The effect of electrolyzed water on phytopathogenic fungi that infect *Prunus persica* var. *nectarine* at post-harvest

Efecto del agua electrolizada en fitopatógenos fungosos que afectan *Prunus persica* var. *nectarine* en postcosecha

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ABSTRACT

Postharvest immersion of *Prunus persica* var. *nectarine* into electrolyzed water, EW (25.2 ppm of active ingredient), at different time periods of inoculation with pathogens previously isolated from rotted fruits (A, immediately before fruit immersion; B, three hours after fruit immersion and C, three hours before fruit immersion), significantly reduced fruit rotting caused by *Botrytis cinerea* (A: 40.2%, B: 43.1% and C: 39.1%), or by *Monilinia laxa* (A: 80.9%, B: 49.8% and C: 46.2%), or by *Penicillium. expansum* (A: 60.3%, B: 31.9% and C: 49.7%) or by *Rhizopus stolonifer* (A: 74.4%, B: 60.8% and C: 72.6%). Immersion of fruits into NaClO (100 ppm of active ingredient), showed significant differences with EW treatment: *B. cinerea* (B/NaClO: 34.5%), *M. laxa* (A/NaClO: 62.2%; B/NaClO: 36.2% and C/NaClO: 36.2%); *P. expansum* (C/NaClO: 60.9%) and *R. stolonifer* (A/NaClO: 81.3%; B/NaClO: 71,2% and C/NaClO: 83.9%) being in most cases, EW better than NaClO. Non inoculated fruits did not show any negative effect after treatment with EW or with NaClO. Also, IC_{50} values for EW and for NaClO obtained in *in vitro* tests for mycelia development and spore germination of the different pathogens, correlate well with the in vivo tests. All results suggest that EW can be used as an alternative method to NaClO to control postharvest fungi of *Prunus persica* var. *nectarine* fruits , considering that the exposure times and the concentration of EW may be different, depending on the pathogen to be controlled.

Keywords: Electrolyzed water (EW), *Botrytis cinerea*, *Geotrichum candidum*, *Monilinia laxa*, *Penicillium expansum*, *Rhizopus stolonifer*

RESUMEN

Tratamientos de inmersión en postcosecha en agua eletrolizada (25,2 ppm de ingrediente activo) de frutos de *Prunus persica* var. *nectarine*, a diferentes tiempos de inoculación con patógenos aislados de frutos con pudrición (A, tratados inmediatamente antes de la inmersión del fruto; B, tres horas después de la inmersión del fruto y C, tres horas antes de la inmersión del fruto), disminuyeron significativamente la pudrición causada por *Botrytis cinerea* (A: 40,2%, B: 43,1% y C: 39,1%), con *Monilinia laxa* (A: 80,9%, B: 49,8% y C: 46,2%), con *Penicillium. expansum* (A: 60,3%, B: 31,9% y C: 49,7%) con *Rhizopus stolonifer* (A: 74,4%, B: 60,8% y C: 72,6%). Los tratamientos de inmersión de frutos en NaClO (100 ppm de ingrediente activo), mostraron diferencias significativas con los tratamientos con agua eletrolizada: *B. cinerea* (B/NaClO: 34,5%), *M. laxa* (A/NaClO: 62,2%; B/NaClO: 36,2% y C/NaClO: 36,2%); *P. expansum* (C/NaClO: 60,9%) y *R. stolonifer* (A/NaClO: 81,3%; B/NaClO: 71,2% y C/NaClO: 83,9%) siendo en la mayoría de los casos, mejor los tratamientos con agua electrolizada que con NaClO. Frutos no inoculados no mostraron un efecto negativo después del tratamiento con agua eletrolizada o con NaClO. También, los valores de IC_{50} con agua electrolizada o NaClO obtenidos en pruebas *in vitro* para el micelio y germinación de esporas de los diferentes patógenos, correlaciona bien con las pruebast *in vivo*. Todos los resultados sugieren que el agua electrolizada puede ser utilizada como un método alternativo al NaClO, para el control de patógenos fungosos de postcosecha en frutos de *Prunus persica* var. *nectarine* considerando que los tiempos de exposición y la concentración de agua electrolizada pueden ser diferentes, dependiendo del patógeno a controlar.

Palabras clave: Agua electrolizada (EW), *Botrytis cinerea*, *Geotrichum candidum*, *Monilinia laxa*, *Penicillium expansum*, *Rhizopus stolonifer*

1 INTRODUCTION

Fruit culture is one of the most important economic areas in Chile, with fresh and processed total fruit exports up to 2.567.717 Ton in 2021, where 72.122 corresponded to *Prunus persica* var *nectarine* exports (ASOEX, 2022). *P. persica* var *nectarine* is a well-recognized species in Chile, being mainly cultivated in the North-Central and Central regions of the country. One of the key aspects that must be considered at pre-harvest, harvest and postharvest periods is the handling of fruits, which influences the development of fungal diseases that occur at postharvest (Morales, 1987). Being this one of the most important problems, special attention must be taken during this period, especially with relation to management of fruits in the orchard during harvest and to the sanitary issues for packaging and preserving of fruits at the postharvest period (Agrios, 2001). *Botrytis cinerea* Pers., *Geotrichum candidum* Link., *Monilinia laxa* (Aderh & Ruhland) Honey, *Penicillium expansum* Link and *Rhizopus stolonifer* (Ehrenb.: Fr.) Vuill are among the most common fungi associated with postharvest diseases in *P. persica* var *nectarine* (Lurie et al., 1995; Margosan et al., 1997), causing large losses mainly due to the high amounts of non-marketable fruits. The most common control methods to prevent postharvest fungal diseases are the use of

chemical products and disinfectants (Pinilla, 2007), although some yeasts have been tested as biocontrol agents of some the fungi producing postharvest nectarine diseases (Karabulut and Baykal, 2003). Postharvest losses could range from 5 to 10% when postharvest fungicides are used; while losses could reach percentages of 50 or higher, when no fungicides are used. The reduction in the use of pesticides has been a public demand since several years, stimulated by a greater concern of environmental care and health issues. Moreover, the development of resistance of some of the pathogens to fungicides, limits increasingly the use of chemicals for postharvest application. Infections by the fungal pathogens already mentioned, have been prevented using common disinfectants based on chlorine, such as calcium or sodium hypochlorite (Al-Haq *et al*, 2002), which reduce the microbial charge (Goodburn and Wallace, 2013) and the possible inoculum dispersal in the water used for hydro-cooling, for washing, for drainage wells or fruit transport in the packaging line (Zoffoli *et al*, 2005).

The use of electrolyzed water (EW) (Feliziania *et al*, 2016) has emerged as a new strategy to decrease the use of chemicals and disinfectants, or to improve processes related to inoculum dispersal, because of its low impact on the environment (Kim *et al*, 2000) and on the human being (Al-Haq *et al*, 2005). EW with neutral pH (7) is a novel agent antimicrobial, which has an effect on a wide variety of microorganisms, safe for humans and the environment ambient. The efficacy of electrolyzed water from super oxidation with neutral pH (SES) is the reduction of spore germination and germ tube development in fungi of postharvest importance (Gómez et al, 2017). This strong oxidation activity of EW that have already been described, where high antimicrobic effect killing bacteria, virus, fungi and parasites in a fast manner was shown, suggested that it can be utilized to disinfect surfaces and water systems (Thorn *et al*, 2012). In addition, there are many other "advantages" of EW over its toxic counterparts (physical, chemical and biological technology) in different areas such as agriculture, food hygiene, medical field and even in human surface disinfection" (Yan *et al*, 2021). Also, recent studies have shown that EW not only could control the microorganisms in postharvest on fruits and vegetables, but also improve the quality of postharvest of those agricultural products, including delaying senescence (Aday, 2016) and Sripong *et al*, 2021).

The use of EW has been tested for the control of *M. laxa* in pure cultures and in post-harvest peach fruits (Guentzel et al, 2010); however, no reports are available on its effect on phytopathogens affecting nectarines.

The present study evaluates the effectivity of electrolyzed water, both *in vitro* and *in vivo*, on *B. cinerea*, *G. candidum*, *M. laxa*, *P. expansum* and *R. stolonifer* infecting nectarines, and compares its effect with that of NaClO.

2 MATERIALS AND METHODS

All reagents were p. a. quality. EW was purchased from Envirolyte®.

Fungal strains.

B. cinerea, *G. candidum*, *M. laxa*, *P. expansum* and *R. stolonifer* were isolated from post-harvested fruits showing symptoms of the disease. Samples were taken from the diseased advancing zone cultivated in potato-dextrose-agar (PDA, DIFCO) at 22ºC and re-plated until pure cultures were obtained. These were identified based on macroscopic and microscopic morphology of colonies and spores (Barnett and Hunter, 1998), and stored on PDA at 5ºC until use.

Fruits.

Nectarines (*Prunus persica* cv *nectarine*) var Summer Grand from commercial orchards, were provided by Del Monte Fresh Produce Chile S. A. (Carretera General San Martín, Curimón, San Felipe, V Region, Chile).

Pathogenicity tests.

Nectarines were washed with tap water, disinfected with 10% commercial NaClO for three minutes, washed thoroughly with sterile distilled water, wounded with a sterile nail (3mm depth and 1-2 mm diameter), and inoculated with 10 □L of a conidial suspension (1 x 10^5 conidia/mL) of the isolated pathogens. Inoculated fruits were placed on damp sterile adsorbent paper, inside plastic boxes (two fruits per box) previously washed with 96% ethanol and disinfected under UV light for 15 minutes. Boxes were maintained at 22ºC for 96 hours. Assays considered 12 fruits and three repeats for each pathogen. All pathogens were re-isolated from fruits and their identity was proved as above.

***In vitro* effectivity of EW and of NaClO on the pathogens.**

Commercial NaClO (10%) and commercial electrolyzed water (180 ppm active ingredient) were standardized at pH 6.8, using acetic acid and NaOH, respectively.

Growth development

Assays used 5 mm mycelia disks from 4-7 days (*B. cinerea*, *G. candidum* and *M. laxa*), and from 1-2 days (*R. stolonifer*) pure PDA cultures; and from 1-2 days (*P. expansum*) pure agar-glucose cultures, to evaluate the effect of different concentrations of active ingredient (a. i.) of NaClO and of EW on growth development of the pathogens. Four mycelia disks form each pathogen were

placed inside tubes containing 9 mL of the corresponding sterile treatment solution and maintained at 22ºC during 0, 2, 6 and 24 hours. Controls were maintained in sterile distilled water in the same conditions. Treatments (Table 1) used the concentrations according to the manufacturer of EW, and to the NaClO used in fruit commercial treatments.

Table 1. Concentrations of EW and NaClO evaluated *in vitro* for mycelial growth

Pathogen	EW (ppm a. i.)	NaClO (ppm a.i.)
Botrytis cinerea	0-9-18-27-36-45-54-63-72	0-40-80-120-160-200
Geotrichum candidum	0-9-18-27-36-45-54-63-72	0-50-100-150-200-250-300
Penicillium expansum	0-9-18-27-36-45-54-63-72	0-3-6-9-12-15-18-21-24
Rhizopus stolonifer	0-9-18-27-36-45-54-63-72	0-20-40-60-80-100-120-140-160-180-200-220-240-260
Monilinia laxa	0-9-18-27-36-45-54-63-72	0-50-100-150-200-250-300-350-400

Mycelia disks were taken from solutions and placed up-side down on Petri dishes containing PDA. They were incubated at 22ºC for 96 hours (*M. laxa*, *P. expansum* and *G. candidum*), or 72 hours (*B. cinerea*) or 24 hours (*R. stolonifer*). Diameter of mycelia growth was measured. Each assay considered four repeats. Results are the mean of four repeats, where controls were subtracted from treatments. IC_{50} was calculated using a linear regression, for each of the used disinfectants, with the Minitab program.

Spore germination

The evaluation of the effect of different concentrations of a.i. of NaClO and of EW on spore germination of the pathogens, used spores obtained from 7 – 12 days PDA cultures at 22ºC of all pathogens, except for *M. laxa* whose sporulation was accomplished after 10 days inoculation of *Annona cherimola* Mill. Spore suspensions were prepared in distilled sterile water, and concentrations were adjusted to 1 x 10^5 spores/mL. Next, 1 mL of each spore suspension was mixed with 8 mL of the corresponding sterile treatment solution and maintained at 22ºC during 0, 2, 6 and 24 hours. Controls were maintained in sterile distilled water in the same conditions. Treatments (Table 2), considered four repeats, and concentrations according to the manufacturer of EW and to the NaClO used in fruit commercial treatments.

Table 2. Concentrations of EW and NaClO evaluated *in vitro* for spore germination

Pathogen	EW (ppm a. i.)	NaClO (ppm a.i.)
Botrytis cinerea	0.00-0.54-1.08-1.62-2.16-2.70-3.78-4.32-5.40	0.0-0.1-0.5-1.0-1.5-2.5-3.5-5.0-7.5
Geotrichum candidum	0.00-0.36-0.72-1.08-1.44-1.80-2.16	0.0-0.1-0.5-1.0-1.5-2.5-5.0
Penicillium expansum	0.00-1.80-5.40-10.80-16.20-21.60-27.00-32.40-37.80	0.0-1.25-2.5-3.75-5.0-6.25-7.5-8.75-10.0
Rhizopus stolonifer	0.00-1.80-5.40-10.80-16.20-21.60-27.00-32.40	0.0-3.0-6.0-9.0-12.0-15.0-18.0-21.0-24.0
Monilinia laxa	0.00-1.80-5.40-9.00-12.60-16.20-19.80-23.40	0.0-0.5-1.0-1.5-2.0-4.0-6.0-8.0

After the time periods stated above, a 0.1 mL aliquot was taken from each treatment; it was seeded on Petri dish containing glucose-agar and incubated during 24 hours at 22ºC. Spore germination was established under microscope, and it was considered a germinated spore when the length of germinating tube was equal or higher than two times its diameter (Latorre and Rioja, 2002). Results, expressed as mortality, correspond to the mean of 100 counted spores from each treatment, that were analyzed using the Probit analysis.

***In vivo* effectivity of EW and of NaClO on nectarines.**

The effect of EW and of NaClO was tested in nectarines from commercial sources, without any post-harvest treatment. Fruit samples (20) that contained a mean of 13.08º Brix and 15.1 pounds/inch^2 hardness were washed, disinfected with 10% NaClO for three minutes, rinsed with tap water and dried with absorbent paper. Dried fruits were wounded (equatorial, diameter and depth 1-2 mm) with a sterile nail, and inoculated with 10 µL of a suspension containing 1 x 10^5 spores/mL of the different pathogens after or before fruit immersion for five minutes in treatment solutions (Table 3), using concentrations according to the manufacturer of EW and NaClO fruit commercial treatments.

Table 3. Postharvest treatments.

Disinfectants (Concentration)	Period of inoculation with pathogenic fungi		
	A	B	C
EW (25.2 ppm a.i.)	Inoculation immediately before fruit immersion in treatment solutions.	Inoculation after three hours fruit immersion in treatment solutions	Inoculation three hours before fruit immersion in treatment solutions
NaClO (100 ppm a.i.)			
Control (sterile distilled water)			

Then, fruits were placed on trays that were placed inside transparent plastic bags containing absorbent paper soaked with sterile distilled water and maintained at 20-22.7 ºC. Experiments considered a random design, with one tray containing ten fruits as the experimental unit, with four repeats per treatment. Results correspond to the mean of rotting diameter (in cm) measured after 96 hours storage, using a Vernier. 100% symptoms were assigned to controls. Percentage inhibition of rotting (IR) was calculated as follows:

$$IR = \frac{RCd - RTd}{RCd} \times 100$$

Where,
IR: Percentage inhibition of rotting
RCd: Rotting control diameter
RTd: Rotting treatment diameter.

The results obtaining in percentage were transformed used the angular Bliss transformation followed by ANOVA and Fisher LSD, if significant differences were detected.

3 RESULTS

In vitro effect of EW and NaClO on the growth of pathogens.

The IC_{50} values for the mycelial growth of each pathogen tested (*B. cinerea*, *G. candidum*, *M. laxa*, *P. expansum* and *R. stolonifer*) in Table 4, show that they depended on the time period of exposure to the different concentrations of EW and NaClO, decreasing these values as the exposure period increases.

Table 4. IC_{50} values (ppm) and NaClO/EW ratios (R) for mycelial growth inhibition of the pathogens in the presence of different concentrations of EW and NaClO for different times exposure.

Pathogen	Exposure times (hours)	IC_{50} values (ppm)		NaClO/EW Ratio
		EW	NaClO	
B. cinerea	0	58.7	106.4	1.8
	2	41.4	35.4	0.9
	6	28.0	28.3	1.0
	24	26.1	28.2	1.1
G. candidum	0	47.1	238.7	5.1
	2	34.4	124.6	3.6
	6	21.7	84.4	3.9
	24	20.9	77.8	3.7
P. expansum	0	66.7	15.7	0.2
	2	54.7	7.2	0.1
	6	35.6	6.9	0.2
	24	39.9	4.0	0.1
R. stolonifer	0	54.6	131.8	2.4
	2	38.6	70.1	1.8
	6	33.0	44.9	1.4
	24	25.8	34.3	1.3
M. laxa	0	84.0	293.8	3.5
	2	77.1	75.4	1.0
	6	64.3	70.4	1.1
	24	34.2	46.3	1.4

The ratio of IC_{50} NaClO/EW reflects the relative effectivity of the two compounds at different time periods in the inhibition of mycelial growth of the corresponding phytopathogen (Table 4), i.e. the concentration times of NaClO that shows the same effect of EW. Based on ratios, EW appears to be more effective for almost all pathogens than NaClO at zero-time treatment, where IC_{50} for NaClO is higher than for EW indicating that NaClO must be more concentrated to achieve an effect like EW. However, no differences in IC_{50} for both compounds on *B. cinerea, R. stolonifer* and *M. laxa* were observed after two hours treatment, as opposed to *P. expansum* where NaClO was 5-10-fold more effective than EW or *G. candidum* where EW continues to be c.a. four-fold more effective than NaClO after 24 hours treatment.

The IC_{50} for the spore germination of each pathogen tested (*Botrytis cinerea, Geotrichum candidum, Monilinia laxa, Penicillium expansum* and *Rhizopus stolonifer*) depended on the time period of exposure to the different concentrations of EW and NaClO (Table 5).

Table 5. IC_{50} values for spore germination inhibition of the pathogens in the presence of different concentrations of EW (A) and NaClO.

Pathogen	Exposure time (hours)	IC_{50} values (ppm)		NaClO/EW Ratio
		EW	NaClO	
B. cinerea	0	2.4	2.5	1.0
	2	1.8	1.2	0.7
	6	1.1	0.6	0.6
	24	0.7	0.4	0.6
G. candidum	0	0.9	1.0	1.1
	2	0.4	0.9	2.2
	6	0.4	0.7	1.9
	24	0.3	0.6	1.8
P. expansum	0	8.5	4.9	0.6
	2	5.5	3.7	0.7
	6	5.5	1.8	0.3
	24	5.1	1.4	0.3
R. stolonifer	0	12.6	9.5	0.8
	2	5.5	5.8	1.1
	6	4.7	5.4	1.2
	24	4.0	4.1	1.0
M. laxa	0	7.9	1.9	0.2
	2	4.0	1.1	0.3
	6	2.3	0.7	0.3
	24	1.0	0.3	0.3

The ratio of IC_{50} NaClO/EW reflects the relative effectivity of the two compounds at different time periods in the inhibition of spore germination of the corresponding phytopathogen (Table), where EW appears to be more effective for almost all pathogens than NaClO at zero-time treatment, where NaClO must be more concentrated to achieve an effect similar to EW. However, no differences in IC_{50} for both compounds on *B. cinerea*, *R. stolonifer* and *M. laxa* are observed after two hours of treatment, as opposed to *P. expansum* where NaClO is 5-10-fold more effective than EW or *G. candidum* where EW continues to be c.a. four-fold more effective than NaClO after 24 hours treatment. Regardless of the IC_{50} ratio, it is important to note that the IC_{50} for EW and for NaClO, decreases for all pathogens with time of exposure.

In vivo effect of EW and NaClO on the control of phytopathogens

The phytotoxicity test of EW on nectarin fruits showed that no damage was found, although some salt deposition was observed at 54 and 108 ppm of the a.i.

Fruit inoculation with the different pathogens, immediately before fruit immersion (period of inoculation A), three hours after fruit immersion (period of inoculation B) and three hours before

fruit immersion in treatment solutions (period of inoculation C), showed a general inhibition of fruit rotting (Table 6).

Table 6. Percentage inhibition of fruit rotting in nectarines inoculated with pathogens at different time periods related to immersion in treatment solutions.

Treatment		Injury inhibition (%)[1]			
Disinfectant (Concentration)	**Period of inoculation**	***B. cinerea***	***M. laxa***	***P. expansum***	***R. stolonifera***
EW (25.2 ppm a.i.)	**A:** Fruit inoculation immediately before fruit immersion in treatment solutions	40.2 a	80.9 a	60.3 a	74.4 b
NaClO (100 ppm a.i.)		37.5 a	62.2 b	53.2 a	81.3 a
Control (sterile distilled water)		0.0 b	0.0 c	0.0 b	0.0 c
EW (25.2 ppm a.i.)	**B:** Fruit inoculation three hours after fruit immersion in treatment solutions	43.1 a	49.8 a	31.9 a	60.8 b
NaClO (100 ppm a.i.)		34.5 b	36.2 b	37.1 a	71.2 a
Control (sterile distilled water)		0.0 c	0.0 c	0.0 b	0.0 c
EW (25.2 ppm a.i.)	**C:** Fruit inoculation three hours before fruit immersion in treatment solutions	39.1 a	46.2 a	49.7 b	72.6 b
NaClO (100 ppm a.i.)		42.3 a	36.2 b	60.9 a	83.9 a
Control (sterile distilled water)		0.0 b	0.0 c	0.0 c	0.0 c

[1]Identical letters in columns indicate that there are no significant differences after ANOVA and Fisher LSD test ($p \leq 0.05$) within the same period of inoculation.

4 DISCUSSION

In vitro experiments on the effect of electrolyzed water as inhibitor of mycelial growth on *B. cinerea*, *G. candidum*, *M. laxa*, *P. expansum* and *R. stolonifer* isolated from nectarins (Table 4) showed that NaClO was more effective than EW on *P. expansum* independently of the time of exposure; however, as time of exposure increased the effect of NaClO approached that of EW, except for *G. candidum* where EW was always better inhibitor of growth development than NaClO. On the other hand, spore germination was prevented at concentrations of EW and NaClO lower than those for growth of the pathogens (Table 5); thus, at IC_{50} concentrations for preventing mycelial growth (Table 4), spore germination will be also prevented. It has been established that 10 ppm EW showed similar effect on spore germination of *P. expansum* isolated from pears as NaClO (Okull et, 2006), which differs with our results where NaClO appears more effective than EW on this pathogen (Table 5) at all times tested. In addition, it has been reported the use of EW on different pathogens isolated from different fruit sources (Gómez et al, 2017), where treatments for 5 min at concentrations between 3 and 43 ppm resulted in 100% inhibition on spore germination and germ tube length of *Botrytis*, of *Colletotrichum*, of *Fusarium*, of *Monilinia*, of *Penicillium*, of *Rhizopus* isolated from soursop and of *Rhizopus* isolated from jackfruit. (18-43 ppm). However, the concentrations to obtain these results were different for each pathogen. The differences observed in the effect of EW against pathogens isolated from different fruits, suggest that results obtained could not be extrapolated to different fruit-pathogen interaction, as has been indicated (Radical Waters,

2010), where concentrations between 5.4 and 37.8 ppm should be enough to control the pathogens isolated from nectarins, being those lower than the IC_{50} obtained for all the pathogens at the different time periods tested (Table 4).

The i*n vivo* experiments, run simulating different situations that could occur in packings, i.e. fruit that arrives with inoculum from orchards, fruits that are contaminated in the packing during processing or during storage, showed a general inhibition of fruit rotting, results that agree with those of Spirong *et al*. (2021) who determined that by using electrolyzed water at 400 ppm in the fruit hydrocooler, rotting decreased as was indicated by Guentzel *et al.* (2010). These authors showed that electrolyzed water was able to effectively decrease post-harvest infections by *B. cinerea* and *M. fruticola* in grapes and peaches, respectively. Additionally, Spirong *et al*. (2021) indicate that electrolyzed water has additional effects that correlate well with the increase of key plant defense-related enzyme activities such as phenylalanine ammonia lyase and chitinase; and that a better fruit quality was maintained using hydrocooling through weight and respiration rate reduction. However, although electrolyzed water could react immediately with pathogens on the surface and first layers of fruits, it was shown that it was unable to control pathogens such as *Botryosphaeria berengeriana* in more deep wounds of pears, situation that should be taken into account when receiving at the packing, fruits from orchards. (Al-Haq *et al*, 2002). Thus, the latter should be inspected carefully to discard those fruits showing deep wounds that could bring inoculum facilitating its spread.

Also, the effect of EW has been studied on other pathogens, where its effect has been tested in different post-harvest fruits attacked by different phytopathogens that cause disease in humans (Chen *et al*, 2017; Tango et al, 2017; Strano *et al*, 2017; Di Francesco *et al*, 2016).

Our results, along with those available in the literature suggest that EW can be used as an alternative method to control postharvest fungi, considering that the exposure times and the concentration of EW may be different, depending on the pathogen and the fruit that they attack in postharvest.

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