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CONTROL OF BROWEN ROT ON SOME STONE FRUITS DURING STORAGE USING SOME SALTS AND INDUCING RESISTANCE

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ABSTRACT

Brown rot disease of Canino apricots and FlordaPrince peaches is a major serious decay disease during cold storage in Egypt and worldwide, Infection of stone fruits may occur during blooming until harvest harvest which cause decay during cold storage. The effect of fungicide safe alternatives, (Chemical salts and Inducing resistance). The effect of fungicide safe alternatives, *i.e*. sodium bicarbonate, calcium chloride, potassium sorbate, potassium silicate,boric acid and salicylic acid, on growth of *Monilinia laxa M. fructigena* and *Monilinia* sp. as major pathogens on apricots and peaches ,was investigated at different concentrations ranged from 1000 ppm to 5000 ppm amended in PDA *in vitro*. Sodium bicarbonate at 1000 ppm completely suppressed the growth of the three isolates of *Monilinia* spp., Calcium chloride at 1000 ppm to 5000 ppm, did not show any suppression of *M. laxa* or *Monilinia* sp., while it suppressed *M. fructigena* when used at ≥4000 ppm. Potassium silicate did not show considerable effectiveness against different tested isolates of *Monilinia* spp. IC50 values (chemical concentration that reduce fungal growth to 50%) of sodium bicarbonate, potassium sorbate and salicylic acid on *M. fructigena* were less than 1000 ppm. On *M. laxa,* only sodium bicarbonate showed IC50 less than 1000 ppm, while the IC50 values of potassium sorbate and boric acid were less than 2000 ppm. Regarding *Monilinia* sp. sodium bicarbonate and potassium sorbate IC50 values were less than 1000 ppm. Generally, sodium bicarbonate, potassium sorbate and salicylic acid showed IC50 values less than 1000 ppm, 2000 ppm, and 3000 ppm, respectively.

These salts and inducers at 3000 ppm, were used as three preharvest sprays starting at growth stage no. 64 and then repeated twice at 10 days intervals in orchard located at Qualyubia and Ismailia, during seasons 2015 and 2016. These salts and acids were also adopted at 3000 ppm on naturally infected or artificially inoculated fruits after harvest at growth stage no. 81 during season 2016. Sodium bicarbonate, calcium chloride, potassium sorbate and boric acid were the most effective treatments to control brown rot disease on apricots and peaches during cold storage at 0^oC and 90% RH for 15 days and 30 days, either these chemicals were sprayed preharvest or adopted after harvest. These treatments maintained fruit quality regarding firmness and acidity.

Key words: Brown rot, Apricot, Peach, Fruit, Chemical salts, Inducing resistance, Cold storage,

INTRODUCTION

Cultivation of stone fruits, mainly apricot and peach, are increasing annually in Egypt for both local consumption and exportation. Brown rot disease incited by *Monilina* species is a most serious disease causing economic losses due to stone fruit decay either preharvest or during cold storage, transportation, as well as during marketing. *Monilinia* spp. could also cause blossom and twig blight and shoot cankers of stone fruit trees **(Poniatowska et al 2013)**. Infection of stone fruit with *Monilinia* spp. begins preharvest at blooming where fungal conidia from infected twigs or ascospores released from apothecia infect opening flowers **(Watson et al 2002)**. Apricot and peach blooming lasts for about 3-4 weeks according to the predominant environmental conditions, where they are subjected to infection with *Monilinia* spores. Latent infection of flower ovary is established with *M. laxa*, *M. fructigena* and *M. fructicola* and cause blossom blight or stay quiescent until fruit nutrition content are more developed to be proper for fungus development as the fruit develop to be mature or ripe causing huge economic losses worldwide with value reached about1.7 M€ annually **(Moreira and Mio 2007 and Martini and Mari 2014)**.

Protecting stone fruit from infection with *Monilinia* and suppressing the establishment of its infection, as early as possible, are the major strategies to control brown rot diseases incidence and development. Several approaches for controlling the infection of the disease are available all over the world, but mainly focus on preharvest application with fungicides, even before bud break. **Thomidis et al (2007)** found that three calcium products including calcium chloride at concentrations 1g to 4 g/L significantly suppressed *M. laxa in vitro*. Preharvest spray with calcium chloride did not control brown rot of artificially inoculated immature or mature peaches, while postharvest dip of peaches in 2, 4 and 6 g of calcium chloride per liter highly decreased brown rot on artificially inoculated peaches.Calcium chloride was expected to enhance resistance of peaches toward brown rot disease on apples and potato tubers as examples of horticultural crops as proposed by **Conway et al (1994)** and also calcium works as mechanical barrier where it increases the integrity of cell wall. Calcium can suppress invasion of fungi produce pectolytic enzymes due to transforming pectin into calcium pectate that reduce or inhibit polygalacturonase activity and consequently reduce the maceration of cell wall even when calcium is used at low concentrations, surplus calcium ion delays fruit ripening and senescence by inhibiting ethylene effect through cell membrane **(Conway et al 1994, Yamane 2014 and Madani and Forney 2015)**. **Casals et al (2010)** examined the effect of sodium bicarbonate at 4 concentrations (1% and 4%) to control brown rot of peaches and nectarines caused by *M. laxa* as individual treatments or in combination with hot water temperatures ranged between 55°C and 70°C. They found that dipping the fruits in sodium bicarbonate at 2% for 40 seconds gave satisfactory effect, while dipping in hot water at 60°C for 40 seconds was the most effective treatment, but with negative effects on fruit quality. Combination treatments did not show significant control of *M. laxa* more than individual treatments. **(Karabulut et al 2001)** Sodium bicarbonate at 2% was found to be the most effective treatment to control sweet cherries fungal decay caused by *M. fructicola*, *Botrytis cinerea* and *Penicillium expansum*. Also, **Karaca et al (2014)** found that sodium bicarbonate was one of the most superior treatments to control brown rot of plums caused by *M. fructicola*.

The effect of two inorganic and organic commercial products in, *i.e*. Borax (inorganic boric acid is the active ingredient) and Power B, respectively, containing 20% boron on *M. laxa* growth on PDA *in vitro* and brown rot on peaches as preharvest application or postharvest dipping showed promising treatments **(Thomidis and Exadaktylou 2010)**.

They showed that Borax, at 750 ppm or Power B at 1000 ppm as actual boron in both chemical products inhibited the mycelial growth of *M. laxa* on PDA medium. Borax concentration that reduced the mycelial growth by 50% (EC_{50}) was found to be 107.9 ppm, while Power B EC_{50} was 522.4 ppm. Increasing concentration of boron in peach leaves was associated with lower infection of peach fruits with brown rot incited by *M. laxa*. Postharvest dipping of peaches could be considered a supplementary method to increase boron content and to reduce brown rot of peaches resulting in increase of their storability.

Salicylic acid (SA) as a phenolic compound and impose the systemic acquired resistance was tested to reduce brown rot of peaches incited by *M. fructicola*.**(Xu et al 2008**, **Panahirad et al 2012 and Tareen et al 2012)** found that postharvest treatment of peaches with 2 mM salicylic acid, 0.276 g/L, increased the shelf-life period and fruit firmness. Treatment of peaches with SA after fruit inoculation with *R. stolonifer* achieved better disease control than when adopted before artificial inoculation (**Panahirad et al 2012)**.they found that SA at 5 ppm completely inhibited the fungal growth on PDA medium. The minimum inhibitory concentration of SA that reduce the fungal growth by 50% was found to be 1 mM. o.138 g/L,SA was found to have a fungicidal effect at 5 mM rather than fungistatic.

While no fungicides were registered as pre- or post-harvest disease control on stone fruits and simultaneously brown rot disease is considered a serious disease-causing decay and postharvest losses, as well as environmental concern of fungicides use on perishable fruits alternatives to fungicides should be tested especially safe agents and environmentally accepted. So, the present study aimed to investigate the efficacy of certain mineral salts and organic acids as safe alternatives to fungicides, to suppress growth of major and pathogenic isolates of *Monilinia* spp. *in vitro*. Preharvest spray or postharvest application of tested compounds agent were evaluated to control *Monilinia* brown rot of apricots and peaches during cold storage at 0^oC and 95% RH for up to 30 days.

MATERIALS AND METHODS

Source of isolates

Three isolates of *Monilinia* spp.,proved to be highly pathogenic to apricot and peach were selected from Isolated collection at Department of postharvest diseases, Plant Pathology Research Institute, ARC, Giza.

Chemical Treatments used

Sodium bicarbonate ($NaHCO_3$) coded E-500 (ii), calcium chloride ($CaCl_2$) coded E-509, potassium sorbate ($C_6H_7O_2K$) coded E-202 and potassium silicate (K_2SiO_3) coded E-560, which are used as food additives or preservatives recognized by the United Nations-Food and Agriculture Organization (FAO), European Food Safety Authority (EFSA) and USA-Food and Drug Administration (FDA) as regarded as generally safe when used appropriately, and coded according to **Commission Regulation (EU) No 1129/2011**.

Boric acid (H_3BO_3) coded E-284 as food additive with concern about the dose and salicylic acid ($C_7H_6O_3$).

In vitro assay

Effect of different salts and acids on *Monilinia* isolates growth was investigated using poisoned food technique **(Sharvelle 1961; Mohana and Raveesha 2007 and Balouiri et al 2016)**. The salts and acids were tested *in vitro* at serial concentrations, 1000, 2000, 3000, 4000 and 5000 ppm, as incorporated equal certain amount of stock solutions of salts and acids into worm sterile PDA medium before medium solidification, 45-55°C, in aseptic conditions providing target concentration. Then petri plates were inoculated with 5-mm discs from periphery of 7-day-old cultures of such *Monilinia* isolate by placing fungal discs on solidified medium surface at the centre. Inoculated plain medium with fungus discs was used as a control. Four petri dishes were used as replications per each tested concentration and the control. Inoculated cultures were incubated at 22°C under dark and fluorescent light at 12 hrs intervals until the growth of control of any isolate covered medium surface in Petri dishes. Average linear growth for each replicate of such treatment was determined (mm) and its efficacy (%) was calculated by relating the reduction of fungal growth to the control treatment of each isolate. The chemical concentration that inhibit *Monilinia* linear growth (IC_{50}) was determined for each salt and acid treatment through the function considering the efficacy (%) as dependent parameter and chemical concentration (ppm) as independent parameter. First order functions were generally obtained without data transformation, where the range of tested concentrations was selected precisely according to preliminary tests.

Effect of Preharvest spray with Mineral salts and inducers

Preharvest applications were carried out on apricot and peach trees in Qualyubia and Ismailia Governorates during seasons 2015 and 2016. Peach (*Prunus persica*) on Nemaguard rootstock and Apricot (*Prunus armeniaca* L.) private orchards of 7 years old were chosen for adopting three preharvest sprays with tested salts and acids on peach and apricot trees at the growth stage no. 64 representing about 40% of open flowers**,** and then repeated twice at 10-day intervals **(Meier 2001; Villarino et al 2010 and 2012; and Polat and Caliskan 2013)**.

The trees were cultivated at 4*6 and 4*5 meters apart for apricot and peach, respectively. Three trees as a plot replicate and four replicates set for each treatment were allocated to achieve randomized block design according to each orchard cultural conditions. Tested salts and acids *in vitro* were also used for preharvest applications but applied only at 3000 ppm concentration. Each tree was sprayed with chemical solution with a CP3 classic series 20L Knapsack sprayer until runoff for apricot and peach. No other chemical control treatment for fungal diseases control was adopted in the blocks allocated for the preharvest trials with a boarder of one row between rows and three trees left among each replicate plots as barrier preventing chemical draft pollution.

First experiment

Peaches and apricots were harvested at proper maturity stage no. 81 **(Meier 2001)**, beginning of ripening, and could be demonstrated by fruit colour where ground colour of apricot fruit developed from light green into light yellowing, while peach fruit skin colour developed from green to red and its external colour developed from light yellow to yellow **(El-Khoreiby et al 2011).** Fruits were harvested from the three trees of each replicate, and a certain number of random fruits that uniform in size and colour, sound and apparently visually free from decay were selected. Four replicates of apricot and peach fruits were obtained for each preharvest treatment and each replicate was packed in 4 sets of plastic punnets kept at 0°C and 90% RH for 2 cold storage periods ended by pathology and quality evaluations. The replicate consists of four punnets and each punnet contained 12 apricots or 6 peaches. After 15 days and 30 days of cold storage, brown rot disease incidence and disease severity were evaluated for each replicate as well as quality measurements including firmness and TSS**.**

Second experiment

Postharvest treatments of apricots and peaches with mineral salts and inducer

Apricot and peaches fruits were purchased from commercial orchards in Ismailia Governorate at maturity stage no. 81. Uniform and apparently healthy fruits, free from injuries and decay were selected for postharvest experiments. Both apricot and peaches fruits were divided into two groups, one for the natural infection investigation and the other for artificial inoculation trials. The fruits allocated for artificial inoculation were surface sterilized by dipping in 70% alcohol for 2 min followed by dipping in 2% commercial bleach Sodium hypochloride, 5.25%), then washed thoroughly with sterilized distilled water **(Moreira and Mio, 2007)**. Surface sterilized fruits were left for air drying at room temperature. Fruits were punctured using a stainless-steel rod with 2-mm diameter and to 2-mm depth, as one puncture for fruit at the middle of one fruit side. Fruits were rinsed in *Monilinia laxa* (isolate NO.300) spore suspension of 10^6 spores/ml for 30 seconds.. Control fruits were injured as above and treated with sterile distilled water containing Tween 20. Both artificially inoculated and naturally infected fruits were stored in dark at 0^oC and 90% RH for 24 hours, then rinsed in solutions containing(3000 ppm) concentration of tested moment such salt and acid for (2 min). The treated fruits were allowed for air drying at room temperature under aseptic conditions, then packed in plastic punnets. Four replicates were used for such treatment, each replicate consists of 4 punnets each contained 12 apricots or 6 peaches. After cold storage for 15 days or 30 days, brown rot disease incidence (%), disease severity, fruit firmness and TSS were determined.

Disease assessment:

(A) Brown rot disease incidence (%) was determined for each replicate by relating decayed fruits with brown rot to the total number of fruits. Disease severity was calculated as follows:

(B) Disease severity = ∑decayed area (%) of each fruit*100/No. of fruits of each replicate
Where, decayed area (%) for each single fruit was determined as 10% periods.

Assay of fruit quality parameters:

(A) Total soluble solids (TSS): The TSS of fruit juice of such replicate obtained from 3 fruits through fruit Juicer was determined using a temperature-compensated Atago hand refractometer, Japan, and data were expressed as TSS (%). **(Gregori et al 2008)**.

(**B) Firmness**: Firmness was determined after removing the fruit skin from both opposite equatorial sides using a blade. Firmness of each fruit flesh was measures using Ametec Firmness Tester with 8-mm probe. Data of firmness were expressed as Newton (N). **(Gregori et al 2008).**

Statistical analysis of data

Complete randomized block experimental design was followed for the preharvest experiments, while complete randomized experimental design was followed for the postharvest trials. Data were collected and statistically analyzed using one-way ANOVA and LSD values were determined at 95% confidence for comparison among treatments using CoStat version 6.311, CoHort Software.

RESULTS AND DISCUSSION

The efficacy of different salts and acids on *Monilinia* spp. as a response of increasing their concentrations in series from 1000 ppm to 5000 ppm is represented by the functions correlating the chemical concentration and calculated IC_{50} **(Table 1)**. It was found that calculated IC_{50} values of sodium bicarbonate, potassium sorbate and salicylic acid on *M. fructigena* were less than 1000 ppm. On *M. laxa*, only sodium bicarbonate showed IC_{50} less than 1000 ppm, while the IC_{50} values of potassium sorbate and boric acid were less than 2000 ppm. Regarding *Monilinia* sp,sodium bicarbonate and potassium sorbate IC_{50} values were less than 1000 ppm. Calcium chloride showed the least effectiveness against tested Monilinia isolates as its IC_{50} values were more than 5000 ppm. Generally, sodium bicarbonate, potassium sorbate and salicylic acid showed IC_{50} values less than 1000 ppm, 2000 ppm, and 3000 ppm, respectively. Calcium chloride did not suppress *Monilonia* spp. at concentrations up to 5000 ppm, except for ≥4000 ppm on *M. fructigena*. These data were also recorded by other researchers, **Palou et al (2009)** also suggested use of food additives as safe alternatives to control postharvest diseases of stone fruits incited by several fungi including *Monilonia* sp **Thomidis et al (2007)** found that calcium chloride was not effective enough against *M. laxa* where it reduced fungus growth by less than 20% when used at concentration of 4000 ppm. Also, **Talibi et al (2001)** found that the minimum inhibitory concentration of calcium chloride that suppress *Geotrichum candidum* on citrus fruits was more than 2% (w/v), while it was 2500 ppm of boric acid. Potassium silicate did not show considerable effectiveness against different tested isolates of *Monilinia spp*.

On contrary, **Fagundes et al (2013)** found that potassium silicate at 2000 ppm reduced growth of *Botrytis cinerea* pathogenic to cherry tomato by about 94%, while potassium sorbate showed effectiveness of about 58%. More efficacy of potassium silicate was obtained on *Alternria alternate*. Through current work, it was obtained that higher effectiveness of sodium bicarbonate than potassium sorbate and then potassium silicate which showed low efficacy to inhibit growth of *Monilinia* spp. Similar trend of salts efficacy was found on *M. fructicola* by **Karaca et al (2014). Palmer et al** (**1997**) found that ammonium, potassium and sodium bicarbonates inhibited colony growth of *B. cinerea* at concentrations as low as 20 mM. and, **Nigro et al (2006)** who stated that among of 19 salts were tested, potassium carbonate, sodium bicarbonate and sodium carbonate reduced the growth of *Botrytis cinerea in vitro*. Also the reduction in fungal growth was attributed to inhibition of mycelial growth and conidia germination of the grey mold fungus. On the other hand, **Abdel-Mageed et al (2012).** mentioned that. salicylic acid and sodium bicarbonate were the best effective compounds on reducing the growth of *Botrytis cinerea* and *Sclerotinia sclerotiorum* and they were the best effective on the sclerotial formation of *B. cinerea* and *S. sclerotiorum* where it caused complete reduction of sclerotia with all concentrations. These results are agreement with **Abdel-Kader et al (2012).** It was expected that carbonate and bicarbonate inhibit mycelial growth of *M. fructicola* through their effect on medium pH toward alkalinity. Potassium sorbate was attributed to affect *M. fructigena* growth through inhibition of germination of conidiospores at a concentration of 3000 ppm, but its effect on inhibiting *M. fructigena* mycelium was higher than its effect on inhibiting conidiospores germ tube as found by **Nikolov and Ganchev (2011).**

In the present study, Salicylic acid treatment showed that it was more effectiveness than boric acid against *M. laxa* and *M. fructicola in vitro*, while the opposite was true for *M. fructigena*. Boric acid and salicylic acid at 2000 ppm completely suppressed the growth of *M. laxa*, and *M. fructigena*. Salicylic acid at 3000 ppm completely suppressed *M. laxa* and *M. fructicol*a growth. This inhibition observed by both boric and salicylic acids, indicated the direct effect of these acids on *Monilinia* growth *in vitro* and could be expected to find direct effect on controlling brown rot on apricot and peaches *in vivo*. However, the variance obtained among acid effects on different species of *Monilinia* may reflect their effects on suppressing decay development according to prevalent *Monilinia sp*. Similar finding of *in vitro* study about sodium bicarbonate and salicylic acid as the most effective treatments to suppress *M. fructigena* and *M. fructicola* growth, while several treatments were effective against *M. laxa*, i.e. sodium bicarbonate, potassium sorbate, boric acid and salicylic acid indicates how these treatments could work during *in vivo* investigations. However, **Karabulut et al (2001)** found that sodium bicarbonate was more efficient than potassium sorbate to control brown rot incited by *Monilinia spp.* on sweet cherries.

Table 1. Models correlating salts and acids concentrations and their efficacy to inhibit the growth of three different *Monilinia* spp. on PDA medium *in vitro* and their IC_{50}

Treatment	*M. laxa*		*M. fructigena*		*Monilinia* sp.	
	Function	EC50 ppm	Function	EC50 ppm	Function	EC50 ppm
Sodium Bicarbonate	Y=100	<1000	Y = 100	<1000	Y=100	<1000
Calcium chloride	Y=0.00398X–7.6	14410	Y = 0	>5000	Y=0	>5000
Potassium sorbate	Y=37.3-0.01472X	863	Y=14.46+0.01866X	1905	Y=58.14-0.00202X	<1000
Potassium silicate	Y=0.00745X–14.35	8638	Y = 0	>5000	Y=0.00552X–8.08	10522
Boric acid	Y=0.0091X–7.68	6338	Y=15.56+0.02022 X	1703	Y=6.02+0.01046X	4205
Salicylic acid	Y=40.4+0.0149X	644	Y=0.03X-30	2667	Y=0.02682X–15.52	2443

Y: The inhibition (%) of *Monilinia* linear growth measurement on PDA medium

X: The salt or acid concentration amended in PDA medium

First experiment

Efficacy of preharvest applications with mineral salts and inducers on brown rot of Canino apricots

Apricot fruits harvested from trees subjected to preharvest sprays of different salts or acids at concentration of 3000 ppm then cold stored for up to 30 days showed different percentages of disease incidence and severity for both studied seasons, 2015 and 2016, as shown in **Table (2)**. Sodium bicarbonate, calcium chloride, potassium sorbate and boric acid resulted in total suppression of brown rot incidence when apricots cold stored for 15 days, where no brown rot symptoms appeared on apricot of Qualyubia Governorate. Cold storage at 0°C for 15 days of apricots from Ismailia preharvest sprayed with different salts and acids did not show any incidence of brown rot. Prolonged cold storage of apricots for up to 30 days resulted in appearing of brown rot on fruits preharvest treated with sodium bicarbonate, but with non-significant differences of disease incidence and disease severity than the other treatments completely suppressed brown rot incidence in both Governorates during season 2015. However, non-significant differences were observed for disease severity among all chemical treatments except for potassium silicate, while potassium silicate and salicylic acid showed higher disease incidence than the other chemical treatments. However,at the second season, calcium chloride, potassium sorbate and boric acid were the most effective treatments as no decay incidence was detected followed by sodium bicarbonate in Qualyubia and Ismailia Governorates. Similar results were obtained for disease severity in Qualyubia Governorate, while no significant differences were observed among these treatments. Potassium silicate and salicylic acid were the least effective treatments. Most of these treatments were expected to be effective to inhibit brown rot development on apricots as already inhibited the growth of tested *Monilinia spp.* as highly pathogenic isolates *in vitro,* except for calcium chloride. Calcium chloride showed high effectiveness to control brown rot *in vivo* opposite to that obtained *in vitro* study could be attributed to its effect on fruit cell wall by accumulating calcium in fruit epidermis, in cell wall the middle lamella and changing pectin to calcium pectate, which lower the invasion of *Monilinia spp.*as well as other fungal pathogns into apricot and peaches cells **Yamane (2014)** and **Madania et al (2016)**. Potassium sorbate showed high effectiveness to control brown rot in spite of using concentration of 3000 ppm, while **Palou et al (2009)** used it at 200 mM (30 000 ppm) to control brown rot of stone fruits.

Potassium silicate and salicylic acid were the least effective treatments. Less effectiveness of potassium silicate could be attributed to its low efficacy against *Monilinia spp*. *in vitro*. Potassium silicate was expected to affect the fruit cells and indirectly reduce decay development, which was not realized. On the other hand, salicylic acid is well known as a phenolic compound to enhance fruit resistance toward fungal infection **(Han et al 2002)**. **Panahirad et al (2012)** found that 5 mM (0.69 g/L, 690 ppm) of salicylic acid completely inhibited the *in vitro* growth of *Rhizopus stolonifer*. It could be suggested that when use of salicylic acid to control fungal diseases, it could be used at lower concentrations. Also, **Hafez and Haggag (2007)** also investigated the suppressive effect of pre-harvest treatments of boric acid and calcium chloride on apple trees alone or in combination as disinfectants for *Botrytis cinerea* which the cause of fruit rot during cold storage. Two sprays were adopted to reduce fungal decay and to improve quality of Anna apples. The High effectiveness of boric acid to control brown rot on peaches and apricots could be attributed to its direct effect on fungal growth as obtained in *in vitro* evaluation, and also through indirect effect on the fruits by decreasing the microcracking incidence in stone fruit surface cuticle (**Thomidis and Exadaktylou 2010).** On the other hand, boron also facilitates the uptake of calcium.

Table 2. Brown rot incidence (%) and severity (%) of Canino apricot fruits preharvest-sprayed with salts and acids during growing seasons 2015 and 2016 in Qualyubia and Ismailia Governorates, after 15 and 30 days cold storage at 0°C and 90% RH *.

Treatment	Decay of apricots							
	Qualyubia Governorate				Ismailia Governorate			
	15 days		30 days		15 days		30 days	
	Incidence (%)	Severity (%)	Incidence (%)	Severity (%)	Incidence (%)	Severity (%)	Incidence (%)	Severity (%)
Sodium Bicarbonate	0.0	0.0	2.7	2.0	0.0	0.0	3.4	1.3
Calcium chloride	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Potassium sorbate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Potassium silicate	1.3	1.0	17.3	8.7	0.0	0.0	15.2	6.8
Boric acid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salicylic acid	2.0	1.8	11.8	4.8	0.0	0.0	11.8	5.9
Control	4.8	2.9	19.4	14.1	4.8	1.7	20.1	8.8
LSD at 0.05	1.5	0.5	5.2	3.1	0.6	0.3	5.5	2.6

*The data are based of mean of two seasons.

Effect of preharvest sprayed with tested mineral salts and inducers on quality of Canino apricots during cold storage

In the present study, Firmness of apricots from preharvest sprayed trees in Qualyubia and Ismailia Governorates with different salts and acids was reduced with cold storage than it at harvest time. Calcium chloride was the most effective treatment to maintain highest firmness during cold storage in both seasons, 2015 and 2016 **(Table 3)**. Prolonged storage up to 30 days showed high reduction in firmness of control apricots as well as apricots preharvest treated with salicylic acid. While firmness was high in apricots of some treatments stored for 15 days, prolonged storage to 30 days resulted in high loss of firmness as observed for the treatments sodium bicarbonate and potassium silicate. Preharvest treatment with boric acid resulted in higher firmness than salicylic acid treatment along the experiments, particularly with longer cold storage.

Total soluble solids (TSS) content was higher in the fruits cold stored than the initial TSS. However, non-significant differences were obtained among all treatments including the control treatment.. **Hafez et al (2010)** reported that pre-harvest treatments with calcium nitrate, citric acid and ascorbic acid either alone or in combination with reduced the decay percent of Le Conte pear fruits. Moreover, all treatments alone or in combination decreased the weight loss %, increased fruits content of (TSS %) and total sugars during marketing period.

Table 3. Fruit quality of Canino apricot preharvest-sprayed three times with mineral salts and acids at growth stages during growing seasons 2015 and 2016 in Qualyubia and Ismailia Governorates after 15 and 30 days cold storage at 0°C and 90% RH *.

Treatment	Quality							
	Qualyubia Governorate				Ismailia Governorate			
	15 days		30 days		15 days		30 days	
	Firmness (N)	TSS (%)	Firmness (N)	TSS (%)	Firmness (N)	TSS (%)	Firmness (N)	TSS (%)
Initial apricot quality	39.20	10.0			37.24	11		
Sodium Bicarbonate	29.4	11.6	13.7	13.0	27.0	12.2	14.7	13.8
Calcium chloride	32.3	10.5	17.2	13.1	33.8	11.1	23.0	13.1
Potassium sorbate	29.4	11.7	17.2	13.2	29.4	11.4	21.1	13.2
Potassium silicate	30.4	12.2	10.8	15.6	32.8	12.4	14.7	15.7
Boric acid	27.0	10.9	14.7	13.7	27.9	11.9	19.6	13.1
Salicylic acid	20.6	12.4	7.8	15.8	21.6	12.2	9.8	15.4
Control	19.6	13.9	4.9	16.5	20.1	13.5	4.9	16.7
LSD at 0.05	**7.4**	**Ns****	**4.9**	**Ns****	**6.8**	**Ns****	**5.4**	**Ns****

*The data are based of mean of two seasons.

Ns**: non-significant differences were obtained among all tested treatments including the control treatment.

Efficacy of preharvest applications with mineral salts and inducers on brown rot of FlordaPrince peaches

While all salts and acids sprayed preharvest suppressed infection of FlordaPrince peach of Ismailia Governorate with brown rot disease during cold storage for 15 days in both seasons, 2015 and 2016, potassium sorbate, boric acid and sodium bicarbonate were significantly the most effective treatments **(Table 4)**. On the other hand, calcium chloride achieved more brown rot control on peaches than salicylic acid and potassium silicate when peaches were stored for 15 days, and more effective than both of them and sodium bicarbonate with prolonged storage for 30 days. Potassium silicate and salicylic acid significantly controlled brown rot on peaches comparing with the control treatment, but with less effectiveness than other treatments in Qualyubia Governorate. All salt and acid treatments were significantly effective to suppress brown rot on peaches of Ismailia Governorate, but potassium silicate and salicylic acid showed less effectiveness during prolonged storage comparing with other chemical treatments. Most of these treatments were expected to be effective to inhibit brown rot development on peaches as already inhibited the growth of tested *Monilinia spp.* as highly pathogenic isolates *in vitro,* except for calcium chloride. Calcium chloride showed high effectiveness to control brown rot *in vivo* opposite to that obtained *in vitro* study could be attributed to its effect on fruit cell wall by accumulating calcium in fruit epidermis, in cell wall the middle lamella and changing pectin to calcium pectate, which lower the invasion of *Monilinia spp.*as well as other fungal pathogns into apricot and peaches cells **Yamane (2014)** and **Madania et al (2016)**. Potassium sorbate showed high effectiveness to control brown rot in spite of using concentration of 3000 ppm, while **Palou et al (2009)** used it at 200 mM (30 000 ppm) to control brown rot of stone fruits.

Potassium silicate and salicylic acid were the least effective treatments. Less effectiveness of potassium silicate could be attributed to its low efficacy against *Monilinia spp*. *in vitro*. Potassium silicate was expected to affect the fruit cells and indirectly reduce decay development, which was not realized. On the other hand, salicylic acid is well known as a phenolic compound to enhance fruit resistance toward fungal infection **(Han et al 2002)**. It could be attribute less effectiveness of applied salicylic acid to high tested concentrations, where **Han et al (2002)** found that dipping peaches in salicylic acid at 100 ppm resulted in lowering the respiration rate, ethylene production and consequently delaying fruit ripening which reflect less decay development.

Table 4. Brown rot incidence (%) and severity (%) on FlordaPrince peach fruits preharvest-sprayed three times with salts and acids at growth stages during growing seasons 2015 and 2016 in Qualyubia and Ismailia Governorates after 15and 30 days cold storage at 0^oC and 90% RH *.

Treatment	Decay of peaches							
	Qualyubia Governorate				Ismailia Governorate			
	15 days		30 days		15 days		30 days	
	Incidence (%)	Severity (%)	Incidence (%)	Severity (%)	Incidence (%)	Severity (%)	Incidence (%)	Severity (%)
Sodium Bicarbonate	0.0	0.0	5.5	2.7	0.0	0.0	2.7	2.0
Calcium chloride	2.0	0.3	4.8	1.6	0.0	0.0	0.7	0.7
Potassium sorbate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Potassium silicate	5.5	2.7	11.8	4.8	0.0	0.0	7.6	3.8
Boric acid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salicylic acid	4.8	1.3	9	4.5	0.0	0.0	8.3	2.5
Control	11.1	5.5	21.5	18.0	6.9	5.2	20.1	14.9
LSD at 0.05	**3.0**	**1.5**	**4.9**	**6.2**	**1.5**	**1.2**	**5.1**	**3.5**

*The data are based of mean of two seasons.

Effect of preharvest sprayed with tested mineral salts and inducers on Quality of FlordaPrince peaches during cold storage

High firmness and relatively low total soluble acids were determined for FlordaPrince peach fruits at harvest time. Among salt and acid preharvest treatments, calcium chloride almost showed highest firmness of peaches stored for 15 days or 30 days in Qualyubia and Ismailia Governorates **(Table 5)**. On the other hand, salicylic acid showed the least firmness comparing with other salt and acid treatments, particularly when fruits were kept for 15 days at cold storage. Prolonged storage resulted in non-significant differences of firmness among salt and acid treatments, except for calcium chloride and potassium sorbate sprayed in Qualyubia Governorate, which achieved highest firmness. Potassium silicate showed high firmness of peaches preharvest treated in Ismailia and Qualyubia Governorates, except for 30 days cold storage of peaches from Qualyubia Governorate.

On the other hand, TSS was enhanced with cold storage for all treatments including the control treatment. However, non-significant differences were detected among all treatments and the control treatment in both Governorates during both seasons.

The High effectiveness of boric acid to control brown rot on peaches and apricots could be attributed to its direct effect on the fungal growth as obtained in *in vitro* evaluation, and also through indirect effect on the fruits by decreasing the microcracking incidence in stone fruit surface cuticle (**Thomidis and Exadaktylou 2010).** On the other hand, boron also facilitates the uptake of calcium. **Hafez et al (2010)** reported that pre-harvest treatments with calcium nitrate, citric acid and ascorbic acid either alone or combination reduced the decay percent of Le Conte pear fruits. Moreover, all treatments alone or in combination decreased the weight loss %, while increasing fruits content of (TSS %) and total sugars during marketing period.

Table 5. Fruit quality of FlordaPrince peache preharvest-sprayed three times with salts and acids at growth stages during growing seasons 2015 and 2016 in Qualyubia and Ismailia Governorates after 15 and 30 days cold storage at 0°C and 90% RH *.

Treatment	Quality							
	Qualyubia Governorate				Ismailia Governorate			
	15 days		30 days		15 days		30 days	
	Firmness (N)	TSS (%)	Firmness (N)	TSS (%)	Firmness (N)	TSS (%)	Firmness (N)	TSS (%)
Initial apricot quality	33.3	10.8			36.0	10.9		
Sodium Bicarbonate	23.5	11.5	11.3	12.2	31.9	11.5	20.1	12.5
Calcium chloride	28.4	11.1	19.6	12.1	33.3	11.1	26.0	12.3
Potassium sorbate	24.0	11.3	17.6	12	25.0	11.2	20.6	12.2
Potassium silicate	26.0	11.4	17.2	13.6	25.5	11.6	25.5	12.9
Boric acid	25.5	11.2	12.3	12.6	27.0	11.2	20.1	12.2
Salicylic acid	17.6	11.3	10.3	13.1	22.5	11.3	14.7	12.7
Control	14.7	12.4	5.4	13.4	19.6	12.4	10.3	13.3
LSD at 0.05	**4.3**	**Ns****	**4.0**	**Ns****	**4.3**	**Ns****	**4.1**	**Ns****

*The data are based of mean of two seasons.

Ns**: non-significant differences were obtained among all tested treatments including the control treatment

Second experiment

Efficacy of postharvest applications with mineral salts and inducers on brown rot of Canino apricots and FlordaPrince peaches

Postharvest treatments of apricots and peaches with salts and acids during season 2016 resulted in controlling significantly brown rot disease in the naturally infected fruits during cold storage for 15 days, but without significant difference among diseases severity of all treatments and the control **(Tables 6&7)**. Prolonged storage period to 30 days at 0°C magnified the positive effect of salts and acids to control brown rot on natural infected apricots and peaches. However, potassium sorbate and boric acid totally controlled brown rot on naturally infected apricots and peaches during cold storage for 15 days as well as 30 days. Sodium bicarbonate, calcium chloride and potassium silicate were the following significant effective postharvest treatments on apricots fruits. On peaches, sodium carbonate showed significant more effectiveness than calcium chloride and potassium silicate regarding disease incidence, while all of then showed similar disease severity.

Artificial inoculation of apricots and peaches resulted in 100% disease incidence in the control treatment, with 10% and 20% disease severity for both types of fruits respectively, during the 15 days cold storage. Sodium bicarbonate, calcium chloride, potassium sorbate and boric acid completely inhibited brown rot incidence on postharvest treated apricots and peaches. However, potassium silicate and salicylic acid also significantly reduced brown rot incidence and its severity on artificially inoculated apricots and peaches comparing with the control. Prolonged cold storage of artificially inoculated apricots and peaches with *M. laxa* resulted significant reduction in disease incidence and more pronounced reduction in disease severity of apricots and peaches.

Table 6. Brown rot incidence (%) and severity (%) on Canino apricot fruits postharvest-treated with salts and acids (Natural and artificial infection) after 15 and 30 days cold storage at 0°C and 90% RH for during seasons 2016

Treatments	Natural infection				Artificial inoculation			
	15 days at 0°C		30 days at 0°C		15 days at 0°C		30 days at 0°C	
	Incidence (%)	Severity (%)	Incidence (%)	Severity (%)	Incidence (%)	Severity (%)	Incidence (%)	Severity (%)
Apricot, cv. Canino								
Sodium Bicarbonate	0.0	0.0	4.1	4.1	0.0	0.0	87.5	37.5
Calcium chloride	0.0	0.0	8.3	8.3	0.0	0.0	87.5	37.5
Potassium sorbate	0.0	0.0	0.0	0.0	0.0	0.0	87.5	37.5
Potassium silicate	0.0	0.0	8.3	4.1	4.1	2.0	100	50
Boric acid	0.0	0.0	0.0	0.0	0.0	0.0	87.5	37.5
Salicylic acid	0.0	0.0	12.5	12.5	4.1	2.0	100	50
Control	12.5	1.2	20.8	10.4	100	10	100	100
LSD at 0.05	**2.0**	**Ns***	**4.2**	**1.5**	**10.4**	**1.5**	**11.7**	**10.8**

Ns*: non-significant differences were obtained among all tested treatments including the control treatment.

Table 7. Brown rot incidence (%) and its severity (%) on FlordaPrince peach fruits postharvest-treated with salts and acids acids (Natural and artificial infection after 15 and 30 days cold storage at 0°C and 90% RH for during seasons 2016

Treatments	Natural infection				Artificial inoculation			
	15 days at 0°C		30 days at 0°C		15 days at 0°C		30 days at 0°C	
	Incidence (%)	Severity (%)	Incidence (%)	Severity (%)	Incidence (%)	Severity (%)	Incidence (%)	Severity (%)
Peach, cv. FlordaPrince								
Sodium Bicarbonate	0.0	0.0	4.1	4.1	0.0	0.0	87.5	37.5
Calcium chloride	0.0	0.0	8.3	4.1	0.0	0.0	75	37.5
Potassium sorbate	0.0	0.0	0.0	0.0	0.0	0.0	75	37.5
Potassium silicate	0.0	0.0	8.3	4.1	8.3	4.1	100	50
Boric acid	0.0	0.0	0.0	0.0	0.0	0.0	75	37.5
Salicylic acid	0.0	0.0	12.5	12.5	8.2	4.1	100	50
Control	**8.3**	**0.8**	**16.6**	**8.3**	**100**	**20**	**100**	**100**
LSD at 0.05	**4.2**	**Ns***	**2.4**	**2.3**	**10.4**	**3.1**	**18.2**	**10.5**

Ns*: non-significant differences were obtained among all tested treatments including the control

Effect of postharvest treated with tested mineral salts and inducers on Quality of Canino apricots and FlordaPrince peaches during cold storage

Calcium chloride, potassium sorbate and potassium silicate as postharvest treatments showed highest firmness of naturally infected apricots stored for 15 days, but without significant differences from firmness resulted by sodium bicarbonate and boric acid **(Tables 8&9)**. Prolonged storage on naturally infected apricots showed higher firmness of fruits treated with calcium chloride, sodium bicarbonate, potassium sorbate and potassium silicate than tested acids and the control apricots. Firmness of artificially inoculated apricots was less than of naturally infected ones in the short cold storage. With prolonged storage of artificially inoculated apricots, the firmness was highly reduced and the fruits became so soft in most treatments.

Regarding the firmness of naturally infected and artificially inoculated peaches, non-significant differences were obtained among all salt and acid treatments and the control, except for the long cold storage of naturally infected ones. Calcium chloride, potassium sorbate and sodium bicarbonate showed significant higher fruit firmness when naturally infected peaches were cold stored for 30 days. TSS values of both naturally and artificially inoculated apricots and peaches postharvest treated with salts and acids did not show any significant differences.

Table 8. Fruit quality of Canono apricot postharvest-treated with salts and acids after 15 and 30 days cold storage at 0°C and 90% RH during season 2016

Treatment	Natural infection				Artificial inoculation			
	15 days at 0^oC		30 days at 0^oC		15 days at 0^oC		30 days at 0^oC	
	Firmness (N)	TSS (%)	Firmness (N)	TSS (%)	Firmness (N)	TSS (%)	Firmness (N)	TSS (%)
Apricots, cv. Canino								
Initial apricot quality	19.6	10.2			19.6	11.2		
Sodium bicarbonate	12.7	11.4	7.8	12.4	10.8	11.6	4.9	13.2
Calcium chloride	14.7	11.2	8.8	12.2	12.7	11.4	4.9	13.0
Potassium sorbate	14.7	11.2	7.8	12.2	13.7	11.0	4.9	13.2
Potassium silicate	14.7	11.6	7.8	12.4	12.7	11.6	0.0	14.4
Boric acid	13.7	11.2	4.9	12.2	10.8	11.6	4.9	13.0
Salicylic acid	10.8	11.6	4.9	13.0	8.8	12.2	0.0**	14.2
Control	**9.8**	**12.4**	**4.9**	**13.6**	**7.8**	**12.6**	**0.0**	**14.6**
LSD at 0.05	**3.5**	**Ns***	**3.80**	**Ns***	**2.60**	**Ns***	**2.1**	**Ns***

Ns*: non-significant differences were obtained among all tested treatments including the control treatment
0.00**: so soft fruits

Table 9. Fruit quality of Florida prince peaches postharvest-treated with salts and acids s after15 and 30 days cold storage at 0^oC and 90% RH during season 2016

Treatment	Natural infection				Artificial inoculation			
	15 days at 0^oC		30 days at 0^oC		15 days at 0^oC		30 days at 0^oC	
	Firmness (N)	TSS (%)	Firmness (N)	TSS (%)	Firmness (N)	TSS (%)	Firmness (N)	TSS (%)
Peaches, cv. FlordaPrince								
Initial quality	21.6	10.5			14.7	11.0		
Sodium bicarbonate	13.7	11.4	7.8	12.2	10.8	11.6	4.9	13.2
Calcium chloride	15.7	11.0	8.8	12.2	12.7	11.4	4.9	13.0
Potassium sorbate	14.7	11.0	8.8	12.0	12.7	11.2	4.9	13.2
Potassium silicate	15.7	11.6	4.9	12.4	12.7	11.6	0.0	13.6
Boric acid	14.7	11.2	4.9	12.4	10.8	11.4	4.9	13.0
Salicylic acid	12.7	11.6	4.9	13.0	8.82	12.2	0.0	14.2
Control	**9.8**	**12.4**	**4.9**	**13.6**	**7.84**	**12.8**	**0.0**	**14.8**
LSD at 0.05	**Ns***	**Ns***	**2.3**	**Ns***	**Ns***	**Ns***	**Ns***	**Ns***

Ns*: non-significant differences were obtained among all tested treatments including the control treatment0.00**: so soft fruits

CONCLUSION

Generally, it could be concluded that calcium chloride, potassium sorbate and boric acid followed by sodium bicarbonate were the most effective treatments to prevent apricots and peaches from infection with brown rot disease when adopted as preharvest treatment or as postharvest treatment during seasons 2015 and 2016.

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مكافحة مرض العفن البنى فى بعض ثمار الفاكهه ذوات النواه الحجرية اثناء التخزين بإستخدام بعض الاملاح المعدنية ومحفزات المقاومة

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الموجــــــز

تصاب ثمار الخوخ والمشمش بمرض العفن البنى المتسبب عن عدة أنواع من جنس فطر *Monilinia* والتى تصيب ثمار الفاكهه ذات النواه الحجرية من بداية التزهير وحتى الحصاد وتسبب تدهور الثمار اثناء التخزين المبرد. تم دراسة تأثير بعض بدائل المبيدات (الاملاح المعدنية ومحفزات المقاومة) مثل بيكربونات الصوديوم ،كلوريد الكالسيوم، سوربات البوتاسيوم، وسليكات البوتاسيوم ومحفزات المقاومة مثل حمض البوريك والسالسليك على نمو ثلاث عزلات من جنس *Monilinia* هى (*Monilinia laxa* , *M. fructigena* and *Monilinia sp.*) المسببة لمرض العفن البنى فى الخوخ والمشمش، وكذلك دراسة تأثير فعاليتها بالرش قبل الحصاد او كمعاملة للثمار بعد الحصاد على حدوث العفن البنى .أدت أضافة تركيزات مختلفة من الاملاح والاحماض السابقة الذكر (1000 و2000 و3000 و4000 و5000 جزء فى المليون) الى بيئة آجار البطاطس والدكستروز الى اختزال النمو الميسليومى للفطريات الثلاثة وكان اعلاها كفاءة هو بيكربونات الصوديوم حيث بدء التثبيط من التركيز الاول (1000 جزء فى المليون) يليه سوربات البوتاسيوم (3000 جزء فى المليون) تلاها حمض السالسليك وحمض البورك. وكانت نصف الجرعة المثبطة للنمو (التركيز الذى يخفض النمو الى النصف) من بيكربونات الصوديوم فقط اقل من 1000 جزء فى المليون، بينما كانت فى كلا من سوربات البوتاسيوم وحمض البوريك اقل من او يساوى 2000 جزء فى المليون. استخدمت الاملاح والاحماض السابقة رشاً فى الحقل بمعدل 3000 جزء فى المليون كمعاملات قبل الحصاد حيث يتم الرش 3 مرات، الرشة الاولى عند 40% تزهير والرشة الثانية بعد 10 ايام والثالثة بعد 20 يوم وذلك فى موقعين بمحافظتى القليوبية والاسماعلية على محصولي المشمش والخوخ فى موسمى 2015 و2016. كما استخدمت الاملاح والاحماض السابقة كمعاملات بعد الحصاد بغمر الثمار المحقونة بالفطر (عدوى صناعية) والثمار غير المحقونة بالفطر (عدوى طبيعية) فى موسم 2016. اوضحت النتائج ان كلويد الكالسيوم وسوربات البوتاسيوم وحمض البوريك هى اكثر المعاملات كفاءة لاختزال الاصابة بالعفن البنى فى الخوخ والمشمش اثناء التخزين المبرد على صفر درجة مئوى لمدة 30 يوم ورطوبة نسبية 90%، كذلك احتفاظ الثمار بجودتها وصلابتها.

الكلمات الدالة: العفن البنى، انواع المونلنيا، الفاكهه ذوات النواه الحجرية، الاملاح، الاحماض

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