THE EFFECTIVENESS OF SOME CHEMICALS AGAINST POSTHARVEST DISEASES CAUSED BY *PENICILLIUM DIGITATUM, PHYTOPHTHORA CITROPHTHORA* AND *GEOTRICHUM CANDIDUM* ON ORANGE

İSMET YILDIRIM[1], MUSTAFA SAKALDAŞ[2], FERENC LANTOS[3]

[1] Çanakkale Onsekiz Mart University, Agricultural Faculty, Department of Plant Protection. 17020
Çanakkale, Türkiye.
[2] Çanakkale Onsekiz Mart University, Agricultural Faculty, Department of Horticulture. 17020
Çanakkale, Türkiye.
[3] University of Szeged Faculity of Agriculture, Hódmezővásárhely, Hungary

ABSTRACT
The effectiveness of the mixture of Xedabio (1.5%) + KPhos (0.5%) + Xedathane (0.25%) for postharvest control of green mold (*Penicillium digitatum*), brown rot (*Phytophthora citrophthora*) and sour rot (*Geotrichum candidum*) infections on orange c.v. "Jaffa" was investigated. Oranges stored at 18-20 °C for 24 hours were inoculated with spore suspension (10^6 spores/ml) after injured on the ecvatorial area. The chemicals were applied with water at 21±1°C and 46 ±1°C, as two groups. Inoculated fruits were incubated at 9-10 °C in a storage controlled by TFA Datalogger during 15 days. The trial was set up according to the randomized complete block design with three replications. The diameters of symptoms on each fruits were measured with electronic compass everyday.
The interaction between the treatment conditions and storage time were significant at 1% significance level. The mixture of Xedabio + KPhos + Xedathane applied with water at 46±1°C was found more effective than the same mixture used with water at 21±1°C.
As a result, the mixture of Xedabio + KPhos + Xedathane in different water tempratures could be used against some postharvest diseases on orange.

Keywords: Orange, post-harvest disease, Xedabio, KPhos, Xedathane.

INTRODUCTION

The citrus production of the world is about 123,755,750 tons, and 56% of this is orange. According to 2010 data, there were produced 1710.50 tons of orange in the field of 53,236 hectars in Turkey (FAO, 2010). Among the mediterranean countries, Turkey the takes first place with this orange production (TÜİK, 2009).
The post-harvest fungal diseases can cause significant losses of about 20% to 50% of the yield of fresh vegetables and fruits (KLEIN AND LURIE, 1991). They cause serious problems to the harvested citrus fruits during handling, transportation, exportation and the storage process (HOW, 1991; WILSON ET AL., 1994). The post-harvest fungal spoilage was mostly due to green and blue molds (*Penicillium digitatum* and *P. italicum*) and sour rot (*Geotrichum candidum*) (BALI ET AL., 2008; EL-MOUGY ET AL., 2012). The use of synthetic fungicides gave satisfactory control against mold infection. But fungicidal residues can have harmful effect on people and environment (ECKERT AND OGAWA, 1988; WILSON ET AL. 1994). In addition, the excessive and improper use of fungicides could lead to the development of fungi races being resistant against the applied fungicides. Therefore, alternative chemicals are needed for the postharvest management of orange fruits. In this respect, nowadays the researches on microbial biocontrol agents and alternative chemicals against postharvest diseases have been increasing (JANISIEWICZ AND KORSTEN, 2002; HUANG ET AL., 1995; BULL ET AL., 2006).

The main pupose of this study is to investigate the effectivenes of an alternative chemical mixture against post-harwest diseases (*Penicillium digitatum*, *Phytophthora citrophthora* and *Geotrichum candidum*) on orange fruits.

MATERIAL AND METHOD

Plant material

Orange fruits (*Citrus sinensis* Lin. c.v. "Jaffa") were obtained from a private orchard in Köyceğiz town (Muğla province). Harvested fruits were transported by a vehicle (fruco) to Çanakkale on the same day. The fruits were stored at 18 to 20 °C for 24 hours until application.

Fungi and inoculum

Penicillium digitatum, *P. digitatum* and *Geotrichum candidum* were isolated from infected orange fruits. The isolates were grown on PDA medium (39 g potatoes dextrose agar / 1 liter sterile distilled water) at 25 °C for 7 days. At the end of the incubation sterile water and Tween were added into Petri dishes and conidia were passed into the water by rubbing with glass rod. Fungal suspension was filtered through two layers fine muslin to remove the mycelium and other fragments. Spore suspension was then counted with a haemocytometer and adjusted to 10^6 spores / ml. The orange fruits of "Jaffa" variety were wounded by the tip of sterile micropipette in the equatorial areas of fruit peels. They were inoculated with 60 µl spore suspension from their wounded side and left for incubation at room temperature (21 °C-22 °C) during 12 hours.

Treatments and storage conditions

After incubation, orange fruits were separated into two groups and treated with the mixture of Xedabio (1.5%) + KPhos (0.5%) + Xedathane (0.25%) in water at two differend tempratures (21±1 °C and 46±1 °C). Control fruits were only treated with warm water. Then, all of the fruits were dried for one hour naturally. Orange fruits were stored at 9–10 °C and 85-90% RH conditions after inoculation in a storage controlled by TFA Datalogger for 15 days. The daily improvement of the infected area was measured by digital calipers.

Statistical analysis

The experiment was arranged in randomized complete design with 3 replications. 10 fruits were used for each replication. Analysis of variance was conducted on the efficacy of the chemical mixture by using the Tukey Method and means were compared by using LSD Range Test at $p<0.01$ level. Effectiveness of the chemical mixture on disease was calculated by Abbott formulation.

$$\text{Corrected \%} = \left(1 - \frac{\text{infected area in T after treatment}}{\text{infected area in Co treatment}}\right) \times 100$$

T= Treated Co= Control

RESULTS

Orange fruits inoculated with *Penicillium digitatum, Phytophthora citrophthora, Geotrichum candidum* were treated by the combination of Xedabio (1.5%) + KPhos (0.5%) + Xedathane (0.25%) in dipping water with two different temperatures (21±1°C and 46 ±1°C). The combined treatment at both water temperatures affected three mold types.

Green mold (*Penicillium digitatum)*

Control fruits inoculated with *Penicillium digitatum* were all infected on the 9th day. However, 22% of fruits treated by the combination with dipping water at 21±1°C were infected. Furthermore, infection in fruits treated by the combination with dipping water at

46 ±1°C was 18%. Moreover, 47% of fruits treated at both 21±1°C and 46 ±1°C were infected on the 15th day after innoculation.
Infected area increased on all fruits. Besides, this increase was highly determined on the control fruits (*Fig. 1*).

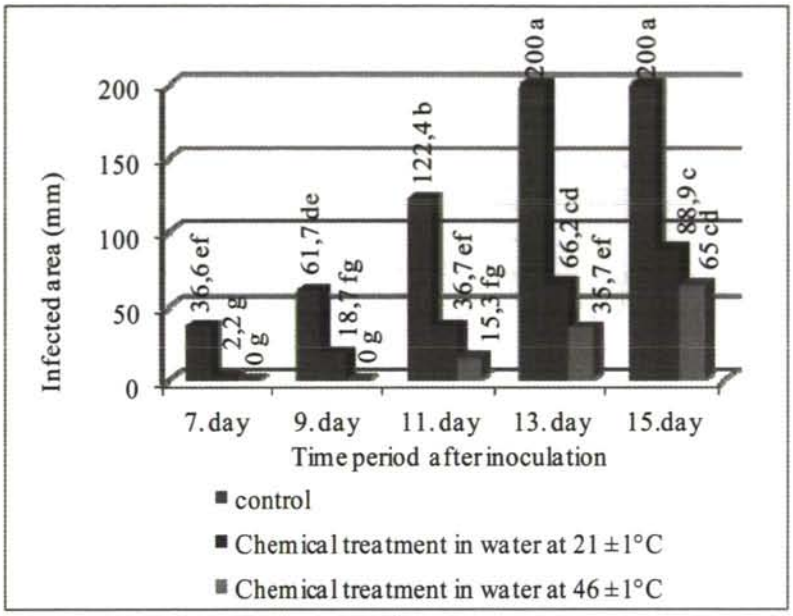

Figure 1. Improvement of green mold on orange storage as infected area

Infected area increased rapidly after the 7th day of innoculation. However, this increase was slower in treated fruits (*Fig. 1*). No significant difference was fixed between fruits treated at different water temperatures. However, significant difference between treated and untreated fruits was determined (p=0,01). Furthermore, significant difference between treatment temperatures was fixed on the 13th day after innoculation (*Fig. 1*). The combination of three chemicals prevented the growth of green mold on orange fruits during 15 days storage (*Table 1*). The level of effect increased with dipping water temperature.

Table 1. Effects of chemical mixture on green mold caused by *P. digitatum* on orange fruits (%)

Time period after inoculation	Chemical treatment in water at 21 ±1°C	Chemical treatment in water at 46 ±1°C
7. day	94.0 a	100 a
9. day	69.7 ab	100 a
11. day	70.0 bc	87.5 ab
13. day	66.9 de	82.2 bc
15. day	55.6 e	67.5 de

Brown rot (*Phytophthora citrophthora*)
Control fruits inoculated with *Phytophthora citrophthora* were all infected on the 9th day. However, 11% of the fruits treated at 21±1 °C and 7% of the fruits treated at 46±1 °C were infected in the same period. Furthermore, 51% of the fruits treated at 21±1 °C and 37% of the fruits treated at 46±1°C were infected on the 15th day after innoculation. The improvement of brown mold was at highest level in control fruits compared to treated fruits. The difference was found to be significant (p<0.01) (*Fig. 2*).

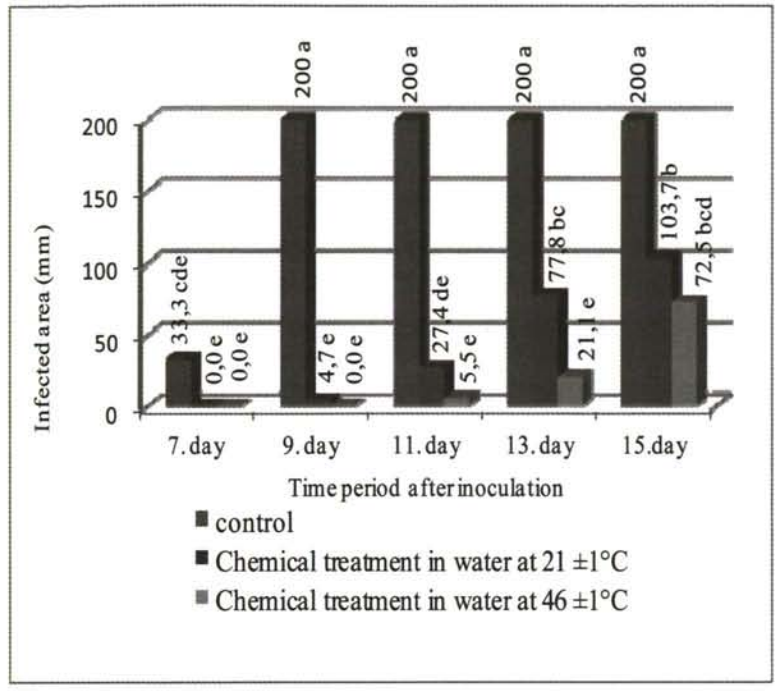

Figure 2. Improvement of brown rot on orange storage as infected area

The maximum level of infected area in control fruits was materialized on the 9th day. The area on the treated fruits was significantly lower ($p<0.01$). Moreover, minimum infected area was found on fruits treated at 46±1 °C (*Fig. 2*). Combined treatments were found to be protective againts brown rot during the whole storage (*Table 2*).

Table 2. Effects of chemical mixture on brown rot caused by *P. citrophthora* on orange fruits

Time period after inoculation	Chemical treatment in water at 21 ±1°C	Chemical treatment in water at 46 ±1°C
7. day	100 a	100 a
9. day	97.6 a	100 a
11. day	86.3 ab	97.2 a
13. day	61.1 cd	89.4 a
15. day	48.2 d	63.8 abc

The difference of effects between treatment temperatures became visible by the 13th day after innoculation. Thus, the treatment at 46±1 °C was found to be more effective. (*Table 2*).

Sour rot (*Geotrichum candidum*)

The infection rate of control fruits achieved 81% on the 9th day after innoculation. Besides all fruits became infected with *G. candidum* after 13 days. However the spread of infection reduced with treatments. Thus, the rate of infection was 19% on fruits treated at 21±1°C on the 9th day and increased to 44% till the 15th day after innoculation. Similar and more visible results were determined on the fruits treated at 46 ±1 °C. In this context the rate of infection was 7% on the 9th day and 11% on the 15th day. The symptoms became visible on the 7th day after inoculation. The infected area was determined at higher levels significant in control fruits ($p<0.01$) (*Fig. 3*).

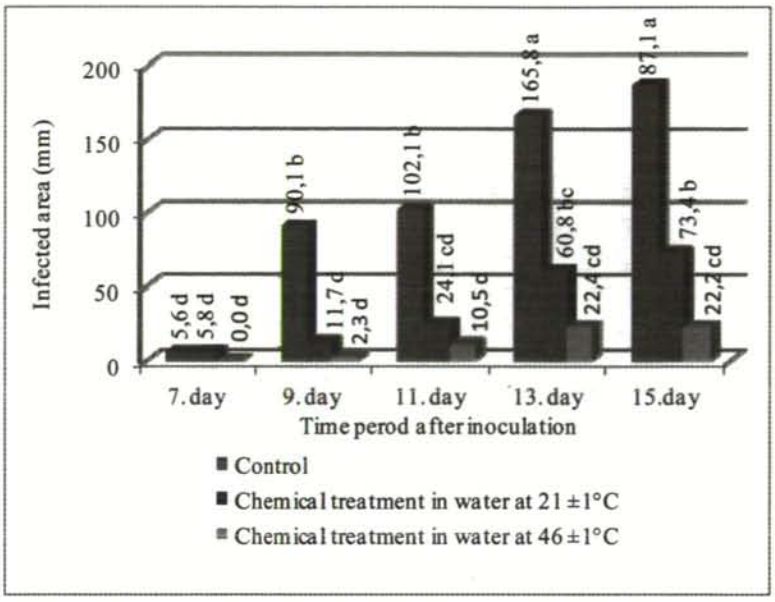

Figure 3. Improvement of sour rot on orange storage as infected area

The increase of the infected area in control fruits was similar to that of the treated fruits until the 7th day. However, a significant difference occured by the 9th day ($p<0.01$). Furthermore, no significant difference was determined between treatment temperatures until 13 days. Besides, significant difference in infected area between treatment temperatures was determined on the 15th day ($p<0.01$) (*Fig. 3*).
Combined treatment affected the growth of sour rot during 15 days of storage (*Table 3*). Furthermore, significant difference between treatment temperatures occured 15 days after inoculation ($p<0.01$). The most effective treatment temperature was found as 46 ±1 °C.

Table 3. Effects of chemical mixture on sour rot caused by *Geotrichum candidum* on orange fruits (%)

Time period after inoculation	Chemical treatment in water at 21 ±1°C	Chemical treatment in water at 46 ±1°C
7. day	0 d	100 a
9. day	87.0 a	97.4 a
11. day	76.4 ab	89.7 a
13. day	63.3 bc	86.5 ab
15. day	60.8 c	88.1 ab

DISCUSSION AND CONCLUSION

Pathological disorders cause significant postharvest losses (KLEIN AND LURIE, 1991). Synthetical fungicides are used to prevent these losses, however residues are the main problems including these treatments (ECKERT AND OGAWA, 1988; WILSON ET AL., 1994). Thus, alternative chemicals and usages are found againts postharvest pathological disorders without residues.
Penicillium digitatum, *Phytophthora citrophthora* and *Geotrichum candidum* are the main fungi of orange in the postharvest period.
In this research, the semi *in vivo* effect of Xedabio, KPhos and Xedathane combination was determined. Xedabio including clove oil is a natural compound used againts postharvest molds in citrus, stone fruits and pome fruits. Besides, it can be combined with synthetic

fungicides. Xedathane includes prymethanil and was found effective againts grey mold in many fruit and vegetable species (HINTON AND INGRAM, 2005). In addition, potassium phosphite (KPhos) was found effective againts green mold (*P. digitatum*), blue mold (*P. italicum*), phomopsis and *Alternaria citri*, respectively.

In this research, the combination of Xedabio, KPhos and Xedathane at different water dipping temperatures such as 21 ±1 °C and 46 ±1 °C prevented green mold, brown rot and sour rot significantly during 15 days of storage. The effect of combined treatment increase with hot water treatment, however combination of Xedabio, KPhos and Xedathane prevented these pathological disorders even at 21 ±1°C.

According to the results, combined treatment of Xedabio (1.5%) + KPhos (0.5%) + Xedathane (0.25%) prevented and reduced the spread of *Penicillium digitatum*, *Phytophthora citrophthora* and *Geotrichum candidum* in orange fruits without residue problem. Thus, the treatment including this combination can be used in fruit industry.

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