SAFE POSTHARVEST TREATMENTS TO CONTROL *BOTRYODIPLODIA THEOBROMAE* AND *BOTRYTIS CINEREA* CAUSING BANANA FINGER ROTS AND TO MAINTAIN FRUIT QUALITY

Journal

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ABSTRACT

Sodium carbonate and three commercial disinfectants were evaluated as safe alternatives to fungicides to control banana finger rots incited by *Botryodiplodia theobromae* and *Botrytis cinerea* compared with the fungicide Tecto. The tested disinfectants, i.e. Bafry (hydrogen peroxide/silver ions), Sanosil Super 25 (hydrogen peroxide/silver ions) and Max Guard (sodium dichloroisocynurate) and Sodium carbonate were investigated *in vitro* against mycelial growth of *B. theobromae* and *B. cinerea*. All tested alternative materials completely inhibited the growth of *B. cinerea* at the rate of 0.3 %. Meanwhile, Max Guard, Sanosil Super 25 Bafry and sodium carbonate reduced colony diameter of *B. theobromae* by 100, 86.7, 33.3 and 33.3%, respectively, at the rate of 0.3%. Postharvest treatment of banana fruits with Bafry, Sanosil Super 25 and Max Guard and Sodium carbonate at the rates of 0.1, 0.2 and 0.3% revealed high successive efficacy against tested fungi. During season 2007, all investigated treatments at 0.3% gave 100% efficacy against finger rots except for Bafry which gave 81.1% efficacy under natural infection conditions. Next season, in 2008, only Max Guard at 0.3% gave 100% efficacy, while the efficacy of Sanosil Super 25 and Sodium carbonate and Bafry was 93.3, 93.3 and 87.7%, respectively. The disinfectants and sodium carbonate tested against *B. cinerea* and *B. theobromae* on

artificially infected bananas achieved high efficiency during seasons 2007 and 2008. All tested materials at 0.3% were highly effective against *B. cinerea* in both seasons except for sodium carbonate only in season 2007 which achieved less efficacy, 43.6%, comparing with the other treatments. On the other hand, sodium carbonate at 0.3% was the most suppressive treatment on *B. theobromae* in both seasons, while efficacy of Max Guard was relatively the least. However, Sanosil Super 25 and Bafry at 0.3% achieved good control of *B. theobromae* comparing with the control. fungicide Tecto which recorded the highest effect its efficiency percentage was 93.3 % . Generally, all tested disinfectants and sodium carbonate achieved less efficacy than tecto in seasons 2007 and 2008, but they achieved high control on both diseases comparing with the control fruits.

On the other hand all the safe compounds studded extended the shelf-life of banana fruits by decreasing weight loss percentage, color transmition and maintaining higher values for TSS, acidity and starch at the end of storage maintained fruit quality.

INTRODUCTION

Banana (*Musa* sp.) is considered one of the most important commercial fruit crops in most producing countries. It is highly subjected to the infection with fungi causing postharvest diseases during storage, transit and marketing. Some of these diseases, such as finger rot incited by *Botryodiplodia theobromae*, develop and reduce quality and quantity of banana fruits (El-Goorani and Sommer, 1981, and Boruah *et al.,* 2003 and 2004). *B. theobromae* is an important as a postharvest pathogen because the environmental conditions in storage favor the pathogen development (Abdel- Sattar, 1978). Many attempts were made to protect banana fruits against certain postharvest pathogens during marketing and storage. Grey mold disease caused by *Botrytis cinerae* was inhibited by several salts such as calcium chloride (Wasna *et al.* 1999 and Younis, 2002). Potassium bicarbonate, ammonium bicarbonate and sodium bicarbonate had a good inhibitory effect on growth of *B. cinerea,* affected the germination of conidia and reduced Botrytis fruit rot incidence and severity (Palmer *et al.*, 1994 a & b, Palmer, 1996, and Khafagi, 2002). Sanosol-25, a disinfectant containing 48% hydrogen peroxide and silver salts as stabilizing agents, inhibited the mycelial growth of the two main melon decay fungi, *Alternaria alternata* and *Fusarium*

solani, *in vitro*. However, *in vivo* experiments, Sanosil-25 markedly decreased decay at a concentration of 5000 ppm (Aharoni *et al.*, 1994). Soltan (2002) reported inhibitory effects of potassium chloride, potassium sorbate and sodium chloride on spore germination of *B. cinerea*. These salts at different concentrations gave satisfactorily results in controlling grey mold decay on stored apricots. Soltan *et al.* (2006) stated that among 7 salts tested, calcium nitrate and calcium chloride at a concentration of 0.2% were the best effective treatments in controlling snap bean pod rots caused by *B. cinerea* with efficacy of 90% and 77%, respectively. Carlos and Garner (2007) recorded that dipping of 'Wonderful' pomegranates in 3% solution of potassium sorbate at 21 °C for 3 min was the most effective against artificial infection of grey mold comparing to sodium bicarbonate, sodium carbonate. (Conway *et al.*, 1991) stated that calcium salts had been reported to play an important role in the inhibition of postharvest decay of apples. These findings referred to the significance of using salts to control postharvest diseases of fruits.

The effects of wax emulsion coating, ethylene absorbent, fungicide, and growth regulators alone and in various combinations, on physical characters and shelf-life of bananas held under ambient conditions were investigated. Of the different combinations, fungicide (450 ppm Bavistin [carbendazim]) with ethylene absorbent was better at minimizing physiological weight loss and decay loss at 20 days after storage and this treatment was the best, extending shelf-life of bananas by maintaining higher values for TSS, sugars, acidity and starch to 22 days (Rao and Chundawat (1991). The same trends were illustrated by (Patil and Hulamani (1998)).

The effects of various concentrations of ethanol or acetaldehyde vapour on weight loss, firmness, total soluble solids (TSS) and titratable acidity (TA) of mature green Cavendish bananas were investigated. Whereas ethanol had a negligible effect on fruit ripening, acetaldehyde (1 or 4 ml/kg fruit added to a 3-litre sealed container) was effective at maintaining fruit firmness and preventing increases in TSS and titratable acidity levels (Hewage *et al.*, (1995)).

Cool chamber storage significantly slowed down the rate of increase in physiological weight loss and decrease in firmness of banana cv. Dwarf Cavendish fruits compared with rapid changes in fruits stored in ambient conditions (AC). The rate of increase in titratable acidity and total sugars and decrease in starch were slow in

fruits stored in cool chamber compared with those stored in AC. Irrespective of the storage conditions (Nagaraju and Reddy, (1995)).

The change from the unripe stage was characterized by decreasing starch content, increasing total sugar, total soluble solids and titratable acidity. Titratable acidity increased until colour index 3 (more green than yellow) and then declined as the fruit turned yellow in colour (Munasque and Mendoza (1990)).

This study aimed to evaluate the effectiveness of salt and disinfectant treatments against banana finger diseases, in comparison with fungicide Tecto as standard to introduce safe alternatives to fungicidal control and to maintain fruit quality during cold storage.

MATERIALS AND METHODS

Pathological studies

Pure and aggressive isolates of *Botryodiplodia theobromae* and *Botrytis cinerea* previously isolated from decayed bananas were used. Sodium carbonate and three commercial disinfectants were evaluated throughout this investigation compared with tecto as a standard fungicide. The commercial disinfectants were Bafry (D-50/500, hydrogen peroxide-silver ions, Hess Products, Germany), Sanosil Super 25 (50% hydrogen peroxide/silver ions, MF Trade Company, Egypt) and Max Guard (3.3 gm sodium dichloroisocynurate, Kanza Group for Projects Development and Services, Egypt) (safe treatments).

In vitro studies:

The effect of sodium carbonate, hydrogen peroxide/silver ions (Bafry and Sanosil) and sodium dichloroisocynurate (Max Guard) at different concentrations on mycelial growth of *B. theobromae* and *B. cinerea* was tested *in vitro*. Each salt or disinfectant was amended in PDA medium at concentrations of 0.1, 0.2 or 0.3%. Treated or untreated medium was poured into five Petri dishes (replicates) per each treatment. After solidification, the medium was inoculated with 5-mm discs of 7-day-old culture of each fungus, incubated at 20 ± 2°C and daily observed until the dishes of the control treatment were completely covered with the fungal growth. Mean diameters of linear growth were recorded and reduction percentages in colonies diameters caused by the tested treatments were calculated using the formula suggested by Fokemma (1973) as follows:

$$\text{Reduction percentage} = \frac{(de - di)}{de} \times 100$$

Where; de = maximum linear growth in control set.
di = maximum linear growth in treatment set.

Store experiments:

Source of banana:

Mature green bunches of Williams banana cultivar were obtained from El-Ebor market, Egypt and used for such study during seasons 2007 and 2008. Banana fruits were sorted to eliminate the damaged fruit and to obtain the samples of uniform maturation.

Effect of postharvest fungicide alternatives on the severity of finger rots on banana during cold storage:

A- Natural infection:

Freshly harvested banana fruits were dipped in solutions of sodium carbonate, Bafry, Sanosil and Max Guard (safe treatments) at the rate of 0.1, 0.2 or 0.3%. and Tecto at the rate of 1ml/L for three Minutes, then air dried in room temperature to remove excess water and placed in carton boxes. Each treatment contained three replicates, 6 hands of banana fruits each, and each hand consisted of 5 fingers. Three replicates left without treatment as a control. All treatments were stored at 13°C and 95% RH for 45 days. After cold storage, disease severity was calculated as a percentage of diseased area in proportion to the total area of the fingers according to Fallik *et al.* (1993).

B- Artificial inoculation:

Other group of freshly harvested banana fruits were artificially inoculated with pathogenic isolates of *B. theobromae* and *B. cinerea.* Fingers were wounded at the peel by scratching the surface up to place 3-mm discs of 7 days old cultures from *B. theobromae* and *B. cinerea* entirely, then it was replaced. Banana fruits were left in room temperature for 24 hr to allow establishment of fungal infection. The inoculated banana fruits were dipped in solutions of sodium carbonate, Bafry, Sanosil and Max Guard (safe treatments) at the rate of 0.1, 0.2 or 0.3%. and Tecto at the rate of 1ml/L for three minutes, then left to dry in room temperature and placed in carton boxes. Replication was adopted as in the natural infection. Three replicates left without

treatment as control. All treatments were stored at 13° C and 95% RH for 45 days. Then disease severity was calculated.

Quality studies:

Effect of different treatments used as alternatives to fungicides on fruit quality was evaluated. Tested quality parameters were as follows:

Weight loss percentage:

Three replicates each had ten fingers were weighed at each examination period and weight loss percentage was calculated during storage period

Fruit color:

Three replicate each had ten fingers were used to evaluate external skin color objectively, on opposite sides of every fruit, by a Hunter colorimeter, Color space a* and b* parameters were used to calculate the hue angle according to McGuire, 1992).

Total soluble solids contents were determined by abb'e rafractometer according to (A.O.A.C., 1980).

Total acidity:

Total acidity percentage was determined by titration and calculated as citric acid according to (A.O.A.C., 1980).

Statistical design and analysis:

A complete randomized design was used for such experiment and obtained data were analyzed using analysis of variance (ANOVA) according to Gomez and Gomez (1983).

RESULTS

Pathological studies

The results illustrated in Table (1) indicate that all tested disinfectant treatments Max Guard, Sodium carbonate, Sanosil Super 25 and Bafry completely inhibited the growth of *Botrytis cinerea* (100 % Reduction of colony diameter) at the rate of 0.3 %. On the other hand, only max Guard completely inhibited the growth of *B. cinerea* at the rate of 0.1 , 0.2 and 0.3%. Similar finding was found for max Guard, where it completely inhibited the growth of *Botryodiplodia theobromae* at the rate of 0.1, 0.2 and 0.3%. Meanwhile, sodium carbonate, Sanosil Super 25 and Bafry reduced colony diameter of *B. theobromae* by 33.3, 86.7and 33.3%, respectively at the rate of 0.3%.

Table (1) Effect of sodium carbonate or three disinfectants on reduction of colony diameter of *Botrytis cinerea* and *Botryodiplodia theobrome* grown on PDA medium and incubated at 20±2°C for 7 days.

Treatment	Reduction of colony diameter %					
	B. cinerea			*B. theobrome*		
	Concentration			Concentration		
	0.1%	0.2%	0.3%	0.1%	0.2%	0.3%
Max Guard	100	100	100	100	100	100
Bafry	12.2	24.4	100	0.0	24.4	33.3
Sanosil Super 25	81.1	87.8	100	0.0	33.3	86.7
Sodium carbonate	0.0	24.4	100	0.0	18.9	33.3
L.S.D. at5% for T	1.44			1.56		
C	1.25			1.35		
T X C	2.50			2.71		

The efficacy of tested materials including sodium carbonate and some disinfectants on banana fruit rots under natural infection determined in seasons 2007/2008 is demonstrated in Table 2. The alternatives substances to fungicides provided protection against fruit rot infection on banana during storage period and could be comparable with the efficacy of the fungicide Tecto which recorded the highest effect. Max Guard and sodium carbonate proved to be the most effective treatments at the rate of 0.1% with efficacy of 80.1% in both treatments. Other tested treatments, Sanosil Super 25 and Bafry at the same rate, 0.1%, showed effectiveness of 59.9% and 50%, respectively. On the other hand, all tested disinfectant materials at the rate of 0.3% gave 100% efficacies except for Bafry which gave 81.1% efficacy, during season 2007, while the results in season 2008 indicated that Sanosil Super 25 and sodium carbonate proved to be the most effective at the rate of 0.1% with efficacy of 75.6% in both treatments. The other treatments, Max Guard and Bafry at the rate of 0.1%, showed effectiveness 72.0% and 55%, respectively. On the other hand, Max Guard at the rate of 0.3% gave 100% efficacy while Sanosil Super 25 and sodium carbonate gave 93.3% efficacy and Bafry gave 87.7% efficacy.

Table (2) Effect of sodium carbonate or three disinfectants comparing with tecto on reduction of disease severity of natural infection during storage period season 2007/2008 after 45 days from storage.

Treatments	Disease severity %													
	Natural infection 2007							Natural infection 2008						
	Cont	0.1%	E%	0.2%	E%	0.3 %	E%	Cont	0.1%	E%	0.2%	E%	0.3%	E%
Max Guard	22.2	4.4	80.1	2.2	90.0	0.0	100	18	4.9	72.0	2.2	87.7	0.0	100
Sanosil Super 25	22.2	8.9	59.9	4.4	80.1	0.0	100	18	4.4	75.6	4.4	75.6	1.1	93.9
Bafry	22.2	11.1	50.0	4.4	80.1	4.4	80.1	18	8.1	55.0	4.9	72.0	2.2	87.7
Sodium carbonate	22.2	4.4	80.1	4.4	80.1	0.0	100	18	4.4	75.6	2.2	87.7	1.1	93.9
Tecto	22.2	0.0	100	0.0	100	0.0	100	18	0.0	100	0.0	100	0.0	100
L.S.D. at 5% for T	1.36							1.26						
C	1.22							1.13						
T X C	2.73							2.53						

Cont*: control treatment

E = efficacy (%) was calculated relative to control treatment.

Data in table (3) showed that all disinfected material gave protection on banana fruit during storage period under artificial infection by *B. cinerea* during season 2007 when used at the rate of 0.1, 0.2 and 0.3 % as compared with fungicide Tecto which recorded the highest effect, 89.7 %. Meanwhile, efficiency of Max Guard, Sanosil Super 25, Bafry and sodium carbonate at the rate of 0.3% was 76.9, 74.4, 71.7 and 43.6%, respectively. Furthermore, all tested disinfectant treatments decreased decay development on banana fruits artificially inoculated with *B. theobromae* during storage period. However, it was obtained that sodium carbonate was the most effective treatment to control fruit rots when used at the rate of 0.3 % achieving efficacy of 69.3% followed by Sanosil Super 25 and Bafry with efficacy of 57.8 % at the same rate comparing with fungicide Tecto which recorded efficacy of 94.4 %

Table (3) Effect of sodium carbonate or three disinfectants comparing with tecto on reduction of disease severity of artificial inoculation by *B. cinerea* and *B. theobromae* during storage period season 2007, after 45 days from storage.

Treatments	Disease severity % season 2007													
	B. cenirae							*B. theobromae*						
	Cont*	0.1%	E%	0.2%	E%	0.3%	E%	Cont*	0.1%	E%	0.2%	E%	0.3%	E%
Max Guard	86.7	28.9	66.7	24.5	71.7	20.0	76.9	79.9	53.3	33.3	53.3	33.3	48.9	38.8
Sanosil Super 25	86.7	51.1	41.1	48.9	43.6	22.2	74.4	79.9	64.5	19.2	57.8	27.7	33.3	57.8
Bafry	86.7	39.9	53.9	28.9	66.7	24.5	71.7	79.9	60.0	24.9	44.5	44.3	33.3	57.8
Sodium carbonate	86.7	55.5	35.9	51.1	41.1	48.9	43.6	79.9	60.0	24.9	40.0	49.9	24.5	69.3
Tecto	86.7	8.9	89.7	8.9	89.7	8.9	89.7	79.9	4.5	94.4	4.5	94.4	4.5	94.4
L.S.D. at 5% for T C TXC	1.44 1.29 2.89							1.52 1.32 3.03						

Cont*: control treatment

E = efficacy (%) was calculated relative to control treatment.

Data in table (4) indicated that rate of 0.3% of all disinfectant materials gave highest efficacy compared with other rates, 0.1 and 0.2 %. Under artificial infection by *B. cinerea*, Max Guard and sodium carbonate gave the highest efficacy to reduce disease severity, 72.7%, followed by Sanosil Super 25 and Bafry achieving efficacy of 69.8% and 64.4%, respectively, comparing with 90.0 % efficacy of Tecto. Meanwhile, Max Guard, Sanosil Super 25, Bafry and sodium carbonate at the rate of 0.3% reduced banana fruit rots of artificial infected by *B. theobromae* with efficacy of 54.7, 66.7, 66.7 and 69.8%, respectively with 93.3 % efficacy of Tecto.

Table (4) Effect of sodium carbonate or three disinfectants comparing with tecto on reduction of disease severity of *B.theobromae* and *B. cinerea* on artificially inoculated banana fruits stored at 13°C and 95% RH during season 2008.

Treatments	Disease severity % season 2008													
	B. cenirae							*B. theobromae*						
	Cont.	0.1%	E%	0.2%	E%	0.3%	E%	Cont.	0.1%	E%	0.2%	E%	0.3%	E%
Max Guard	81.2	39.9	50.7	24.5	69.8	22.2	72.7	73.6	55.5	24.6	48.9	33.6	33.3	54.7
Sanosil Super 25	81.2	48.9	39.8	28.9	64.4	24.5	69.8	73.6	53.3	27.6	44.5	39.5	24.5	66.7
Bafry	81.2	28.9	64.4	24.5	69.8	22.2	72.7	73.6	48.9	33.6	44.5	39.5	24.5	66.7
Sodium carbonate	81.2	51.5	24.1	48.9	39.8	28.9	64.4	73.6	55.5	24.6	51.1	30.6	22.2	69.8
Tecto	81.2	8.1	90.0	8.1	90.0	8.1	90	73.6	4.9	93.3	4.9	93.3	4.9	93.3
L.S.D. at 5% for T C TXC	1.56 1.48 3.30							1.61 1.44 3.22						

Cont*: control treatment
E = efficacy (%) was calculated relative to control treatment

Quality studies:

Weight loss percentage:

Data presented in table (5) clearly indicated that weight loss percentage of Bananas stored at 13°C for 45 days was increased gradually and significantly with prolonging of storage period. All post harvest treated banana fruits with the examined compounds had significantly less weight loss percentage than both treated fruits with tecto (the standards treatment) and untreated fruit (control). On the other hand, the effect of post harvest treatments to reduce fruit weight loss was slightly increased with the increasing of the used concentrations.

Table (5): Effect of some postharvest treatments on banana fruit weight loss percentage during cold storage at 13°C and 95% RH.

St. period	Treatments																			
	Max Gard					Sanosil Super 25				Bafry				Sodium carbonate				Tecto	Means
	0%	0.1%	0.2%	0.3%	Means	0.1%	0.2%	0.3%	Means	0.1%	0.2%	0.3%	Means	0.1%	0.2%	0.3%	Means		
1st season																			
0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0.00	0.00
15	1.22	0.69	0.71	0.92	0.88	0.67	0.92	0.90	0.93	0.83	0.71	0.82	0.90	0.95	1.11	0.69	0.99	1.41	1.02
30	2.93	1.84	2.25	1.92	2.23	1.72	1.88	1.98	2.13	2.07	1.79	1.80	2.15	2.14	2.16	1.80	2.26	3.09	2.37
45	4.64	2.99	3.78	2.92	3.58	2.77	2.85	3.06	3.33	3.31	2.87	2.78	3.40	3.33	3.21	2.92	3.52	4.77	3.72
Means	2.20	1.38	1.69	1.44	1.67	1.29	1.41	1.48	1.60	1.55	1.34	1.35	1.61	1.60	1.62	1.35	1.69	2.32	1.78
2nd season																			
0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0.00	0.00
15	1.11	0.60	0.62	0.77	0.78	0.59	0.79	0.75	0.81	0.83	0.71	0.82	0.87	0.83	0.96	0.59	0.87	1.31	0.93
30	2.65	1.60	1.94	1.61	1.95	1.51	1.62	1.67	1.86	1.81	1.56	1.52	1.88	1.87	1.87	1.53	1.98	2.82	2.10
45	4.26	2.60	3.26	2.45	3.14	2.42	2.46	2.58	2.93	2.90	2.49	2.34	3.00	2.91	2.77	2.47	3.10	4.40	3.31
Means	2.00	1.20	1.45	1.21	1.47	1.13	1.22	1.25	1.40	1.38	1.19	1.17	1.44	1.40	1.40	1.15	1.49	2.13	1.59

Conc. Means				
	0.0%	0.1%	0.2%	0.3%
1st season	2.20	1.63	1.66	1.59
2nd season	2.00	1.45	1.48	1.38

LSD values at 5% level.

Factor	Treat. (a)	Conc. (b)	St. Periods (c)	a x b	a x c	b x c	a x b x c
1st season	0.194	0.174	0.174	0.388	0.388	0.348	0.78
2nd season	0.181	0.162	0.162	0.362	0.362	0.325	0.73

Banana fruit Color:

Color data represented in table (6) indicate that banana fruit color changed from green (hue angel more than 90) to yellow (hue angel less than 90) with prolonging of storage period. Data also indicated that all post harvest treatments with the examined compounds significantly decreased the rate of changes in color transmission compared with untreated fruits and treated ones with tecto. Increasing the concentration of used such chemicals did not show obvious trend of effect on fruit color development during the two seasons, that means the high and the low concentrations of disinfectants had nearly the same effect during storage. On the other

hand, there was a significant interaction within treatments and used concentrations.

Total soluble solids:

Data represented in table (7) show that total soluble solids contents of banana fruits were increased gradually and significantly with prolonging of storage period during the two seasons in this study. Moreover, data revealed that all examined compounds significantly decreased the increasing rate of TSS during storage in the two seasons in this work compared with either treated or untreated fruits. However data represented that, fruits treated with the highest concentrations had the lowest TSS contents during the two seasons of this work. On the other hand, there was an interaction among the examined concentrations and storage period affecting increasing of the total soluble solids contents in banana fruits in this work.

Total acidity contents:

Data represented in table (8) cleared that total acidity contents of banana fruits decreased gradually and significantly with the extension of storage period during storage. Moreover, data obtained indicated that all examined compounds significantly decreased the increasing rate of banana fruits total acidity contents during storage compared to untreated fruits. On the other hand, total acidity contents of banana fruits treated with tecto still had titratable acidity contents higher than those treated with the tested compounds. Data also indicated that the reduction of decreasing rate of the titratable acidity of banana fruit significantly increased with the increasing of the used concentration during the two seasons of this work. Also, there was a significant interaction among treatments and the used concentrations.

Table (6): Effect of some postharvest treatments on banana fruit color represented as hue angle during cold storage at 13°C and 95% RH.

St. period	Treatments																			
	Max Gard					Sanosil Super 25				Bafry				Sodium carbonate				Tecto	Means
	0%	0.1%	0.2%	0.3%	Means	0.1%	0.2%	0.3%	Means	0.1%	0.2%	0.3%	Means	0.1%	0.2%	0.3%	Means		
1st season																			
0	116.	116.	116.	116.8	116.	116.8	116.8	116.8	116.	116.	116.	116.	116.	116.	116.	116.	116.	116.	116.
15	92.3	92.3	98.1	95.8	94.6	99.1	92.3	98.1	95.5	95.8	99.1	92.3	94.9	98.1	95.8	99.1	96.3	97.4	95.8
30	68.3	70.5	79.5	75.6	73.5	80.7	71.0	79.4	74.8	75.5	81.7	70.3	74.0	79.4	75.6	81.2	76.1	77.4	75.2
45	53.7	56.9	67.7	62.8	60.3	68.9	57.7	67.5	61.9	62.7	70.6	56.6	60.9	67.5	62.8	69.7	63.4	64.9	62.3
Means	82.8	84.1	90.5	87.8	86.3	91.4	84.4	90.4	87.3	87.7	92.1	84.0	86.6	90.4	87.8	91.7	88.2	89.1	87.5
2nd season																			
0	106.3	106.3	106.3	106.3	106.3	106.3	106.3	106.3	106.3	106.3	106.3	106.3	106.3	106.3	106.3	106.3	106.3	106.3	106.3
15	72.9	74.0	82.4	86.0	78.8	89.5	82.7	79.6	81.2	85.9	71.8	73.9	76.1	70.5	86.0	71.5	75.2	72.9	76.8
30	53.3	62.0	77.9	59.0	63.1	71.0	55.3	77.8	64.3	58.9	71.9	54.9	59.7	77.8	68.8	71.4	67.8	53.3	61.6
45	52.7	55.7	52.8	55.3	54.1	53.7	50.7	52.6	52.4	55.2	69.2	55.5	58.1	61.4	49.0	68.3	57.8	52.7	55.0
Means	71.3	74.5	79.9	76.6	75.6	80.1	73.8	79.1	76.1	76.6	79.8	72.6	75.1	79.0	77.5	79.4	76.8	71.3	75.0

Conc. Means				
	0.0%	0.1%	0.2%	0.3%
1st season	82.79	88.56	88.79	88.61
2nd season	71.27	76.30	76.45	75.81

LSD values at 5% level.

Factor	Treat. (a)	Conc. (b)	St. Periods (c)	a x b	a x c	b x c	a x b x c
1st season	3.87	3.47	3.47	7.74	7.74	6.94	15.50
2nd season	4.11	3.69	3.69	8.22	8.22	7.37	16.47

Table (7): Effect of some postharvest treatments on banana fruit TSS contents (%) during cold storage at 13°C and 95% RH.

St. period	Treatments																			
	Max Gard					Sanosil Super 25				Bafry				Sodium carbonate				Tecto	Means
	0%	0.1%	0.2%	0.3%	Means	0.1%	0.2%	0.3%	Means	0.1%	0.2%	0.3%	Means	0.1%	0.2%	0.3%	Means		
1st season																			
0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0
15	19.1	19.0	17.6	17.5	18.3	18.1	18.8	18.4	18.6	19.5	21.9	17.9	19.6	18.9	19.5	18.1	18.9	18.7	18.8
30	20.3	20.8	19.5	19.2	19.9	19.5	20.1	19.1	19.7	19.5	20.6	18.7	19.8	20.2	19.9	19.0	19.9	20.3	19.9
45	22.2	23.1	22.2	22.2	22.4	21.4	22.2	21.1	21.7	20.0	20.1	20.7	20.7	21.9	21.2	21.3	21.6	23.0	21.9
Means	19.7	20.0	19.1	19.0	19.4	19.0	19.5	18.9	19.3	19.0	19.9	18.6	19.3	19.5	19.4	18.9	19.4	19.8	19.4
2nd season																			
0	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8
15	18.5	18.7	17.5	17.1	18.0	17.4	17.4	16.2	17.4	16.3	15.7	15.8	16.6	17.8	16.6	16.3	17.3	19.0	17.7
30	19.0	21.9	18.8	18.2	19.5	17.9	18.1	18.3	18.3	19.3	20.8	16.6	18.9	17.3	18.5	17.5	18.1	19.9	18.9
45	19.7	22.0	19.5	18.6	20.0	19.1	19.0	18.7	19.1	19.1	19.5	17.2	18.9	19.1	18.8	16.6	18.6	20.3	19.4
Means	18.3	19.6	17.9	17.4	18.3	17.5	17.6	17.3	17.7	17.6	18.0	16.4	17.5	17.5	17.4	16.6	17.4	18.7	17.9

Conc. Means				
	0.0%	0.1%	0.2%	0.3%
1st season	19.66	19.44	19.54	19.02
2nd season	18.26	18.19	17.92	17.27

LSD values at 5% level.

Factor	Treat. (a)	Conc. (b)	St. Periods (c)	a x b	a x c	b x c	a x b x c
1st season	0.28	0.25	0.25	0.56	0.56	0.50	1.12
2nd season	0.24	0.22	0.22	0.48	0.48	0.43	0.97

Table (8): Effect of some postharvest treatments on banana fruit Total acidity contents (%) during cold storage at 13°C and 95% RH.

St. period	Treatments																			
	Max Gard					Sanosil Super 25				Bafry				Sodium carbonate				Tecto	Means
	0%	0.1%	0.2%	0.3%	Means	0.1%	0.2%	0.3%	Means	0.1%	0.2%	0.3%	Means	0.1%	0.2%	0.3%	Means		
1st season																			
0	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
15	0.45	0.85	0.75	0.86	0.73	0.60	0.65	0.60	0.58	0.45	0.65	0.70	0.56	0.65	0.65	0.85	0.65	0.75	0.65
30	0.36	0.68	0.64	0.71	0.60	0.52	0.52	0.51	0.48	0.37	0.56	0.56	0.46	0.55	0.54	0.73	0.55	0.64	0.54
45	0.29	0.54	0.54	0.59	0.49	0.44	0.42	0.43	0.40	0.31	0.48	0.45	0.38	0.47	0.45	0.63	0.46	0.54	0.45
Means	0.50	0.74	0.71	0.76	0.68	0.61	0.62	0.61	0.59	0.51	0.65	0.65	0.58	0.64	0.63	0.78	0.64	0.71	0.64
2nd season																			
0	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
15	0.35	0.75	0.59	0.83	0.63	0.47	0.57	0.47	0.46	0.44	0.59	0.62	0.50	0.57	0.64	0.66	0.56	0.65	0.56
30	0.35	0.53	0.56	0.55	0.50	0.45	0.51	0.50	0.45	0.34	0.44	0.55	0.42	0.54	0.42	0.64	0.49	0.59	0.49
45	0.25	0.53	0.53	0.52	0.46	0.43	0.32	0.38	0.35	0.24	0.47	0.35	0.33	0.41	0.41	0.61	0.42	0.43	0.40
Means	0.45	0.67	0.63	0.69	0.61	0.55	0.56	0.55	0.53	0.47	0.59	0.59	0.52	0.59	0.58	0.69	0.58	0.63	0.57

Conc. Means				
	0.0%	0.1%	0.2%	0.3%
1st season	0.50	0.64	0.66	0.70
2nd season	0.45	0.58	0.60	0.63

LSD values at 5% level.

Factor	Treat. (a)	Conc. (b)	St. Periods (c)	a x b	a x c	b x c	a x b x c
1st season	0.012	0.011	0.011	0.024	0.024	0.022	0.05
2nd season	0.009	0.008	0.008	0.016	0.018	0.016	0.04

DISCUSSION

Fresh bananas are important source of vitamins and minerals which are essential elements for human health. Economic losses caused by postharvest diseases are among the most important concerns of growers. Postharvest fruit decay has typically been controlled by application of synthetic fungicides. However, important problems associated with the massive use of these chemicals, such as proliferation of resistant strains of the pathogens and concerns about public health and environmental contamination have increased the need for alternatives (Crisosto, 2006).

The most serious postharvest diseases attack banana fingers are *Botrytis cinerea* and *Botryodiplodia theobromae* (El-Goorani and Sommer, 1981, Boruah *et al.,* 2003 and 2004 and Abdel- Sattar,1978). Investigating the effect of certain disinfectants containing hydrogen peroxide/silver ions and sodium dichloroisocynurate as well as sodium carbonate on *B. cinerea* and *B. theobromae in vitro* revealed a promising effect to be tested *in vivo*. This finding emphasized investigating the impact of these materials to suppress fungal attack on banana fingers during cold storage. The rate of 0.3% of such mentioned chemicals completely inhibited the growth of *B. cinerea*. On the other hand, sodium dichloroisocynurate at 0.3% only completely suppressed *in vitro* growth of *B. theobrome*. Different salts were also used to protect fresh fruits and vegetables from certain postharvest pathogens during marketing and storage Palmer *et al.* (1997) found that at concentrations as low as 20 mM of sodium bicarbonate inhibited colony growth of *B. cinerea*. Current work revealed that sodium carbonate was found to be effective against *B. cinerea* and *B. theobromae* on banana fingers *in vitro* and *in vivo* during cold storage. This finding was in harmony with that obtained by Palou *et al.* (2001 and 2002) who mentioned that sodium carbonate and sodium bicarbonate had inhibitory action against fruit postharvest pathogens and are more fungistatic than fungicidal and not very persistent. Venditti *et al.* (2005) and Palou *et al.* (2007) suggested that potassium sorbate, sodium bicarbonate and sodium carbonate combine a week direct toxic effect to the fungal pathogen with indirect effects related to non-permenant modifications of the conditions within the site of infection (pH, physical change or induction of antifungal compounds.

Hydrogen peroxide was tested combined with silver ions in two commercial disinfectants and sodium dichloroisocynurate proved to be effective against *B. cinerea* and *B. theobromae*. However, different commercial formulations of hydrogen peroxide/silver ions showed varied effectiveness. Aharoni *et al.* (1994) found that Sanosol-25, a disinfectant containing 48% hydrogen peroxide and silver salts as stabilizing agents, inhibited the mycelial growth of the two main melon decay fungi, *Alternaria alternata* and *Fusarium solani in vitro*. However, *in vivo* experiments, Sanosil-25 markedly decreased decay at a concentration of 5000 ppm. The silver ion combined in hydrogen peroxide seems to have positive effect to control fungal pathogens including *B. cinerea*. This expected effect of silver could be clarified by De Capdeville *et al.* (2003) who found that silver thiosulfate affected severity of *B. cinerea* and extended vase life of rose buds.

Tested chemical treatments maintained banana fruit quality during the cold storage at 13°C and 95% RH for up to 45 days. Weight loss is considered the most critical factor reducing banana postharvest shelf life. Many investigators handled reducing the weight loss of bananas during the cold storage. Findings in current study referring to high effectiveness of commercial disinfectants and sodium carbonate to reduce weight loss are supported by Rao and Chundawat (1991) and Patil and Hulamani (1998). They cleared the positive effects of Bavistin [carbendazim] on minimizing physiological weight loss and decay of banana during storage. Observed effectiveness of such tested disinfectants and sodium carbonate on total soluble solids, titratable acidity and development of fruit color indicated slow development of fruit toward ripeness. The tested chemicals suppressed decay development which reflected unaccelration of fruit respiration. So, keeping bananas longer in cold storage with proper quality depends on treatments that eliminate or reduce development of fungal decay. This finding was also demonstrated by Munasque and Mendoza (1990) who mentioned that the change from the unripe stage was characterized by increasing total soluble solids and titratable acidity and the fruit color turned from more green than yellow to yellow.

Generally, it was found that all tested alternative for fungicides including Bafry (hydrogen peroxide/silver ions), Sanosil Super 25 (hydrogen peroxide/silver ions) and Max Guard (sodium dichloroisocynurate) and Sodium carbonate at rate of 0.3% proved to

be highly effective against fungal rots of banana fingers and achieved good control during cold storage at 13°C for 45 days.

REFERENCES

Abdel-Sattar, M. A. (1978). Studies on banana fruit rot during developing harvesting and ripening. Ph.D. Thesis, Fac. Agric. Cairo University 213pp.

Aharoni, Y., A. Copel and E. Fallik (1994). The use of hydrogen peroxide to control postharvest decay on 'Galia' melons. Annals Appl. Biol., 125(1):189-193.

Association of Official Analytical Chemists (1980): Official methods of analysis, the A.O.A.C., 13th Ed. Published by A.O.A.C. Washington, DC 20044, U.S.A.

Boruah, P.; P. D. Bhuyan, and R. S. Singh, (2003). Fungal spoilage of banana in eastern sub Himalayan region. Journal of Mycopathological Research. Indian Mycological Society, Calcutta, India: 2003. 41: 2, 171-175.

Boruah, P.; P. D. Bhuyan, and R. S. Singh, (2004). Fungal spoilage of banana in Eastern Sub-Himalayan region. Jodhpur, India: 2004. 9: 27-36.

Carlos, H.C. and D. Garner (2007). Combination of postharvest antifungal treatments and controlled atmosphere storage to control gray and improve storability of "wonderful" pomegrnates. Postharvest Biology and Technology, 43 (1):133-142.

Conway, W.S., Sams, C.E., Abbott, J.A. and Bruton, B.D. (1991). Postharvest calcium treatment of apple fruit to provide broad-spectrum protection against postharvest pathogens. Plant Dis. 75 (6): 620-622.

Crisosto, C.H. (2006). Peach quality and postharvest technology. Proc. 6th Intl. Peach symposium, Acta Hort. 713. ISHS 2006.

De Capdeville, ., L.A. Maffia, F.L. Finger and U.G. Batista. (2003). Gray mold severity and vase life of rose buds after pulsing with citric acid, salicylic acid, calciumsulfate, sucrose and silver thiosulfate. Fitopatol. Bras. 28(4): 380-385.

El-Goorani. M. A. and N. F. Sommer (1981). Effect of modified atmospheres on postharvest pathogens of fruits and vegetables. Horticultural. Rev. 3: 412-52.

Fallik, E., J. Klein, S. Grinberg, E. Lomanies, S. Lurie and A. Lalazar (1993). Effect of postharvest heat treatment of tomatoes on fruit ripening and decay caused by *Botrytis cinerea*. Plant Dis., 77:985-988.

Fokemma, N. J. (1973). The role of saprophytic fungi in antagonism against *Drechslera sorokiniana* (*Helminthosporium sativum*) on agar plates and on rye leaves with pollen. Physiol. Plant Pathol. 3:195-205.

Gomez, K.A. and A.A. Gomez (1983). Statistical Procedures for Agricultural Research. John Willey and Sons, New York.

Hewage, K., S.; H., Wainwright and Y., Luo. (1995). Effect of ethanol and acetaldehyde on banana ripening. Journal-of-Horticultural-Science. 70: 1, 51-55; 13 ref.

Khafagi, Eman, Y. S. (2002). Studies on the fungi accompanied with strawberry fruits. M. Sc. Thesis, Fac. Agric., Cairo Univ., 130pp.

McGuire, R. G. (1992): Reporting of objective color measurements. Hort. Science, Vol., 27(12): 1254-1255.

Munasque, V., S., and D., B., Mendoza, (1990). Developmental physiology and ripening behaviour of 'Senorita' banana (Musa sp. L.) fruits. ASEAN-Food-Journal. 5: 4, 152-157; 7 ref.

Nagaraju, C., G. and T., V., Reddy, (1995). Deferral of banana fruit ripening by cool chamber storage. Advances-in-Horticultural-Science. 9: 4, 162-166; 1 fig.; 16 ref.

Palmer, C. L., (1996). *In vitro* and *in vivo* effects of bicarbonate on *Botrytis cinerea*. Ph. D Diss., Cornell University, Ithaca, N. Y.

Palmer, C. L., R. K. Horst, and R. W. Langhans (1997). Use of bicarbonates to inhibit in vitro colony growth of *Botrytis cinerea*. Plant Dis. 81(12): 1432-1438.

Palmer, C. L., R. K. Horst, H. W. Israel and R. W. Langhans (1994a). Bicarbonates and Botrytis: IV- Additional concentration of effects on germination of *Botrytis cinerea* conidia. Phytopathology, 84: 1374.

Palmer, C. L., R. K. Horst, R. W. Langhans and H. W. Israel (1994b). Bicarbonates and Botrytis: VII- Viability of fungal conidia. Phytopathology, 84: 1204.

Palou, L., C.H. Crisosto and D. Garner (2007). Combination of postharvest antifungal chemical treatments and controlled

atmosphere storage to control gray mold and improve storability of 'Wonderful' pomegranates. Postharvest Biology and Technology 43 : 133–142.

Palou, L., J. Usall, , J.L. Smilanick, , M.J. Aguilar and I. Vi˜nas (2002). Evaluation of food additives and low-toxicity compounds as alternative chemicals for the control of *Penicillium digitatum* and *Penicillium italicum* on citrus fruit. Pest Manag. Sci. 58, 459–466.

Palou, L., J.L. Smilanick, , J. Usall, and I. Vi˜nas (2001). Control of postharvest blue and green molds of oranges by hot water, sodium carbonate, and sodium bicarbonate. Plant Dis. 85, 371–376.

Patil, S., N. and N., C., Hulmani (1998). Effect of post harvest treatments on the storage of banana fruits. Karnataka-Journal-of-Agricultural-Sciences. 11: 1, 134-138; 8 ref.

Rao, D., V., R., and B., S., Chundawat, (1991). Chemical regulation of ripening in banana bunches cv. 'Lacatan' at non-refrigerated temperatures. Haryana Journal of Horticultural Sciences, 20: 1-2, 6-11; 8 ref.

Soltan, H.H.M. (2002). Control of postharvest decay of apricot by use of certain preservatives. Egypt. J. Appl. Sci., 17(7):61-74.

Soltan, H.H.M., Tomader J. Abd-Elrahman and Azza M.A. Naffa (2006). The efficacy of preharvest salts treatment on incidence of snap bean pod rots during storage. Egypt. J. Phytopathol., 34(1):31-40.

Venditti, T., M.G. Molinu, A. Dore, M. Agabbio and G. D'hallewin, , (2005). Sodium carbonate treatment induces scoparone accumulation, structural changes, and alkalinization in the albedo of wounded Citrus fruits. J. Agric. Food Chem. 53, 3510–3518.

Wasna, N. P., K. Kawada and T. Matsui (1999). Pre-harvest foliar applied calcium and post-harvest CO_2 increment improve storability of "Nyoho" Strawberries. J. Soc. High Tech. in Agric., 11(3): 165-172.

Younes, H. E. H. (2002). Induction of resistance to postharvest rots and extension shelf life of strawberry fruits by biological methods. M. Sc. Thesis, Fac. Agric., Al-Azhar Univ., 104pp.

معاملات ما بعد الحصاد الامنة لمقاومة *Botryodiplodia theobromae* and *Botrytis cinerea* مسببات اعفان اصابع الموز وللمحافظة على جودة الثمار

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تم تقييم ملح كربونات الصديوم وثلاثة مطهرات تجارية كبدائل امنة ما بعد الحصاد لمقاومة أعفان اصابع الموز المتسببةعن فطر ***Botryodiplodia theobromae***، ***Botrytis cinerea*** مقارنة بالمبيد الفطرى تكتو . المطهرات المختبرة فى المعمل ضد النمو المسليومى لفطر ***Botryodiplodia theobromae***، ***Botrytis cinerea*** هى ملح كربونات الصديوم، بافرى دى 500/50 (فوق أيدروكسيد الهيدروجين + أيونات الفضة) ، سانوسيل سوبر 25 (50% فوق أيدروكسيد الهيدروجين + أيونات الفضة) وماكس جارد (داى كلورو أيزو سينورات الصوديوم) كل المطهرات المختبرة ادت الى تثبيط كامل للنمو الميسليومى للفطر ***Botrytis cinerea*** عند تركيز 0.3% بينما ماكس جارد، سانوسيل سوبر 25، كربونات الصديوم و بافرى دى 500/50 ادت الى تثبيط النمو الميسليومى لفطر ***Botryodiplodia theobromae*** بنسبة 100، 86.7، 33.3 و 33.3 على التوالى عند تركيز 0.3%. معاملات ما بعد الحصاد لاصابع الموز بافرى ، سانوسيل سوبر 25، ماكس جارد و كربونات الصديوم بمعدل 0.1، 0.2، 0.3% أعطت كفاءة عالية ضد الفطريات المختبرة. أثناء موسم 2007 كل المعاملات المختبرة بمعدل 0.3% أعطت كفاءة 100% ضد أعفان الاصابع ما عدا بافرى الذى أعطى كفاءة 81.1% تحت ظروف العدوى الطبيعية، فى الموسم التالى 2008 فقط ماكس جارد بمعدل 0.3% أعطى كفاءة 100% بينما سانوسيل سوبر 25، كربونات الصديوم و بافرى أعطى كفاءة 93.3، 93.3 و 87.7 على التوالى. المطهرات وكربونات الصديوم المختبرة ضد عدوى الموز الصناعية بفطر ***Botryodiplodia theobromae***، ***Botrytis cinerea*** أظهرت كفاءة عالية خلال موسم 2008/2007. كل المواد المختبرة بمعدل 0.3% كانت فعالة ضد فطر ***Botrytis cinerea*** فى كلا الموسمين ما عدا كربونات الصديوم فقط فى موسم 1007 التى أظهرت كفاءة أقل 43.6% بالمقارنة بالمعاملات الاخرى، على الوجه الاخر كربونات الصديوم بمعدل 0.3% كانت فعالة على الفطر ***Botryodiplodia theobromae*** فى كلا الموسمين، بينما كفاءة ماكس جارد كانت أقل. على اية حال سانوسيل سوبر 25، و بافرى بمعدل 0.3% أعطى مقاومة جيدة لفطر ***Botryodiplodia theobromae*** مقارنة بمبيد النكتو الذى سجل تأثير عالى حيث كانت الكفاءة 93.3%. عموما كل المطهرات وكربونات الصديوم أظهرت كفاءة أقل بالمقارنة بالنكتو فى موسم 2008/2007، ولكن أظهرت مقاومة عالية على كل الامراض مقارنة باصابع الموز المقارنة.

ومن ناحية اخرى فان استخدام المركبات الامنه "تحت الدراسه" كان له تاثيرا فعالا فى اطالة العمر التسويقى لثمار الموز وذالك نتيجة تقليل الفقد فى الوزن و التغير فى لون الثمار والمحافظه على محتوى الثمار من المواد الصلبه الذائبه و الاحماض الكليه.