseases and *Pseudomonaes fluorescens*.

Mango (*Mangifera indica* L.) is one of the most popular fruits in the world as well as in Egypt. All mango fruits are subjected to serious postharvest decay during harvesting handling, marketing and cold storage, most of these rots are latent infection which start in the orchard as early as the flowering stage and attack the fruits during cold storage causing great economic losses (El-Boghdady, 1993).

Postharvest diseases of mango fruits have been reported by many investigators in the world where mango is grown (Opera and Nguyen, 1999 and Prusky, 1996). The most important diseases are (anthracnose) fruit rot caused by *Colletotrichum gloeosporioides* Pass. and fruit rot caused by *Botryodiplodia theobromae* Pat. (Snowdon, 1990). All these fungi can grow and cause fruit rots at low temperature down to 0°C (Peterson, 1984). These losses could be reduced to a considerable extent by minimizing mechanical damages, maintaining the natural resistance of the product and storing at optimal conditions such as low temperature and high CO_2 (10-15%) atmosphere (Shewleft, 1996). Although a high CO_2 concentration is effective in controlling decay and delaying ripening it may cause discoloration of the tissue and off flavour of the fruit when it exceeds the tolerance limit (Pursky and Plumbley, 1992). A number of fungicides successfully controlled postharvest decay pathogens fruits (Du and Sun, 1994 and Abd-El-Kareem & Abd-Alla, 2002). However, chemical control programs have been facing certain problems. The use of chemical fungicides imposes a selective pressure upon the pathogen population and has residual harmful effect to the human that causes dangerous diseases (Bower *et al*., 2003). There is a growing need to develop alternative approaches for safe controlling postharvest diseases of mango fruit. Chitosan is biopolymer, which has numerous applications in agriculture and agroindustries. Coating fruits and vegetables with chitosan has some advantages for the long term storage of foods, because the film of chitosan provides a kind of an active package, which allows a gradual release of preservations, thus inhibiting fungal growth and maintaining the external appearance of fruit for a longer time (Galad *et al*., 2004). It has been shown to have fungicidal activeness against several fungi (Du and Sun, 1994 and Abd-El-Kareem *et al*., 2002) and causes complete inhibition with chitosan 6g/l for *Geotricum candidum* and at 8g/l for *P. digitatum* and *P. italicum*. They also found that lime fruits coated with chitosan at concentration 1.5 and 2% reduced sour mango rots caused by *B. theobromae* and *C. gloeosporioides*.

Essential oils have shown considerable activities against postharvest pathogens of citrus (Cacioni *et al*., 1998) and may be more potent than some commercial fungicides (Singh *et al*., 1993). The inhibitory effect of citral on postharvest pathogens was reported by El-Mohamedy *et al*. (2002) and Abd-El-Kareem and Abd-Alla (2002) who stated that citral solutions at 8m1/1 caused complete inhibition for linear growth of *P. digitatum* and *P. italicum*. Krishanthi *et al*. (2004) reported that the components of essential oils such as phenolic compounds, terpenic alcohols and aldehydes exert their antimicrobial activity on pathogenic fungi by causing damages to microbes by altering membrane permeability, denaturation and precipitation of cell protein, inactivation of enzymes and leakage of amino acids from microbial cells.

Biological control using either natural products or antagonistic microorganisms proved to be successful for controlling various plant pathogens in many countries (Papavizas and Lumsden, 1980 and Sivan & Chest, 1989).

Research and development of biological control products for postharvest use has been on a fast track. Several commercial products are already available and others will be in the near future. Several antagonistic bacteria and yeast showed high

protection to various fruits against postharvest pathogens (Janisiewiez and Roitman, 1988 and Wisniewski *et al*., 2001). *Bacillus subtilis* was found to be effective against some fruits (El-Ghaouth *et al*., 2002 and Obagwu and Korsten, 2003). Bull *et al*. (1997) found that were some citrus diseases controlled by *P. syringe*. Filonow (1999) found that yeasts *Cryptcoccus laurentii* and *Sporobolomyces roseus* were more effective in reducing the stimulatory effect than *Saccharomyces cerevisiae* on conidia of *B. cinerea* the causal of some fruits and vegetables rote during storage.

Heat treatment to prevent postharvest decay of fruits has been tried as mean of control with number of rot–causing fungi. Promising results were obtained in reducing *Monilina* spp. and *Rhizopus* spp. in peach (Wisniewski *et al*., 1988 and El-Ghaouth *et al*., 2002). *Colletotrichum* spp. in mango and papaya (Pursky and Plumbley, 1992 and Koomen and Jeffries, 1993). Couey (1989) reported that heat treatments have the advantage of insecticidal and fungicidal action with ease of application and absence of chemical residues. The disadvantages are probable for fruit damage and a relatively high cost. Barkai and Phillips (1991) stated that postharvest exposure to relatively high temperature (40-42°C) for a certain period often increases storage life and improve the flavour of a number of fruits. Many fruits and vegetables tolerate exposure to water temperature of 50-60°C for up to 10 min, but shorter exposure at these temperatures can control many postharvest plant pathogens (Lurie, 1998 and Shellie and Mangan, 1998). Similarly, Jacobi *et al*. (1996) recommended 53°C for hot water dipping for 5min as a successful treatment. Also, vapour heat treatment (VHT) at 47°C for 15-20 min was found to be suitable for disease control of Kensington mango. Grove *et al*. (1997) noted that immersing any of eight mango cultivars, *i.e.* Tommy Atkins, Irwin, Zill, Neldica, Kent, Keitt, Heidi and Sensation, at 46.1°C for 90 min and refrigerated after 24h were not damaged, while water temperatures of 48.1°C and higher affected the fruits. Results of Nguyen *et al*. (1998) indicated that HW treatment of Buoi mango at 52°C for 10 min induced higher shrivel incidence while at 52°C for 5min had been potential for reducing postharvest diseases with minimal fruit mass loss and shrivelling compared with untreated fruits.

The objective of this study is to evaluate the protective effect of chitosan and citral solution for coating fruit against postharvest diseases incidence of mango fruits. Also, the effect of two bioagents, *i.e*. *Pseudomonaes fluorescens* and *Candida tennis*, as well as heat treatment on the disease incidence and shelf life was studied.

Materials and Methods

Estimation of naturally decayed mango fruits:

Mango fruits (cvs. Keitt, Kent and Tommy Atkins) were at 3/4 slip mature, collected from Ismaillia, Nobaria and different local markets during summer and winter seasons (2011), were classified into two groups apparently healthy and naturally infected with initial decay. The two groups were surface disinfected by dipping in 5% sodium hypochlorite for 2min, washed with sterilized water and left to dry, then placed in sterilized moist desiccators and incubated for 5-7 days at 20±2°C and then examined. The appearing fungal colonies were picked up. The fungi purified by single spore technique by (Ezekiel, 1930) then kept in refrigerator

on potato dextrose agar PDA medium. Pure colonies of fungal isolates were examined microscopically and identified according to (Kenneth *et al*., 1968; Ellis, 1971 and Barnett and Hunter, 1972). Verification of the identification was done by the Mycology Dept., Plant Pathol., Fac. of Agric., Assiut, Univ., Egypt.

Pathogenicity test and varietals susceptibility:

The isolated fungi *Colletotrichum gloeosporioides* and *Botryodiplodia theobromae* were investigated for their pathogenicity on healthy mango fruits of cvs, Keitt, Kent and Tommy Atkins. Fruits were washed and their surfaces sterilized by dipping in 1% sodium hypochlorite solution for two min. then washed several times with sterilized distilled water and allowed to dry. Three replicates for each fungus, with 10 fruits for each were wounded at the petiole region with a sterilized needle to l mm. depth and sprayed with a spore suspension of each fungus at a concentration of $1x10^4$ spores/ml. The inoculated fruits were put in sterilized fibreboard cartons and stored at 12°C and 90-95% RH for four weeks. For the assessment of fruit rots, an empirical scale was employed as follows:

0 =healthy fruit.
1= decayed tissue less than 10%.
2=10-25% decayed tissue.
3= 25 to 50% decayed tissue.
4= 50% to 75% decayed tissue.
5= decayed tissue more than 75%.

Disease incidence (DI) was determined according to Forsberg (1970) as follows:

$$DI= \sum(n \times v)/5N \times 100$$

Whereas: n= the number of affected fruits for each rate;
v= rate of disease incidence of the affected fruits;
N= total number of fruits;
5= maximum rate for disease incidence.

In vitro effect of chitosan and citral on the pathogenic fungi:
A- Effect on linear growth:

The study was conducted to test the efficacy of two natural compounds chitosan, citral (volatile oil from the exocarpe of fresh citrus fruit) on the linear growth of the two pathogens.

Chitosan solution was prepared by method described by El-Ghaouth *et al*. (1992). It dissolved in HCI and neutralized with NaOH. The precipitated chitosan was collected, washed with deionised water and subsequently lyophilized. Chitosan solution was added to conical flasks containing PDA medium to obtain the proposed concentrations, *i.e*. 0, 2, 4, 6 and 8 g/1, then mixed gently and dispensed in sterilized Petri plates (9-cm-diam.). Also, citral solution was added as chitosan at the same concentrations m1/l. Plates were individually inoculated at the centre with equal disks (5-mm-diam.) of 10 days old culture of *C. gloeospirioides* and *B. theobromae*. Inoculated plates were incubated at 20±2°C. The linear growth was measured when the check plates reached full growth and the average linear growth of fungi was calculated. Each treatment was represented by three replicates.

B- Effect on spore germination:

Spores of 10 days old cultures of *C. gloeospirioides* and *B. theobromae* were harvested in sterilized water containing (0.1% Tween-80) and adjusted to concentration of (10^6 spore/m1). One m1 of each prepared spore suspension was inserted into Petri plates. PDA media containing different concentration of 0, 2, 4, 6 and 8 g/1 from chitosan and citral were poured before solidification into the previous inoculated plates and rotated gently to ensure even distribution of fungal spores. Three plates as replicates were used for each treatment and inoculated plates were incubated at 20°C for 24hr. The germinated spores were counted microscopically and percentage of spore germination was calculated according to the following formula:

$$\text{Germination (\%)} = \frac{\text{Number of germinated spores}}{\text{Total number of fruits}} \times 100$$

In vitro effect of the bioagents on the pathogenic fungi:

Pseudomonaes fluorescens and *C. tennis*, obtained from Plant Pathol. Dept., NRC., were tested for their antagonistic capability against *C. gloeospirioides* and *B. theobromae* using dual culture technique (Ferreia *et al*., 1991). Cultures of pathogenic fungi and antagonistic fungi on PDA medium for 10 days as well as bacterial cultures of *P. fluorescens* grown on nutrient broth for 48hr were used in this test. Mycelial disks (5-mm-diam.) of pathogenic fungal tested on PDA medium were aseptically transferred singly to the centre of the PDA plates. A loop full of bioagent taken from 48 hr old nutrient broth cultures was placed at each of the four corners of the plate in perpendicular positions. Three Petri plates were used as replicates for each bioagent. A set of plates inoculated only with pathogenic fungal disks was served as check. All plates were incubated at 20±2°C for 7 days. Cell suspensions of *C. tennis* was prepared by dissolving 10g of *C. tennis* yeast in 200m1 sterilized distilled water to obtain $2.5x10^3$ CFU. Thereafter, under aseptic conditions, 10 m1 of spore suspension was added to one litre of melted nutrient yeast extract agar (NYDA) medium to obtain $2.5x10^3$ CFU. Mycelial disks (5-mm-diam.) of the tested fungi grown on PDA medium were aseptically transferred singly to the centre of the plates (9-cm-diam.) containing the same medium. Four loops full of yeast growth taken from 10 days old nutrient broth cultures were placed at four corners of plate perpendicular positions 10 mm apart from the edge of the Petri plates were used as replicates. The inoculated plates were kept at 20±2˚C for 7 days and examined.

The reduction in the fungal and yeast growth due to antagonistic effect of bioagent was calculated using the following formula:

$$\text{Growth reduction (\%)} = \frac{\text{Growth diam. in check - growth diam. in treatment}}{\text{Growth diam. in check}} \times 100$$

Effect of chitosan, citral and bioagents on postharvest disease of mango fruits:

Fresh mango fruits (cvs. Tommy Atkins, Keitt and Kent) apparently free from physical damage and disease were surface disinfected with sodium hypochlorite (5%) for 2 min, then washed several times with sterilized water. Fruits were gently injured with sterilized needle and dipped in 0.5, 1.0, 1.5 and 2.0% chitosan or citral at the same concentration and two bioagent *P. fluorescens* (10^4 spore/ml) and *C. tennis* ($2.5x10^6$ CFU) suspension as mentioned before for three minutes. Control fruits (untreated) were dipped in sterilized water. The treated and untreated fruits were air dried for 2 hr in laminar flow. Inoculation of fruits was carried out by spraying them individually with spore suspension (10^6 spore/ml) of each *C. gloeospirioides* and *B. theobromae*. Treated and untreated fruits stored at 20°C for 28 days. Mango fruits were examined daily for disease assessment. Each treatment was represented by 5 replicates with 10 fruits of each.

Disease assessment:

Percentage of infection severity was recorded after 7, 14, 21 and 28 days of storage (Falik *et al*., 1996). Fresh weight of rotted tissue was recorded after 28 days of storage and percentage of rotted tissue in relative to the whole weight of fruit was calculated.

Statistical analysis:

Data were statistically analyzed, whenever needed, using MSTAT-C computer program, 2.10 of 1988.

Effectiveness of heat treatments on postharvest diseases and mango fruit quality during cold storage:

A- Effect on naturally infected fruits.

Uniformly and freshly harvested mango fruits from the three varieties were immersed in hot water by using water bath digitally regulated with a differentiation of 0.5°C at 40, 45 and 50°C for 1, 3, 5 and 7min, air bubbles continuously passed through the water were used to obtain homogenous water temperature at desired degree along the dipping period. The treated fruits were pre cooled to about 22°C, and let to dry by forcing air to remove excess water and placed in carton boxes. Each treatment contained three replicates, with ten fruits for each. The treated and untreated fruits were kept at 12°C for 28 days. The infection rate was determined as percentage of infection; disease severity and efficacy of each treatment were calculated.

B- Effect on artificially inoculated fruits:

Uniform healthy mango fruits were surface sterilized by immersing in 70% ethanol for 30 seconds. After drying, the inoculation was carried out by scratching the fruit surface, four wounds/fruit (6mm length and 4mm depth). Mango fruits were artificially inoculated with spore suspension of each of *C. gloeospirioides* and *B. theobromae*, at diluted of $1x10^4$ spore/ml. Inoculated and uninoculated fruits were kept at 20-22°C and 90-95% RH for 24hr to allows establishment of fungal infection. The fruits were immersed in hot water at 40, 45 and 50°C for 1, 3, 5 and 7min, followed by fast cooling as mentioned before. The treated fruits used for evaluation of the impact of tested treatments against fruit decay or kept as control,

were set in sterilized plastic boxes at rate of 10 fruits for each of the three replicates and stored at 0°C and 90-95% relative humidity for 28 days, followed by 8 days at room temperature as shelf life of the fruits. The infection rate was determined as percentage of infection and efficacy of each treatment was calculated. The shelf life estimated for the naturally infected mango fruits either treated or untreated with hot water.

C- Shelf life:

After storage at 12°C for 2 or 4 weeks, the uninoculated (naturally infected) and artificially inoculated mango fruits, chitosan, citral, bioagents (*P. fluorescens* and *C. tennis*) and hot water treatments treated as above, were kept at 20±2°C. Shelf life was determined as the period (in days) through which the fruits remained healthy at 20±2°C. Development of fruit rot during the shelf life period was determined as disease incidence (DI).

D- Quality of mango fruits:

Surface sterilized healthy uninoculated fruits of each cultivar uniform in size and colour were treated with chitosan, citral (0.5, 1.0, 1.5 and 2.0%), *P. fluorescens* (10^4 spore/ml) and *C. tennis* ($2.5x10^6$ CFU) and hot water as mentioned above and stored at 12°C for 4 weeks. Each treatment was replicated three times, with 5 fruits for each. At the end of storage period, total soluble salt (TSS) were determined using a hand refractometer, titralable acidity (TA) was determined according to (AOAC, 1990) and vitamin C by the method of Jemey and Kovacs (1968). Data were statistically analyzed using the completely randomized design in factorial arrangement method as outlined by (Steel and Torrie, 1980).

Statistical analysis:

Complete randomized blocks design was used. Each treatment contained three replicates. Obtained data were analyzed according to (Gomez and Gomez, 1984) and Tukey test for multiple comparisons among means was utilized (Neler *et al*., 1985).

Results

Survey of mango fruits decay:

Samples of mango fruits (cvs. Keitt, Kent and Tommy Atkins) were collected from different orchards at Ismaillia, Nobaria regions, 6th October and El-Aboor central markets in Cairo. The collected fruits were classified into two groups healthy natural decay fruits. Decayed fruits were stored at 20°C for 5-7 days then examined.

The fruits were stored at 20°C under laboratory conditions and examined 7 days later for disease incidence. Data in Table (1) show the frequency of isolated fungi. *Colletotrichum gloeosporioides* and *B. theobromae* were isolated from rotted fruits in mean rates of 65.95 and 43.23%, respectively. *C. gloeosporioides* was the more frequent fungus in all inspected localities.

Fungi isolated from rotten fruits:

Two species belonging to two genera were isolated from rotted fruits of the three tested cultivars (Table 2). *Colletotrichum gloeosporioides* was the commonest fungus on cvs. Keitt, Kent and Tommy Atkins (51.7, 41.5 and 45.5%, respectively),

Table 1. Frequency of isolated fungi associated with postharvest diseases of mango fruits incubated at 20°C for 7 days

Location	Frequency (%) of isolated Fungus		
	C. gloeosporioides	*B. theobromae*	Mean
Ismaillia	62.0	40.8	51.4
Nobaria	63.0	42.9	52.95
6th Oct. Market	68.8	45.0	54.9
El-Aboor Market	70.0	44.2	57.1
Mean	65.95	43.23	---

Table 2. Frequency (%) of the fungi causing fruit rot on three mango cultivars

Fungus	Cultivar		
	Keitt	Kent	Tommy Atkins
C. gloeosporioides	51.7	41.5	45.5
B. theobromae	33.3	40.0	44.8

followed by *B. theobromae* (33.3, 40.0 and 44.8%, respectively). Meanwhile, on cv. Keitt, *C. gloeosporioides* was the most frequent (51.7%) followed by *B. theobromae* (44.8%) on cv. Tommy Atkins.

Pathogenicity of isolated fungi:

Table (3) shows that *C. gloeosporioides* gave the highest disease incidence on the tested cultivars, being 83.0, 81.0 and 80.0%, respectively, followed by *B. Theobromae*, being 72.0, 60.5 and 65.0%, respectively.

Table 3. Pathogenicity of fungi isolated from rotted mango fruits on the healthy fruits of the three mango cultivars

Mango variety	DI	
	C. gloeosporioides	*B. theobromae*
Keitt	81.0a	60.5b
Kent	80.0a	65.0b
Tommy Atkins	83.0c	72.0abm

- Fruits were inoculated and stored at 12°C for 4 weeks and then examined for DI determination.
- The same letters within a column are not significantly different ($P \leq 0.05$).
- DI= disease incidence calculated as in Materials and Methods.

In vitro studies:

Effect of chitosan and citral on linear growth and spore germination of postharvest fungi:

Chitosan at four concentration, 2, 4, 6 and 8g/1 and citral solution at the same concentration (m/1) were tested against the linear growth and spore germination of the two tested fungi. Results in Table (4) indicated that all tested concentrations of chitosan and citral significantly inhibited the linear growth and spore germination of

Table 4. Effect of different concentrations of chitosan and citral solution on linear growth and spore germination of two pathogenic fungi

Treatment and concentration	*C. gloeosporioides*		*B. theobromae*	
	Linear growth (mm)	Spore germination (%)	Linear growth (mm)	Spore germination (%)
Chitosan (g/l) 2.0	45.6 b	38.5 b	33.5 d	30.0 c
4.0	36.5 d	28.8 c	23.0 e	20.0 d
6.0	28.0 f	22.0 e	0.0 f	0.0 e
8.0	0.0 h	0.0 g	0.0 f	0.0 e
Citral (ml/1) 2.0	51.0 b	43.0 b	53.0 b	51.3 b
4.0	35.7 c	31.0 c	42.0 c	30.0 c
6.0	20.0 e	18.5 e	23.0 e	22.1 d
8.0	0.0 h	0.0 h	0.0 f	0.0 e
Control	90.0 a	91.0 a	90.0 a	90.0 a

- The same letters within a column are not significantly different (P≤ 0.05).

the two tested fungi compared with control. Inhibition was increased by increasing the concentration of citral and chitosan. At any concentration, chitosan was significantly more effective against *C. gloeosporioides* and *B. theobromae* than citral; high inhibition was obtained with chitosan at 6 g/1 for *B. theobromae* and at 8 g/1 for *C. gloeosporioides*, while citral at 8m1/1 completely inhibited the two tested fungi.

Effect two bioagents on the linear growth of tested fungi:

Date in Table (5) indicated that bioagents tested had inhibitory effect on the linear growth of the pathogenic fungi. *Colletotrichum gloeosporioides* and *B. theobromae* reduced by 95.0 and 100.0%, respectively, in presence of *P. fluorescens*, while the presence of *C. tennis* caused 70.3 and 75.0% reduction in growth of the two pathogens, respectively.

Table 5. Inhibitory effect of two bioagents on the linear growth of *C. gloeosporioides* and *B. theobromae*

Tested bioagent	Growth reduction	
	C. gloeosporioides	*B. theobromae*
P. fluorescens	95.0 a	100.0 a
C. tennis	70.3 b	75.0 b
Control	0.0 c	0.0 c

- The same letters within a column are not significantly different (P≤ 0.05).

Effect of chitosan, citral and bioagents on the post-harvest disease of mango fruits:

Tables (6a, b and c) illustrated the percentage of rotted mango fruits treated with different concentrations of chitosan and citral or the two bioagents *P. fluorescens* or *C. tennis* as a postharvest treatment, after 28 days of storage.

On cv. Keitt (Table 6a) the percentages of rotted mango fruits ranged between 37 and 100% in control treatment when infected with *C. gloeosporioides*. While, they were 45 and 100% when infected with *B. theobromae* after 28 days of storage. However, in the other tested treatment, a significant reduction of rotted fruit was observed during storage period. The efficiency of treatment decreased with increasing period until 28 days of storage. The percentages of rotted mango fruits increased with the increase of storage period after 28 days, which reached 40% when treated with 0.5% chitosan on *C. gloeosporioides*, while it was 10.3% when treated with chitosan with 2% concentration, where it was 100% in control. Similar results were found when the previous treatments were applied with *B. theobromae*. After 28 days of storage, percentages of rotted mango fruits were 18% when treated with 2% chitosan compared with 100% in control treatment.

When using the two bioagents, *i.e. P. fluorescens* and *C. tennis*, moderate efficiency was obtained with chitosan and citral. The results on *C. gloeosporioides* were 27 and 35.5% when using *P. fluorescens* and *C. tennis*, respectively. While with the pathogen *B. theobromae* they were 24.0 and 32.0% for *P. fluorescens* and *C. tennis*, respectively, after 28 days from storage. On the other hand, increasing percentages of concentration resulting of reduction in rotted mango fruits. When using chitosan with 2% the rotted mango fruits with *B. theobromae* was 7.8% after 28 days of storage, while it was 12.7% when using citral treatment.

Table 6a. Percentage of rotted mango fruits (cv. Keitt) treated with different concentrations of chitosan and citral or two bioagents (*P. fluorescens* or *C. tennis*) as a postharvest treatment, after 28 days of storage

Treatment and conc. (%)	Rotted fruits (%)							
	C. gloeosporioides				*B. theobromae*			
	Storage period (day)				Storage period (day)			
	7	14	21	28	7	14	21	28
Chitosan 0.5	9.0c	27.7c	33.0c	40.0c	10.5d	25.7c	33.0c	18.0c
1.0	7.0d	19.0e	24.0e	31.0d	6.5f	15.0d	22.0e	33.0f
1.5	4.5e	10.7j	14.0g	22.0f	5.6hi	9.8f	12.0h	25.0h
2.0	4.0e	8.5g	10.3i	15.0j	4.6i	7.8i	10.5j	7.8
Citral 0.5	11.0b	30.0i	35.0b	50.0b	18.7b	45.0b	50.0b	65.0b
1.0	8.0c	23.0d	25.7d	31.0d	16.8c	28.0c	31.0d	38.0d
1.5	3.0f	9.3g	18.0f	24.0e	8.7e	14.0d	19.7f	27.0h
2.0	1.3g	3.5i	10.5i	16.6i	4.3i	6.7g	12.0h	12.7i
P. fluorescens	2.6f	5.0h	10.7h	27.0g	5.1hi	9.8f	18.0g	24.0h
C. tennis	3.0f	7.0h	13.0g	35.5g	6.5fg	12.0e	21.0ef	32.0g
Control	37.0a	65.0a	93.0a	100.0a	45.0a	90.0a	99.0a	100.0a

- The same letters within a column are not significantly different (P≤ 0.05).

The same results were realized in the cvs. Kent and Tommy Atkins (Tables 6b and c). On cv. Kent, the percentages of rotted mango fruits ranged between 37.5 and 88.0% in control treatment when infected with *C. gloeosporioides*. While they were 38.8 and 95% when infected with *B. theobromae* after storage period of 28 days. However, in the other tested treatment, a significant reduction of rotted fruit was observed during storage period. The efficiency of treatment decreased with increasing period until 28 days of storage. The percentages of rotted mango fruits increased with the increase of storage period after 28 days which reached 27.5% when treated with 0.5% chitosan on *C. gloeosporioides*, while it was 9.0% when treated with chitosan with 2% concentration, where it was 88.0% in control treatment.

Table 6b. Percentage of rotted mango fruits (cv. Kent) treated with different concentrations of chitosan and citral or two bioagents (*P. fluorescens* or *C. tennis*) as a postharvest treatment, after 28 days of storage

Treatment and conc. (%)	Rotted fruits (%)							
	C. gloeosporioides				*B. theobromae*			
	Storage period (day)				Storage period (day)			
	7	14	21	28	7	14	21	28
Chitosan 0.5	10.0b	17.0b	21.0b	27.5c	10.0c	25.5c	35.0c	39.7c
1.0	6.3f	8.5d	15.0c	17.0f	6.5d	18.0e	23.0e	30.0d
1.5	3.8i	6.0d	9.8d	12.0i	4.0e	10.0f	13.7g	21.0f
2.0	2.5j	4.8f	7.5e	9.0k	3.6e	8.0g	10.0i	14.5j
Citral 0.5	9.5c	10.7c	24.8i	35.5b	10.6b	30.1b	37.0b	48.0b
1.0	8.0d	9.0d	14.5c	30.0d	8.1c	22.5d	20.3d	30.2d
1.5	5.6g	6.0e	8.0e	16.0g	2.8f	9.3g	17.7f	23.0e
2.0	4.7h	5.0ef	10.0e	13.0h	1.0g	3.3i	16.3i	16.2i
P. fluorescens	2.1j	5.0ef	7.3e	15.0g	7.3e	10.9c	14.5c	21.0e
C. tennis	7.8e	11.0c	15.0c	21.0e	8.7e	12.5e	22.0c	27.5c
Control	37.5a	72.0a	83.0a	88.0a	38.8a	56.2a	88.0a	95.0a

- The same letters within a column are not significantly different ($P \leq 0.05$).

Similar results were found when the previous treatments were applied with *B. theobromae*. After 28 days of storage percentages of rotted mango fruits was 14.5% when treated with 2% chitosan compared with 95.0% in control treatment, (Table 6a) also indicated that the two bioagents *P. fluorescens* and *C. tennis* gave moderate compared with chitosan and citral. The results on *C. gloeosporioides* were 15 and 21.0% when using *P. fluorescens* and *C. tennis*, respectively. Meanwhile, with the pathogen *B. theobromae* they were 21.0 and 27.5% for *P. fluorescens* and *C. tennis*, respectively, after 28 days from storage.

On cv. Tommy Atkins (Table 6c), the percentages of rotted mango fruits ranged between 30.0 and 97.0% in control treatment when infected with *C. gloeosporioides*. While, they were 31.5 and 91.1% when infected with *B. theobromae* with storage

Table 6c. Rotted mango fruits (Tommy Atkins) treated with different concentrations of chitosan and citral or two bioagents (*P. fluorescens* or *C. tennis*) as a postharvest treatment, after 28 days of storage

Treatment and conc. (%)	Rotted fruits (%)							
	C. gloeosporioides				*B. theobromae*			
	Storage period (day)				Storage period (day)			
	7	14	21	28	7	14	21	28
Chitosan 0.5	10.3d	27.0c	32.0c	40.0c	10.0b	16.5b	17.4c	22.0b
1.0	6.3f	14.0e	21.0e	30.0f	6.0f	8.5d	14.7c	16.7f
1.5	4.5hi	9.5f	11.5h	26.0h	3.3i	5.5e	9.7d	11.0i
2.0	4.2i	7.0g	8.0i	11.0J	2.0J	4.3e	7.3e	8.6k
Citral 0.5	18.3b	43.2b	48.5b	53.5b	9.8c	11.0c	23.0b	37.0b
1.0	16.3c	27.8c	30.5d	37.5d	7.9d	8.9d	14.5c	25.9d
1.5	8.4c	13.5d	20.0f	26.8h	5.3g	5.7e	7.7e	15.5g
2.0	4.7i	7.6g	12.6h	13.0i	4.3h	4.8ef	6.9e	12.5h
P. fluorescens	6.0fg	11.0e	18.0g	20.8ef	7.0e	10.0c	13.7c	15.9g
C. tennis	6.5e	11.0e	19.3b	30.0d	7.5e	10.3e	20.1d	24.5d
Control	30.0a	72.0c	91.0a	97.0a	31.5a	90.0a	81.0a	91.1a

- The same letters within a column are not significantly different ($P \leq 0.05$).

period of 28 days. However, in the other tested treatment, a significant reduction of rotted fruit was observed during storage period. The efficiency of treatment decreased with increasing storage period until 28 days. The percentages of rotted mango fruits increased with the increase of storage period after 28 days which reached 32.0% when treated with 0.5% chitosan on *C. gloeosporioides*, while it was 11.0% when treated with chitosan with 2% concentration, where it was 97.0% in control treatment. Similar values were found when the previous treatments were applied with *B. theobromae*. After 28 days of storage, percentages of rotted mango fruits were 12.5% when treated with 2% chitosan compared with 91.1% in control treatment. While, using the two bioagents *P. fluorescens* and *C. tennis* on cv. Tommy Atkins, moderate efficiency was were 20.8 and 30.0% when using *P. fluorescens* and *C. tennis*, on *C. gloeosporioides*, respectively. While, with the pathogen *B. theobromae*, they were 15.9 and 24.5% for *P. fluorescens* and *C. tennis*, respectively, after 28 days from storage. On the other hand, increasing percentages of concentration resulting of reduction in rotted mango fruits. Table (6a and b) also show that when using chitosan with 2% the rotted mango fruits with *B. theobromae* was 14.5% after 28 days of storage, while it was 16.2% when using citral treatment on cv. Kent. But when using chitosan with 2% the rotted mango fruits with *B. theobromae* was 8.6% after 28 days of storage, while it was 12.5% when using citral treatment on cv. Tommy Atkins.

Hot water treatment:

Control of postharvest diseases of mango fruits was investigated by postharvest application of heat treatment. The effect of dipping naturally infected or artificially inoculated mango fruits in hot water (Tables 7a, b and c) checked the development of fruit rots during cold storage at 12°C for 28 days.

Table 7a. Effect of hot water treatment on naturally infected or artificially inoculated mango fruits (cv. Keitt) with *C. gloeosporioides* and *B. theobromae* stored at 20ºC for 28 days

Temperature (˚C)	Exposure Time(min)	Rotted fruits (%)			
		C. gloeosporioides		*B. theobromae*	
		A.I*	N.I**	A.I	N.I
40	1	47.0	20.0	44.0	20.0
	3	35.0	18.0	34.5	17.0
	5	22.0	15.7	21.0	14.1
	7	10.0	5.0	9.1	4.7
45	1	42.0	23.5	37.0	22.0
	3	37.0	13.0	20.0	13.3
	5	12.0	5.0	9.0	6.3
	7	6.5	3.3	52.0	3.7
50	1	21.0	20.0	20.0	19.0
	3	20.0	16.0	20.0	16.5
	5	9.1	8.0	8.3	8.3
	7	4.0	3.0	5.0	3.2
Control		100	70.0	100	78.0

* A.I= Artificial inoculation.
** N.I= Natural infection.

Table 7b. Effect of hot water treatment on naturally infected or artificially inoculated mango fruits (cv. Kent) with *C. gloeosporioides* and *B. theobromae* stored at 20º C for 28 days

Temp. (°C)	Exposure Time (min)	Rotted fruits (%)			
		C. gloeosporioides		*B. theobromae*	
		A.I*	N.I*	A.I	N.I
40	1	42.0	18.7	44.0	18.3
	3	34.0	15.5	33.5	15.0
	5	22.5	14.0	22.3	13.7
	7	11.7	4.3	11.5	4.0
45	1	29.7	18.1	30.0	18.0
	3	22.0	12.7	21.0	12.5
	5	3.7	5.3	3.5	5.5
	7	8.2	4.0	8.0	4.0
50	1	20.3	17.5	20.0	18.5
	3	19.7	15.3	19.2	15.0
	5	8.3	8.1	8.0	8.0
	7	6.7	3.0	6.5	2.7
Control		100	75.0	100	80.0

* A.I= Artificial inoculation.
** N.I= Natural infection.

Table 7c. Effect of hot water treatment on naturally infected or artificially inoculated mango fruits (cv. Tommy Atkins) with *C. gloeosporioides* and *B. theobromae* stored at 12ºC for 28 days

Temp. (˚C)	Exposure Time (min)	Rotted fruits (%)			
		C. gloeosporioides		*B. theobromae*	
		A.I*	N.I**	A.I	N.1
40	1	40.0	19.0	41.0	19.0
	3	30.3	15.9	30.8	16.3
	5	20.0	14.0	24.0	14.0
	7	7.0	4.0	12.0	4.5
45	1	35.0	19.5	29.0	18.5
	3	20.0	12.7	20.0	13.0
	5	9.0	5.7	4.3	6.3
	7	4.8	3.3	8.1	4.3
50	1	20.0	18.5	21.0	18.0
	3	18.7	17.0	20.1	16.0
	5	8.3	8.7	8.7	9.2
	7	4.7	4.0	6.7	2.5
Control		100	82.0	100	77.0

* A.I= Artificial inoculation.
** N.I= Natural infection.

Percentage of infection decreased with increasing exposure to hot water and reached the maximum against the disease at 7 min especially in the artificial infection on the three cultivars. Disease infection reached 4.8% with 7 minutes dipping at 45°C and 3.8% at 50°C. In the same time, it was 70-100% in check treatment.

Effect of hot water treatments on shelf life of inoculated and uninoculated (naturally infected) fruits:

The shelf life at 20°C of fruits inoculated with *C. gloeosporioides* and *B. theobromae* compared with the uninoculated fruits after 2 and 4 weeks of storage at 12°C (Tables 8a, b and c) showed that hot water at 50°C of 7 min was the most favourable for increasing it. In fact shelf life was higher after two weeks than four weeks of storage. The highest shelf life of fruits treated by 50°C after two weeks of storage was 10 days for cv. Keitt inoculated with *C. gloeosporioides* and Tommy Atkins inoculated with *B. theobromae*. The highest shelf lives were 8 days for cvs. Tommy Atkins, Kent and Keitt, respectively. After 7 min at 50°C, same result was obtained after 8 days of shelf life inoculated with *B. theobromae* in cv. Keitt. It was the most safely and effectively treatment to minimize postharvest diseases of mango fruits during 28 days of cold storage.

Table 8a. Effect of hot water treatments on shelf life in days of mango fruits (cv. Keitt) uninoculated or inoculation with *C. gloeosporioides* and *B. theobromae*

Heat temp. (°C)	Time (min)	Rotted fruits (%) of artificially inoculation ones after weeks				Rotted fruits (%) of uninoculated ones after weeks	
		C. gloeosporioides		*B. theobromae*			
		2	4	2	4	2	4
40	1	3	2	2	3	2	4
	3	5	4	3	3	2	4
	5	7	6	8	6	7	6
	7	6	5	6	5	7	6
45	1	3	2	5	3	5	4
	3	7	4	6	5	5	6
	5	8	7	9	7	8	7
	7	3	3	5	3	5	5
50	1	7	4	7	4	5	3
	3	6	6	8	3	6	4
	5	9	8	10	7	8	5
	7	7	6	8	3	6	4
Control		3	0	4	1	2	0

Table 8b. Effect of hot water treatments on shelf life of mango fruits (cv. Kent) uninoculated or inoculation with *C. gloeosporioides* and *B. theobromae*

Heat temp. (°C)	Time (min)	Rotted fruits (%) of artificially inoculation ones after weeks				Rotted fruits (%) of uninoculated ones after weeks	
		C. gloeosporioides		*B. theobromae*			
		2	4	2	4	2	4
40	1	4	2	5	4	5	3
	3	8	6	8	5	7	5
	5	5	5	9	8	10	8
	7	4	5	8	6	8	6
45	1	3	3	5	3	5	4
	3	7	5	7	6	8	6
	5	8	6	8	4	9	7
	7	4	3	4	4	5	4
50	1	3	3	5	3	5	5
	3	4	5	6	6	8	6
	5	8	7	8	5	9	7
	7	6	5	6	4	6	4
Control		1	0	3	0	2	0

Table 8c. Effect of hot water treatments on shelf life of mango fruits (cv. Tommy Atkins) uninoculated or after inoculation with *C. gloeosporioides* and *B. theobromae*

Heat temp. (°C)	Time (min)	Rotted fruits (%) of artificially inoculation ones after weeks				Rotted fruits (%) of uninoculated ones after weeks	
		C. gloeosporioides		*B. theobromae*			
		2	4	2	4	2	4
40	1	3	3	5	3	5	5
	3	6	5	6	4	6	5
	5	8	7	8	6	9	7
	7	8	7	8	6	8	6
45	1	4	3	4	3	4	2
	3	4	3	4	4	5	4
	5	9	7	6	5	7	6
	7	3	4	5	3	5	4
50	1	3	4	4	3	4	4
	3	5	4	7	5	8	5
	5	10	7	6	5	10	8
	7	4	3	4	4	5	4
Control		1	0	3	0	1	0

Effect of chitosan, citral, P. fluorescens and C. tennis and heat treatments on the quality of healthy uninoculated fruits:

TSS, TA, TSS/TA and vitamin C contents in healthy fruits of the three cultivars with the treatment with chitosan and citral at 0.5, 1.0, 1.5 and 2.0% as well as the two tested bioagents and stored for 4 weeks at 12°C are recorded in Tables (9a, 9b and 9c). There were no significant differences ($P \leq 0.05$) in TSS, TA and TSS/TA among fruits of the three varieties treated with the different chitosan, citral and bioagent *P. fluorescens* at 10^4 spore/ml and *C. tennis* $2.5x10^3$ CFU when compared with untreated fruits. An exception was found in case of cv. Kent, where TSS was higher and TSS/TA was lower in the control. On the other hand, vitamin C content in all heat-treated (Tables 10a, 10b and 10c) was not significantly differed from that in untreated fruits. Vitamin C content was slightly higher in fruits singly treated with chitosan and citral at 2.0% than 1.5% concentration and treated with hot water at 50°C of 5min, while at50°C of 7 min was harmful on fruit.

Hence there were considerable no much changes in TTS, TA with the different treatments carried out in this study. But slight high was observed in vitamin C content in all tested cultivars.

Table 9a. Effect of chitosan, citral and bioagents ((*P. fluorescens* and *C. tennis*) treatment and storage on quality characteristics (total soluble solids, TSS; titratable acidity, TA and vitamin C) of healthy uninoculated mango fruits (cv. Keitt) treated with chitosan and stored at 12°C for 4 weeks

Treatment and concentration (%)	TSS%	TA%	TSS/TA	Vitamin C (mg/100g fruit juice)
Chitosan 0.5	15.0 a	0.355 a	40.5 h	35.0 ab
1.0	13.7 bc	0.327 bc	42.0 gh	34.1 ab
1.5	14.0 ab	0.323 bcd	42.6 fg	34.0 ab
2.0	14.0 a	0.321 bcd	43.6 fg	33.6 ab
Citral 0.5	13.4 c	0.354 b	40.0 h	34.0 ab
1.0	13.8 bc	0.328 bc	44.0 gh	33.3 ab
1.5	14.1 a	0.327 bc	42.0 fg	35.0 ab
2.0	14.3 a	0.325 bcd	45.0 fg	34.1 ab
P. fluorescens	14.4 a	0.355 b	43.3 fg	34.0 ab
C. tennis	14.5 a	0.343 b	41.5 gh	32.0 ab
Control	14.5 a	0.356 a	40.6 h	34.0 ab

- The same letters within a column are not significantly different (P≤ 0.05).

Table 9b. Effect of chitosan, citral and bioagents ((*P. fluorescens* and *C. tennis*) treatment and storage on quality characteristics (total soluble solids, TSS; titratable acidity, TA and vitamin C) of healthy uninoculated mango fruits (cv. Kent) treated with chitosan and stored at 12°C for 4 weeks

Treatment and concentration (%)	TSS%	TA%	TSS/TA	Vitamin C (mg/100g fruit juice)
Chitosan 0.5	17.0 a	0.364 a	46.0 bcd	33.0 abc
1.0	15.3 b	0.333 b	47.0 b	34.7 ab
1.5	14.0 b	0.323 bcd	52.3 a	35.0 ab
2.0	14.5 b	0.333 b	53.0 a	33.4 abc
Citral 0.5	15.2 b	0.355 b	41.0 h	36.0 ab
1.0	16.5 b	0.338 bc	45.0 gh	37.3 ab
1.5	16.3 b	0.329 bc	44.0 fg	33.0 ab
2.0	16.7 b	0.324 bcd	47.0 fg	33.1 ab
P. fluorescens	15.8 b	0.357 b	44.7 fg	30.9 ab
C. tennis	16.0 b	0.356 a	45.4 h	31.5 ab
Control	17.0 a	0.360 b	47.0 fg	32.0 ab

- The same letters within a column are not significantly different (P≤ 0.05).

Table 9c. Effect of chitosan, citral and bioagents ((*P. fluorescens* and *C. tennis*) treatment and storage on quality characteristics (total soluble solids, TSS; titratable acidity, TA and vitamin C) of healthy uninoculated mango fruits (cv. Tommy Atkins) treated with chitosan and stored at 12°C for 4 weeks

Treatment and concentration (%)	TSS%	TA%	TSS/TA	Vitamin C (mg/100g fruit juice)
Chitosan 0.5	15.0 a	0.355 a	40.5 h	35.0 ab
1.0	13.7 bc	0.327 bc	42.0 gh	34.1 ab
1.5	14.0 ab	0.323 bcd	42.6 fg	34.0 ab
2.0	14.0 a	0.321 bcd	43.6 fg	33.6 ab
Citral 0.5	13.4 c	0.354 b	40.0 h	34.0 ab
1.0	13.8 bc	0.328 bc	44.0 gh	33.3 ab
1.5	14.1 a	0.327 bc	42.0 fg	35.0 ab
2.0	14.3 a	0.325 bcd	45.0 fg	34.1 ab
P. fluorescens	14.4 a	0.355 b	43.3 fg	34.0 ab
C. tennis	14.5 a	0.343 b	41.5 gh	32.0 ab
Control	14.5 a	0.356 a	40.6 h	34.0 ab

- The same letters within a column are not significantly different (P≤ 0.05).

Table 10a. Effect of heat treatment and storage on quality characteristics (total soluble solids, TSS; titratable acidity, TA and vitamin C) of healthy uninoculated mango fruits treated with chitosan and stored at 12°C for 4 weeks

Temp. (º C)	Exposure time (min)	TSS%	TA%	TSS/TA	Vitamin C. mg/100g fruit juice
40	1	15.0 a	0.355 a	40.5 h	35.0 ab
	3	13.7 bc	0.327 bc	42.0 gh	34.1 ab
	5	14.0 ab	0.323 bcd	42.6 fg	34.0 ab
	7	12.7 c	0.220 c	34.0 cg	23.5cb
45	1	13.7 bc	0.334 b	41.5 gh	33.0 ab
	3	13.5 c	0.330 b	40.7 h	35.1 ab
	5	13.8 bc	0.330 bc	42.0 gh	37.0 a
	7	11.7 c	0.220 bcd	34.1 fg	34.5 ab
50	1	14.3 bc	0.364 a	43.5 gh	35.0 ab
	3	14.5 c	0.350 a	42.7 gh	37.1 a
	5	14.3 ab	0.340 bc	44.0 fh	35.0 a
	7	11.3 ab	0.300 b	34.1 fg	30.5 a
Control		14.7 a	0.357 a	41.0 gh	33.0 ab

- The same letters within a column are not significantly different (P≤ 0.05).

Table 10b. Effect of heat treatment and storage on quality characteristics (total soluble solids, TSS; titratable acidity, TA and vitamin C) of healthy uninoculated mango fruits (cv. Kent) treated with chitosan and stored at 12°C for 4 weeks

Temp. (ºC)	Exposure time (min)	TSS%	TA%	TSS/TA	Vitamin C. mg/100g fruit juice
40	1	17.1 a	0.361 a	47.0 bcd	34.0 abc
	3	16.1 b	0.332 b	47.0 b	32.3 ab
	5	16.5 b	0.325 bcd	48.5 a	31.0 ab
	7	14.0 c	0.222 c	33.4 c	24.0 c
45	1	33.0 ab	0.363 a	47.0 bcd	32.0 abc
	3	35.1 ab	0.333 b	49.0 b	34.1 ab
	5	37.0 a	0.327 bcd	51.3 a	33.0 ab
	7	24.5 ab	0.232 c	33.4c	27.0 c
50	1	35.0 ab	0.359 a	45.0 bcd	35.0 abc
	3	35.7 ab	0.334 b	47.2 b	32.1 ab
	5	37.0 a	0.335 bcd	50.8 a	35.0 ab
	7	30.5 b	0.225 c	30.1 c	23.0 c
Control		20.0 a	0.362 a	47.0 bcd	32.0 abc

- The same letters within a column are not significantly different (P≤ 0.05).

Table 10c. Effect of heat treatment and storage on quality characteristics (total soluble solids, TSS; titratable acidity, TA and vitamin C) of healthy uninoculated mango fruits (cv. Tommy Atkins) treated with chitosan and stored at 12°C for 4 weeks

Temp. (º C)	Exposure time (min)	TSS%	TA%	TSS/TA	Vitamin C. mg/100g fruit Juice
40	1	14.7 ab	0.296 e	49.1 bc	24.9 ab
	3	14.0 cbc	0.310 de	44.5 ef	32.0 abc
	5	14.7 a	0.313 cde	47.0 cd	33.0 bc
	7	11.3 c	0.231 c	36.5 cd	28.5 ab
45	1	14.5 ab	0.232 e	50.0 bc	25.0 ab
	3	14.7 cbc	0.318 de	47.3 ef	33.0 abc
	5	14.0 a	0.334 cde	45.0 cd	31.0 bc
	7	12.0 c	0.237 c	38.5 cd	24.5ab
50	1	15.0 ab	0.298 e	47.1 bc	25.3 ab
	3	14.7 cbc	0.315 de	45.5 ef	34.0 abc
	5	15.1 a	0.323 cde	43.6 cd	31.0 bc
	7	11.8 c	0.226 c	34.5 c	26.5 ab
Control		14.5 ab	0.297 e	48.7 bc	26.0 ab

- The same letters within a column are not significantly different (P≤ 0.05).

Discussion

Disease control would essential for export mangoes, especially with longer transit times. Storage diseases are very serious to in destroy entire fruits. Survey of major postharvest diseases of mango fruits in different governorates Ismaillia, Behera (Nobaria) were carried out. *Colletotrichum gloeosporioides* and *Botryodiplodia theobromae*, isolated from rotten Keitt, Kent and Tommy Atkins fruits in high frequencies, were the main fungi causing rot of mango fruits. *C. gloeosporioides* was isolated in high frequency from cv. Keitt, while *B. theobromae* was cvs. Kent and Tommy Atkins (Kobiler *et al*., 1998 and 2001).

The mechanism of chitosan or citral coating in reducing post harvest diseases of orange fruits appears to be related to its fungi static property (El-Ghaouth *et al*., 1992 and Rodov *et al*., 1985). The mode of action proposed to explain the antifungal activity of chitosan first, the activity of chitosan is related to its ability to interfere with the plasma membrane function (Leuba and Stossel, 1986) and second the interaction of chitosan with fungal DNA and RNA is the basis of its antifungal effect (Hadwiger and Loschke, 1981). Coating mango fruits with chitosan, citral or bacteria provide preventive effect against infection by green, blue moulds and brown spot and reduced fungal infection and delay disease development under artificial inoculation during storage period up to 28 days. Chitosan at 2% caused the highest decrease in infection severity of three tested varieties comparatively with the check. Citral and bacteria came thereafter.

Antagonistic bacteria and yeast were used for controlling post-harvest diseases (Janisiewiez and Jeffers, 1997; El-Ghaouth *et al*., 2002 and Obagwu and Korsten, 2003). The results indicated that *P. fluorescens* and *C. tennis* inhibited the linear growth of the two tested fungi, and it significantly reduced fruit rot. These finding were in harmony with those reported by Janisiewiez and Jeffers (1997); Bull *et al*. (1997); Kobiler *et al*. (2001) and Obagwu and Korsten (2003). The controlling ability of bacteria against pathogen may be related to competition to nutrients and space, antibiotics production and/or direct parasitism and induced resistance (Wilson and El-Ghaouth, 1993).

Therefore, dipping in hot water has being developed. In the under taken study it was found that hot water at 50°C for 7 min caused no peel blacking of the three varieties, but any further increase in temperature or dipping time or exposure might cause peel blacking. Results of Nguyen *et al*. (1998) indicated that hot water treatment of Buoi mango at 52°C for 10 min induced higher shrivel incidence while at 52°C for 5 min had potential for reducing postharvest diseases with minimal fruit mass loss and shrivelling compared with untreated fruits. Similarly (Jacobi and Wong (1992) and Jacobi *et al*. (1996) recommended 53°C for hot dipping for 5 min as a successful treatment .

The present results suggested that chitosan and citral as fruit coating or hot water treatment can be a safety technique for controlling post-harvest disease of mango fruits.

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بعض المعاملات الآمنة لمقاومة امراض ما بعد الحصاد علي ثمار المانجو

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أجريت هذه الدراسة للكشف عن مدى انتشار وشدة الاصابة بامرا ض المانجو بعد الحصاد واثناء التخزين خاصة علي الاصناف الاكثر تجاريا (كيت ، كنت وتومي اتكنز). تمت دراسة حصرلانتشار المراض على ثمار المانجو جمعت من حقول من منطقتي الاسماعلية والنوبارية بلاضافة الي بعض العينات التي جمعت بعد الحصاد و اثناءالتسويق من سوق السادس من اكتوبر وسوق العبور تم دراسة قابلية الاصناف المختبرة للاصابة تحت ظروف المعمل بأجراء ثلاث اختبارات امنة لمقاومة المرض على النحو التالي:

استخدام الشيتوزان ، السترال ، واثنان من الكائنات المضادة *Pseudomonaes fluorescens* و*Candida tennis* وكذلك الماء الساخن مع درجات حرارة مختلفة ومدة الغمر ودراسة فترة البقاء علي الرف ومدي تاثر مكونات الثمار من المواد الصلبة الكلية والحموضة ونسبة فيتامين ج وضعت ايضا في الاعتبار .

اثبتت الدراسة ان اكثر الفطريات تطفل علي الثمار في الحقل واثناء التسويق هما الفطرين: *Colletotrichum gloeospirioides* و *Botryodiplodia theobromae* حيث نجحت في احداث اصابة بنسبة ٦٥,٠ ٪ و ٤٣،٢٣ ٪ علي التوالي مع قابلية الاصناف المختبرة للاصاب دون اي مقاومة.

اثبتت الدراسة ان كل الوسائل المستخدمة لمقاومة المرض كانت قادرة بنجاح علي السيطرة علي المرض الي جانب اطالة فترة البقاء علي الرف علي درجة حرارة ٢٢±٢°م عند تغطية الثمار بالشيتوزان بنسبة ٨ جم/ لتر ، وفي نفس السياق كان لاستخدام زيت السيترال وهو زيت طبيعي مستخرج من القشرة الخارجية للموالح ولة قدرة عالية علي مقاومة الكائنات الممرضة قدرة علي مقاومة المرض .

بينما كان لاستخدام البكتريا المضادة *Pseudomonaes fluorescens* تاثير اكبر في مقاومة المرض عن الخميرة *Candida tennis* ولكنها اقل تاثير عن الشيتوسان والسترال .

وتعتبر معاملة الماء الساخن فعالة ايضا في خفض نسبة الاصابة الي جابب زيادة فترة البقاء علي الرف كما كان عند المعاملة بالشيتوزان والسيترال .

كشفت الدراسة عدم وجود فروق كبيرة في درجات جودة الثمار في (نسبة الاملاح الذائبة TSS ونسبة الحموضة TA) الي جانب ملاحظة زيادة طفيفة في نسبة فيتامين ج .