Management of Citrus Fruit Rot by Using Hot Water Treatments in Ismailia Governorate

Mohamed, A. N.[1]; I. W. Shaban[1]; A. H. El-Marzoky[1]; A. S. Zaian[2]
[1]Agricultural Botany Department, Faculty of Agriculture, Suez Canal University, Ismailia, Egypt
[2]Plant Pathology Research Institute, Agriculture Research Center, Giza, Egypt

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Abstract: Postharvest decay is the major factor limiting the extension of storage life of many fresh harvested commodities. Isolation and identification of associated organisms on orange fruit rot were studied during seasons 2019/2020 and 2020/2021. Effect of temperature on the mycelia growth tested pathogens in vitro and in vivo were studied. Pathogenicity tests indicated that *Penicillium digitatum*, *Penicillium italicum, A. citri* and *Geotrichum candidum* showed the more pathogens effect on citrus fruits. The tested pathogens were obtained maximum growth of the tested pathogen at 25°C and 30°C. Obtained results in this study indicated that *P. digitatum* and *A. citri* showed moderate results with hot water at 56, 59 and 62°C for 30, 60 and 120s. Treated fruits at tested temperature degree 56, 59 and 62°Cfor 120s did not record any symptoms of orange fruits rot caused by *G. candidum*. Moderate results of fruit rot control was observed on orange fruits which infected with *P. digitatum*, *A. citri* when treated for 30, 60 and 120s at different tested hot water temperatures. Significant results were obtained compared with tested temperature degree and control treatment. Hot water can reduce microorganism populations on commodity surfaces or latent pathogens in the outer cell layers and may also induce plant disease resistance against various pathogens. Significantly, the study provides a model for alternative methods and ecofriendly methods for controlling orange fruit rot compared with traditionally methods or chemical control methods.

Keywords: *P. digitatum, P. italicum, A. citri, G.* candidum, Citrus, fruit rot, hot water

INTRODUCTION

Citrus is an important crop globally as well as in Egypt. Citrus fruit production in Egypt 2019 season reach 1.8 ton according to Ministry of Egyptian agricultures. Fruits of Citrus are susceptible to many postharvest diseases in order to cause respectable losses. Citrus fruits are susceptible to a number of postharvest diseases that cause significant losses during the postharvest phase. Nevertheless, the most common and serious diseases that affect citrus fruit are green and blue molds caused by *Penicillium digitatum* and *P. italicum*, *Geotrichum citri-aurantii*, respectively (Caccioni *et al.,* 1998; Palou *et al.,* 2002; Zheng *et al.,* 2005). These pathogens are strict wound pathogens that can infect the fruit in the grove, in the packinghouse, or during subsequent handling and storage (Palou *et al.,* 2008). Therefore, the challenge is to develop safer and ecofriendly alternative strategies of controlling citrus postharvest diseases, which pose less risk to human health and environment.

Heat treatments in the form of moist either hot air or hot water dips have had some commercial application for the control of post- harvest wastage in fruits. The advantage of hot water dipping is control surface infections as well as infections that have penetrated the skin, without leaving any chemical residues on the produce (Fallik *et al.*, 2002). Good results in controlling citrus fruit rots have been obtained with packing line machinery where hot water at 55-65°C was applied for 10-30 s over rotating brushes Rodov *et al.* (2000). Control of blue mold, however, was less satisfactory when fruit were cold-stored for long periods after treatment Plaza *et al.* (2003). Treatments with hot water were a technology easier, cheaper, and more feasible for heat application than curing. Relatively brief immersions (2-5 min) in water at 45-55°C have repeatedly shown value in reducing citrus green and blue molds Schirra *et al.* (2011).

The main goal of this study is to use hot water in controlling postharvest fruit pathogens.

MATERIALS AND METHODS

Fruit samples:

Citrus rotted fruit samples were collected from different cities in Ismailia such as El-Tal El-Kabir, El-Qantra, Abu Swair and Al-Qassasen. Samples were collected for isolation and identification of different causal pathogens from samples include different citrus species, *i.e* mandarin, oranges and lemons Samples were keeping them in cool conditions. They were transferred into plant pathology laboratory for further studies.

Isolation and Identification of the causal pathogens:

During 2019/2020 and 2020/2021 samples of naturally infected citrus fruits showing fruit rots symptoms were collected from different commercial markets in Ismailia governorate, and transferred to plant pathology laboratory, Agricultural Botany Department, Faculty of Agric., Suez Canal Univ. Samples were checked carefully and examined.

Pure isolates of more pathogens frequency *P. digitatum, P. italicum, A. citri,* and *G. candidum* from each survey location in Ismailia governorate were used in further studies.

Pathogenicity tests were done to confirm which isolated pathogens able to cause infection and appearance typical symptoms on orange fruits pure isolates of *P. digitatum, P. italicum, A. citri* and *G. candidum* from each survey location in Ismailia governorate were prepared by using PDA cultures grown for 10 days for testing their pathogenic

capabilities on fresh citrus fruits. Inoculation procedures were performed under aseptic conditions by inserting 6 mm agar disc of the tested fungus into holes (6mm diameter and 4 mm depth) made in "stem-end blossom-end" of fruit using a sterilized cork borer.

Fifteen fruits were used for each pathogen. After inoculation the holes were plugged with the removed pieces of the peel. Three replicates each of five fruits were used for each tested pathogen and control treatment was carried out by sterilized water. The fruits were arranged in batches of five fruits in clean polythene bags, each moistened with sterilized moist cotton to create a micro-humidity chamber and incubated at 25±1°C. Different fruit rots were identified based on associated symptoms.

The disease incidence of fruit rot was calculated as percentage of infected navel orange fruit relation to the total number of fruits in each replicate according to the following formula.

Disease severity % = Diseased area of fruit surface/Total area of fruit surface×100.

Effects of heat treatments on mycelia growth

Effect of temperature on the mycelia growth of *P. digitatum, P. italicum, A. citri* and *G. candidum* was studied under laboratory conditions. Separate incubators were set at temperatures of 10, 20, 25, 30 and 35°C, respectively, prior to the tests. Disk at 5 mm of PDA 7 days old cultures of tested pathogens cut from the edge of the fungal colony and transferred onto the center of a plate (9 cm diameter) containing PDA sterilized medium. The plates were incubated at the range of temperatures described above. Five plates were used for each fungus and temperature. Fungal colony diameters of the tested pathogens were recorded at 7 days, respectively. The fungal mycelial growth was measured by the colony diameter measurements minus the originally inoculated PDA disk diameter (5 mm). The experiment was repeated twice.

Effects of hot water dip on fruit rot development of artificial infected fruits.

Navel orange fruits were collected from various citrus markets in Ismailia governorate. The fruits were washed in running tap water for 1 min then separated into two groups. Healthy fruits of mature Navel orange were surface sterilized by 2%Sodium hypochlorite solution for 5 min then washed by rinsing these fruits in sterilized distilled water for three times and dried with sterilized filter paper. Inoculation procedures were performed under aseptic conditions by inserting 6 mm agar disc of the tested fungus into holes (6mm diameter and 4 mm depth) made in the fruits using a sterilized cork borer.

A growth discs of each tested pathogen *i.e. P. digitatum, P. italicum, A. citri* and *G. candidum* (6 mm diameter) were taken from the margin of 7 days old PDA –cultures.

After inoculation the holes were plugged with the removed pieces of the peel. Three replicates each of five fruits were used for each tested fungi and control treatment was carried out by sterilized water. Only fruits were marked before administering the treatment to distinguish them from lesions that developed subsequently. Both asymptomatic and symptomatic fruit were dipped in hot water 56, 59, and 62°C for 30, 60 and 120 seconds.

Other set of fruits dipped in water at room temperature for the same above tested periods and used as control.

After treatment, the fruit were air-dried and incubated at 25±1C° with 90% relative humidity (RH). Percent of infected fruits (Diseased area of fruit surface cm) after 7days from treatment according to Er *et al.* (2013).

Determination of the fruit qualities

Orange fruits quality studies i.e. peel color (PC), peel puncture resistance (PPR), total soluble solids (TSS), and titratable acid (TA) were measured. Fruits quality evaluation was performed as described by Ritenour *et al.* (2003). Peel color was measured at three evenly spaced locations around the fruit equator using a Minolta Chroma Meter (model CR-300; Minolta Camera Corp., Ramsey, NJ). Color was reported as a*: b* ratio where a* measures green (negative) to red (positive) and b* measures blue (negative) to yellow (positive). As fruit peel color turns from green to yellow orange, the a*: b* value increases. PPR was determined by puncturing each fruit at three evenly spaced locations around the fruit equator using a texture analyzer (model TA-XT2; Stable Micro Systems, Godalming, England) with a 2-mm-diameter, flat-tipped, cylindrical probe attached to a texture analyzer. After making contact with the fruit surface, the probe was set to travel at a speed of 8 mm·s–1 and the maximum force exerted to puncture the peel were recorded. Juice TSS (Brix) was measured using a Minolta Chroma Meter (model CR-300; Minolta Camera Corp., Ramsey, NJ). Juice TA (% citric acid) was measured by titrating juice to pH 8.3 with sodium hydroxide (NaOH) using an automatic titrimeter (model DL12; Mettler, Highstown, NJ).

RESULTS AND DISCUSSION

Isolation and identification of the causal fungi:

Citrus fruit rot is one of the most serious plant diseases important in Ismailia fruit marketing. During the 2019/2020 and 2020/2021 seasons, more than 221 fungal isolates of different plant pathogens were isolated from examined citrus fruits (Orange, Mandarin and Lemon) which were collected from different markets in Ismailia governorate. Most of the isolates were isolated from Orange fruits. Distribution on isolated fungi between different Ismailia locations and different citrus types are presented in Table (1). Obtained results showed that more than 100 fungal isolates were isolated from Navel orange fruits. In this regards, *P. digitatum* was the most isolated pathogen frequency at 28.9% from the total isolated pathogens followed by *P. italicum, A. citri* and *G. candidum* at 27.6, 22.6 and 20.8 respectively. *A. citri* were isolated from navel orange fruits only comparing the other tested citrus fruits.

Table (1): Frequency of the isolated fruits rot pathogens from different citrus fruits at Ismailia governorate

Locations	Host	*Alternaria citri*	*Penicillium digitatum*	*Penicillium italicum*	*Geotrichum candidum*	Total
Abu Swair	Orange	11	5	5	2	23
	Mandarin	00	6	5	4	15
	Lemon	00	5	5	5	15
Al-Qassasen	Orange	15	5	5	4	29
	Mandarin	00	6	5	4	15
	Lemon	00	5	5	4	14
El-Tal El-kabir	Orange	13	5	6	2	26
	Mandarin	00	5	5	5	15
	Lemon	00	6	5	4	15
El- EL-Qantara Gharb	Orange	11	6	5	3	25
	Mandarin	00	5	5	5	15
	Lemon	00	5	5	4	14
Total		**50**	**64**	**61**	**46**	**221**
Frequency %		**22.6**	**28.9**	**27.6**	**20.8**	**--**

Pathogenicity tests of isolated fungi:

Pure isolate of more frequency pathogens which isolated from different surveyed area was selected to test this pathogenic effect on Navel orange fruit sue in this trial. One isolate for each *P. digitatum*, *P. italicum, A. citri* and *G. candidum* from Abu Swair, Al-Qassasin, El-Tal El-kabir an EL-Qantara Gharb were tested on navel orange fruits. Data presented in Table (2) indicated that pathogenic isolates *P. digitatum* and *P. italicum* which isolated from El-Tal El-Kabir showed the most pathogenic effect comparing with the other tested isolates. In this respect, Abu Swair isolates of *A. citri* and *G. candidum* showed the most pathogenicity isolates comparing with other similar isolates.

Table (2): Pathogenicity test of the isolated fungi on navel orange fruits as Disease incidence and disease severity % / tested fungi

Isolates locations	days	*P. digitatum*		*A. citri*		*P. italicum*		*G. candidum*	
		Infected aria (cm)	Disease severity%	Infected aria (cm)	Disease severity%	Infected aria (cm)	Disease severity%	Infected aria (cm)	Disease severity%
Abu Swair	7	4.10	64.0	3.02	41.0	0.52	8.2	1.81	27
	10	5.46	82.7	5.64	76.5	1.04	16.3	4.68	69
	12	7.42	91.2	6.74	91.4	1.84	28.9	5.6	83
	control	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
L.S.D		0.25		0.07		0.07		0.17	
Al-Qassasen	7	5.07	59.1	3.12	42.3	0.60	9.4	1.68	25
	10	7.42	87.0	5.54	75.1	1.02	16.0	4.73	70
	12	7.96	93.2	6.54	88.7	1.80	27.6	5.66	84
	control	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
L.S.D		0.35		0.10		0.08		0.12	
El-Tal El-Kabir	7	4.90	57.0	3.30	45.0	0.48	7.5	1.59	23
	10	7.02	82.0	5.66	76.8	1.00	15.7	4.32	64
	12	7.99	93.6	6.68	90.6	1.86	29.2	5.34	79
	control	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
L.S.D		0.54		0.28		0.05		0.15	
EL-Qantara Gharb	7	5.44	63.8	3.04	40.8	0.50	7.8	1.62	24
	10	7.21	84.6	5.64	76.5	0.96	15.1	4.64	69
	12	7.97	93.4	6.50	88.2	1.74	27.3	5.74	84
	control	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
L.S.D		**0.24**		**0.07**		**0.05**		**0.20**	

On the other hand, observed results indicated that *P. digitatum* was more virulent on navel orange fruits (93.6% disease severity) comparing with other isolates. On the contrary, *P. italicum* was the least pathogenic isolates in disease severity at the same tested period on the navel orange fruits. Observed results indicated that *P. digitatum* was the most virulent on orange fruits which showed more than 93% disease severity compare with other isolated pathogens. In the contrary, *P. italicum* was the less pathogenic isolates disease severity on the orange fruits. These results are in harmony with Zheng *et al.* (2005), Moss (2008) and Valero and Serrano (2010) who mentioned that some fungal species cause postharvest infections in citrus fruit, resulting in important economic losses. The most important pathogenic fungi causing postharvest infections include *P. digitatum* and *P. italicum* (Ascomycota; Eurotiomycetes; Eurotiales), responsible for green and blue rot, respectively, and *Geotrichum candidum* responsible for sour rot.

Effects of heat treatments on the mycelia growth

Effect of temperature degrees on fungal growth of test pathogens under laboratory conditions have been summarized in Table (3). Obtained results showed that the tested pathogens were grown at the temperature degree ranged from 10-3°5C. However growth of the tested fungi were drastically reduce below 20°C and on the contrary started decline above 35°C as these temperatures did not favor for growth of the fungus. The tested pathogens were obtained maximum growth of the tested pathogen were obtained at 25°C and 30°C after 7 days post of incubation at 25°C. *A. citri, P. italicum* and *G. candidum* grew at optimum temperature at 25°C and 30°C. The optimum growth temperature degree was recorded between 20 to 25°C for *P. digitatum* and *P. italicum*, whereas, optimum temperature degree was recorded between 25 to 30°C for *A. citri* and *G. candidum*. On the other hand, 35°C was the thermal end point for *P. digitatum*, *P. italicum* and *G. candidum*. Obtained results are in agreement with Morris (1998) and Brischke (2006) who demonstrated that the optimum temperature for citrus fruit decay generally between 20-35°C. At the same trend, Morris (1998) noted that pathogenic fungi become dominant below at temperature 10°C, upper growth limit is 46°C, but many fungi are not killed at 67°C. In this regard, Carrillo-Inungaray *et al.* (2014) fund that growth curves of *Penicillium digitatum* were obtained at different conditions of temperature (10-40°C).

Table (3): Effect of different temperature degree on mycelium growth of the tested pathogens

	Fungal growth (cm)			
Temperature degree (°C)	***P. digitatum***	***A. citri***	***P. italicum***	***G. candidum***
10	2.42	2.36	1.26	3.74
20	4.44	4.00	4.00	3.68
25	4.38	4.00	4.00	4.00
30	1.40	4.50	3.85	4.50
35	0.00	2.26	0.00	0.00
L.S.D	0.115	0.365	0.087	0.125

Effect of hot water dip on fruits rot development of artificial infected fruits

Effect of different hot water at different exposure periods on orange fruit rot were studied and presented in Table (4, 5, 6 and 7). Effect of hot water treatment (56, 59 and 62°C) in controlling navel orange fruit rots caused by *P. digitatum, A. citri, P. italicum* and *G. candidum* were studied at three different periods (30, 60 and 120s). Presented data in Table (4, 5, 6 and 7) indicated that *P. digitatum* and *A. citri* showed moderate results when citrus fruit treated in hot water at 56, 59 and 62°C for 30, 60 and 120s. Data presented in Table (4) indicated that no fruit rot symptoms was observed on orange fruits caused by *P. italicum* after fruits treated in hot water at all three tested temperatures. In this regard, treated fruits at tested temperature degree (56, 59 and 62°C) for 120s were did not record any symptoms of orange fruits rot caused by *G. candidum*. On the other hand, moderate results of fruit rot control was observed on orange fruits which infected with *P. digitatum*, *A. citri* when treated for 30, 60 and 120s at different tested hot water temperatures. Data in these trials which recorded after seven days post inoculations were presents in Table (4) *Penicillium italicum* was most susceptible for hot water treatment which showed high orange fruit rot reduction when fruit treated at different tested temperature degree for 30, 60 and 120s followed by *G. candidum*. In this regard, significant results were obtained compared with tested temperature degree and control treatment. Hot water can reduce microorganism populations on commodity surfaces or latent pathogens in the outer cell layers and may also induce plant disease resistance against various pathogens. For example, Pavoncello *et al.* (2001) found exposing fruit to 62°C water for 20 s induced the accumulation of chitinase and b-1,3-glucanases proteins in the flavedo and inhibited green mold incidence on grapefruit. In this trend, Yun *et al.* (2013) noted that explored disease-resistance mechanisms induced by heat in 'Kamei' satsuma mandarin fruit and found a significant accumulation of metabolites, such as tetradecanoic acid and oleic acid

in fruit pericarp, which might play an important role in plant disease resistance.

Obtained results related to hot water treatment can describe by other investigators. Heat treatments in the form of either moist hot air or hot water dips have had some commercial application for the control of post- harvest wastage in fruits. The advantage of hot water dipping is that it can control surface infections as well as infections that have penetrated the skin, without leaving any chemical residues on the produce (Fallik *et al.*, 2002). The principal benefit of hot water (or air) treatments is that they can kill the organisms on and below the fruit surface. Post-harvest fungicides kill only surface pathogens. The heat may affect ripening behavior by slowing it, which could be good or bad (Fallik *et al.*, 2001).

Table (4): Effect of hot water treatment in controlling navel orange fruit rots caused by*Penicillin digitatum*

Infected aria (cm)											
Treatments	**After 7days**						**After 3 days**				
	Temperature° C										
	Time/s	**56**	**59**	**62**	**Con.**	**Mean**	**56**	**59**	**62**	**Con.**	**Mean**
P. digitatum	**30**	5.48	5.52	5.46	6.48	5.74	1.66	1.44	1.36	2.00	**1.62**
	60	5.00	4.98	4.82	6.48	5.03	1.34	1.08	0.64	2.00	**1.27**
	120	4.50	4.38	4.20	6.48	4.88	1.02	0.62	0.08	2.00	**0.93**
	Mean	4.99	4.96	4.93	6.48		1.34	1.05	0.69	2.00	
L.S.D	**T= 0.041 P =0.036 T*P=0.72**						**T= 0.075 P =0.065 T*P=0.131**				

Table (5): Effect of hot water treatment in controlling navel orange fruit rots caused at three different periods with *Alternaria citri*

Infected aria (cm)											
Treatments	**After 7days**						**After 3 days**				
	Temperature °C										
	Time/s	**56**	**59**	**62**	**Con.**	**Mean**	**56**	**59**	**62**	**Con.**	**Mean**
A. citri	**30**	4.94	4.24	3.48	6.00	4.67	1.14	1.02	0.86	1.26	1.07
	60	4.18	3.36	3.06	6.00	4.15	0.66	0.68	0.32	1.26	0.73
	120	3.08	2.28	2.18	6.00	3.49	0.46	0.32	0.0	1.26	0.51
	Mean	4.07	3.29	3.04	6.00	--	0.75	0.67	0.39	1.26	--
L.S.D	**T= 0.62 P =0.054 T*P=0.108**						**T= 0.109 P =0.095 T*P=0.190**				

Table (6): Effect of hot water treatment in controlling navel orange fruit rots by *Penicillium italicum*

Infected aria (cm)											
Treatments	**After 7days**						**After 3 days**				
	Temperature °C										
	Time/s	**56**	**59**	**62**	**Con.**	**Mean**	**56**	**59**	**62**	**Con.**	**Mean**
P. italicum	**30**	0.40	0.28	0.20	0.50	0.35	0.00	0.00	0.00	0.30	0.08
	60	0.20	0.16	0.10	0.50	0.24	0.00	0.00	0.00	0.30	0.08
	120	0.10	0.00	0.04	0.50	0.18	0.00	0.00	0.00	0.30	0.08
	Mean	0.23	0.17	0.11	0.50		0.00	0.00	0.00	0.30	
L.S.D	**T= 0.029 P =0.025 T*P=0.052**						**T= 4.46 P =3.86 T*P=5.80**				

Table (7): Effect of hot water treatment in controlling navel orange fruit rots caused by *G. candidum*

Infected aria (cm)										
Treatments	**After 7days**					**After 3 days**				
	Temperature									
	Time/s	**56°C**	**59°C**	**62°C**	**Con.**	**Mean**	**56°C**	**59°C**	**62°C**	**Con.**	**Mean**
G. candidum	**30**	1.96	1.46	1.16	3.00	1.90	0.38	0.24	0.10	0.70	0.36
	60	1.56	1.02	0.78	3.00	1.59	0.06	0.04	0.00	0.70	0.20
	120	1.10	0.50	0.46	3.00	1.27	0.00	0.00	0.00	0.70	0.18
	Mean	1.54	0.99	0.80	3.0		0.15	0.09	0.03	0.70	
L.S.D	**T= 0.044 P =0.038 T*P=0.077**						**T= 0.037 P =0.032 T*P=0.064**				

Chemical characteristics:

Total soluble solids (TSS):

The amount of total soluble solids was variable in all treated fruit after 7 days of storage at room temperature. There are significant differences between all treatments and between all pathogens except with antioxidants alone. The results presented in Table (8) showed that the highest total soluble solids were found on the fruit at the end of the storage with treatment antioxidants in hot water treatment, whereas the lowest was observed in treated fruits by hot water treatment alone.

Table (8): Effect different tested materials in physical and chemical fruit characters of

Variables	Period	Hot water Treatments
L	control	64.38±0.78^{a}
	7 days	63.25±0.85^{a}
	mean	63.81
a	control	24.75±2.81^{a}
	7 days	22.83±1.83^{a}
	mean	23.79
b	control	63.75±1.91^{a}
	7 days	58.33±5.01^{ab}
	mean	61.04
s	control	3.7±0.9^{b}-^{d}
	7 days	5.5±0.0^{a}
	mean	4.64
T. ss	control	10.0±0.0^{ab}
	7 days	9.3±0.4^{b}
	mean	9.67
Ta	control	0.335a
	7 days	0.245a
	mean	0.290

Total titratable acidity:

The amount of total titratable acidity was valued in all treated fruit after 7 days of storage at 25°C. There are no significant differences between all treatments.

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إدارة عفن ثمار الحمضيات باستخدام معاملات المياه الساخنة بمحافظة الإسماعيلية

نيرة عبد الرحمن محمد عبد القادر[١]، وليد إبراهيم شعبان[١]، حنان احمد المرزوقي[١]، سحر عبده محمود زيان[٢]

[١]قسم النبات الزراعي، كلية الزراعة، جامعة قناة السويس، الإسماعيلية، جمهورية مصر العربية

[٢]معهد بحوث أمراض النبات، مركز البحوث الزراعية، الجيزة، مصر

تعد أعفان ما بعد الحصاد هي العامل الرئيسي الذي يحد من إطالة العمر التخزيني للعديد من الثمار. تمت دراسة عزل وتحديد الكائنات المرتبطة بتعفن ثمار البرتقال خلال موسمي ٢٠١٩/٢٠٢٠ و ٢٠٢٠/٢٠٢١. تمت دراسة تأثير درجة الحرارة على نمو الفطريات التي تم اختبارها مسببات الأمراض في المختبر وفي الجسم الحي. أشارت اختبارات الإمراض إلى أن البنسليوم. ديجيتاتوم، البنسليوم. *Penicillium italicum*، *A. citri*، و *Geotrichum*.أظهر المبيض تأثير مسببات الأمراض على الحمضيات. تم الحصول على مسببات الأمراض التي تم اختبارها على أقصى نمو للممرض الذي تم اختباره عند ٢٥ درجة مئوية و ٣٠ درجة مئوية. أشارت النتائج التي تم الحصول عليها في هذه الدراسة إلى أن *P. digitatum* و *A. citri* أظهرا نتائج معتدلة مع الماء الساخن عند ٥٦ و ٥٩ و ٦٢ درجة مئوية لمدة ٣٠ و ٦٠ و ١٢٠s. لم تسجل الفواكه المعالجة عند درجة الحرارة المختبرة ٥٦ و ٥٩ و ٦٢ درجة مئوية ١٢٠s أي أعراض لتعفن ثمار البرتقال الناجم عن *G. candidum*. لوحظت نتائج معتدلة لمكافحة تعفن الفاكهة على ثمار البرتقال التي أصيبت ب *P. digitatum*، *A. citri* عند معالجتها لمدة ٣٠ و ٦٠ و ١٢٠ ثانية في درجات حرارة مختلفة تم اختبارها بالماء الساخن.