

# UV-C Radiation Effect on the Mortality of Fruit Fly Eggs

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## ABSTRACT

The current work evaluate death kinetics of *Ceratitis capitata* eggs immersed in water and subjected to different doses of UV-C radiation: 0 (Control); 0.087; 0.261; 0.348; 0.461; 0.692; 0.922; 1.384; 4.152; 5.534 and 8.302 kJ m<sup>-2</sup>. After treatments, eggs placed in Petri dishes were incubated at 25°C under light/darkness or in complete darkness. One day after treatments, egg survival was microscopically evaluated. Doses of 1.384 kJm<sup>-2</sup> UV-C or higher led to 100% death of *C. capitata* eggs incubated in a light/darkness cycle.

**Keywords:** Mediterranean fruit fly, postharvest, quarantine treatments, Brazil

## 1. INTRODUCTION

The Mediterranean fruit fly (Diptera - Tephritidae), *Ceratitis capitata* (Weid., 1824), is widespread throughout the five Continents, and it is considered a high invasive colonizing species due to its ability to adjust to diverse climate conditions and hosts, high reproductive performance and quick-spreading faculty (RAGA, 1996). Tephritidae family is one of the biggest within the Diptera order, with 500 genera and approximately 4.000 described species. This family is among those which heavily impacts fruit production worldwide, since it attacks the reproductive plants organs, flowers and fruits. This fact obviously results in economical damage to fruit producers around the world. Currently, about 1 billion dollars/year are lost due to direct damages on fruit production, trade and subsequent sanitary barriers in international trade (SILVA & BATISTA, 2009).

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Stella Vieira; Perla Gómez; Benedito Benedetti, Francisco Artés. “UV-C radiation effect on the mortality of fruit fly eggs”. International Commission of Agricultural and Biological Engineers, Section V. Conference “Technology and Management to Increase the Efficiency in Sustainable Agricultural Systems”, Rosario, Argentina, 1-4 September 2009. The authors are solely responsible for the content of this technical presentation. The technical presentation does not necessarily reflect the official position of the International Commission of Agricultural and Biosystems Engineering (CIGR), and its printing and distribution does not constitute an endorsement of views which may be expressed. Technical presentations are not subject to the formal peer review process by CIGR editorial committees; therefore, they are not to be presented as refereed publications.

Since it is a plague subjected to quarantine rules, there are commercial barriers imposed by importing countries, mainly those who are fruit fly-free zones, limiting fresh-fruits exports. Good and sustainable agricultural practices implies a rational and exclusive use of chemicals officially allowed for each fruit, obeying withdrawal periods, environment protection, analysis of residues and proper harvest and post-harvest handling practices (IBRAF, 2007).

Due to trade barriers and a shift in the world wide trend concerning safe and residue-free food production, plague control by physical alternatives instead of agrochemicals applications has been widely investigated during the past decade, since it is safer for the environment and human beings (VIEIRA, 2004; ARRUDA et al., 2004). Several physical techniques like application of heat, cold, ionizing and non ionizing (UV-C) radiation, in association with modified atmospheres, maturity inhibitors and refrigerated storage have been developed and improved as postharvest treatments in order to support quality requirements of fruit and vegetables importing countries (ALLENDE and ARTÉS, 2003; VICENTE et al., 2006; PINHEIRO et al., 2005).

The UV-C radiation is an effective technique for mold disinfection and fruit and vegetables preservation, due to its germicide properties - basically consisting in destroying microbial DNA and protein denaturation - leading to a longer shelf life of fresh intact as well as minimally processed products (AGUAYO et al., 2007). It also has the great advantage of not producing any unwanted co-products, adverse for the environment and the human consumption. Moreover, it does not stimulate the synthesis of unwanted byproducts that might change sensorial characteristics (flavor, odor, and color) of final products (GUERRERO-BELTRÁN et al., 2004). However, little is known about its effects on insects for quarantine purposes.

The UV-C light has been widely tested as an alternative to chlorine for disinfection of minimally processed fruit and vegetables (ARTES et al., 2009). The UV-C light may also be used to inactivate several kinds of dangerous organisms in processed food, increasing its shelf life, and also in pharmaceuticals, electronics, and to disinfect and purify drinking water. However, no references about the use of UV light to destroy fruit flies or any other quarantine plagues have been found. Thus, the objective of this work was to evaluate the effects of several increasing UV-C light doses on *C. capitata* eggs mortality.

## 2. METHODOLOGY

This experiment was performed at the Pilot Plant for Food Engineering of the Technical University of Cartagena, Murcia (Spain). The *C. capitata* eggs were obtained from mass rearing already carried out at the Instituto Murciano de Investigación y Desarrollo Agrario y Alimentario (IMIDA, Murcia, Spain).

The UV-C equipment consisted of two batches of 15 reflectors with unfiltered germicidal emitting lamps (TUV 36W/G36 T8, Philips, 139 Holland) fixed to a chamber frame. One batch was horizontally suspended on the top of the radiation chamber and the other one was placed below it. The Petri dishes were placed between both lines of UV-C lamps (15 cm of distance) over a polystyrene net. Walls of the experimental chamber were protected with a reflecting inner layer, which enhanced homogeneous distribution of the emitted light and allowed indirect illumination of practically the whole dishes. In order to determine the UV-C radiation intensity of the

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lamps, a VLX 254 radiometer (Vilber 146 Lourmat, Marne la Vallée, France) was used (LOPEZ-RUBIRA et al., 2005). The applied UV-C intensity was calculated from a mean of 18 readings taken at each side of the net. Light intensity was kept constant, and the applied doses varied by modifying the exposure time (ARTES-HERNANDEZ et al., 2009). Eggs were exposed to the following UV-C radiation treatments 0 (control); 0.087; 0.261; 0.348; 0.461; 0.692; 0.922; 1.384; 4.152; 5.534 and 8.302 kJ m<sup>-2</sup>. Twenty replicates were evaluated for each treatment, each one containing twenty eggs, selected with an electronic microscope (Olympus SZ40, Japan), with maximum 48 hours of age, being placed in Petri dishes and immersed in 20 ml of distilled water. After each UV-C treatment, half of the Petri dishes (20) were stored in presence of light (12 h light, 600 lux m<sup>-2</sup>-12 h darkness) while the other half (20) were stored in total absence of light (24 h darkness), at 25 °C. Twenty-four hours after treated, samples were evaluated for egg mortality, using a stereoscope microscope (Olympus SZ61, Japan) provided with a photographic camera (Olympus Altra 20, Japan).

The experiment followed a complete randomized factorial design. Data were submitted to analysis of variance (ANOVA), at 5 % significance level (P = 0.05). Means were contrasted using the Tukey's test. The analysis was performed using the statistical software Infostat version 1.0.

### 3. RESULTS AND DISCUSSION

As main result the application of UV-C light was lethal for the fly fruit eggs, the higher the doses, the higher the level of dead eggs (Fig. 1). In fact, significant higher egg viability in control (T1) than in the rest of treatments was found. All control eggs and some of the lower than 1.384 kJ m<sup>-2</sup> treated ones hatched and became larvae of first stage after 24 h (Fig. 2-B). From the best of our knowledge, results on the effect of UV-C non-ionizing radiation on fruit fly eggs mortality are firstly reported here. For comparison, when the ionizing gamma radiation was applied the increasing destructive effect of increased radiation levels has been previously found (WALDER, 1993; ARTHUR & WIENDL, 1994; RAGA, 1996).

Besides the effect of UV-C dose, an interaction between radiation doses and storage conditions (light or darkness) on the mortality of *C. capitata* eggs was found (Table 1). For control fly eggs, a period of darkness increased their mortality. However, the effect of light was not significant when UV-C light was applied, and eggs died independently of the light conditions.

## RADIATION UV-C EFFECT IN THE MORTALITY OF THE FRUIT FLY EGGS

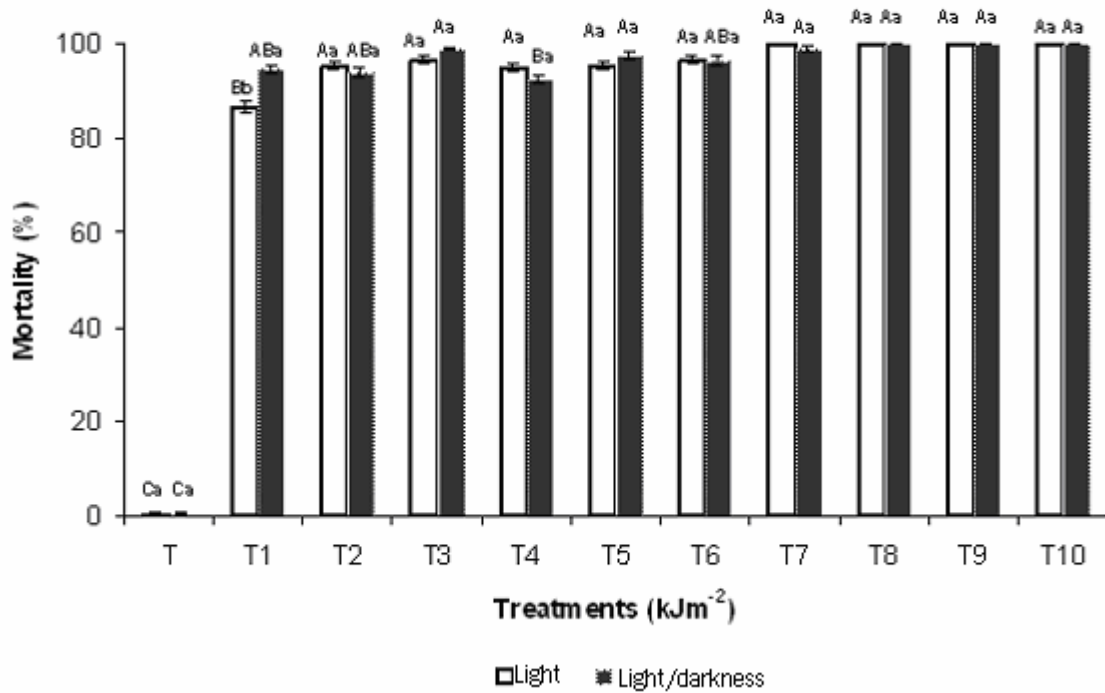


Figure. 1. *Ceratitis capitata* egg mortality when submitted to different UV-C radiation doses and distinct light conditions after 24 h storage. T: 0 (control); T1: 0.087; T2: 0.261; T3: 0.348; T4: 0.461; T5: 0.692; T6: 0.922; T7: 1.384; T8: 4.152; T9: 5.534 and T10: 8.302 kJ m<sup>-2</sup>. Values followed by different letter were different significantly by Tukey's test at 5 % significance level (P = 0.05), Capital letters compare radiation levels and low-case letters indicate light condition.

Table 1. Analysis of variance of *C. capitata* eggs mortality subjected to different UV-C treatments and stored during 24 h at 25°C with or without light.

Source	SS	df	MS	F	p
<b>MODEL</b>	6852.48	21	326.31	668.14	<0.0001
<b>UV-C.</b>	6835.73	10	683.57	1399.66	<0.0001
<b>LIGHT</b>	1.02	1	1.02	2.09	0.1494
<b>UV-C x LIGHT</b>	15.73	10	1.57	3.22	0.0007
<b>ERROR</b>	96.70	198	0.49	-	
<b>TOTAL</b>	6949.18	219	-	-	

SS – Square sum, df - degrees of freedom, MS - Mean square, F - F value, p - significance level.

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Egg mortality by  $1.384 \text{ kJ m}^{-2}$  UV-C (Fig. 2) or higher, followed preferably by 24 h storage under light was fully effective, killing 100% of eggs and reaching the level (99.9968%) required by legal regulations of most importing countries free of fruit flies (MENDONÇA et al., 2000). Based on these findings it could be hypothesized that *C. capitata* eggs are not able to support degenerative damage caused by this UV-C radiation level. Below that dose, there is also high egg mortality, but some of the eggs are able to survive.

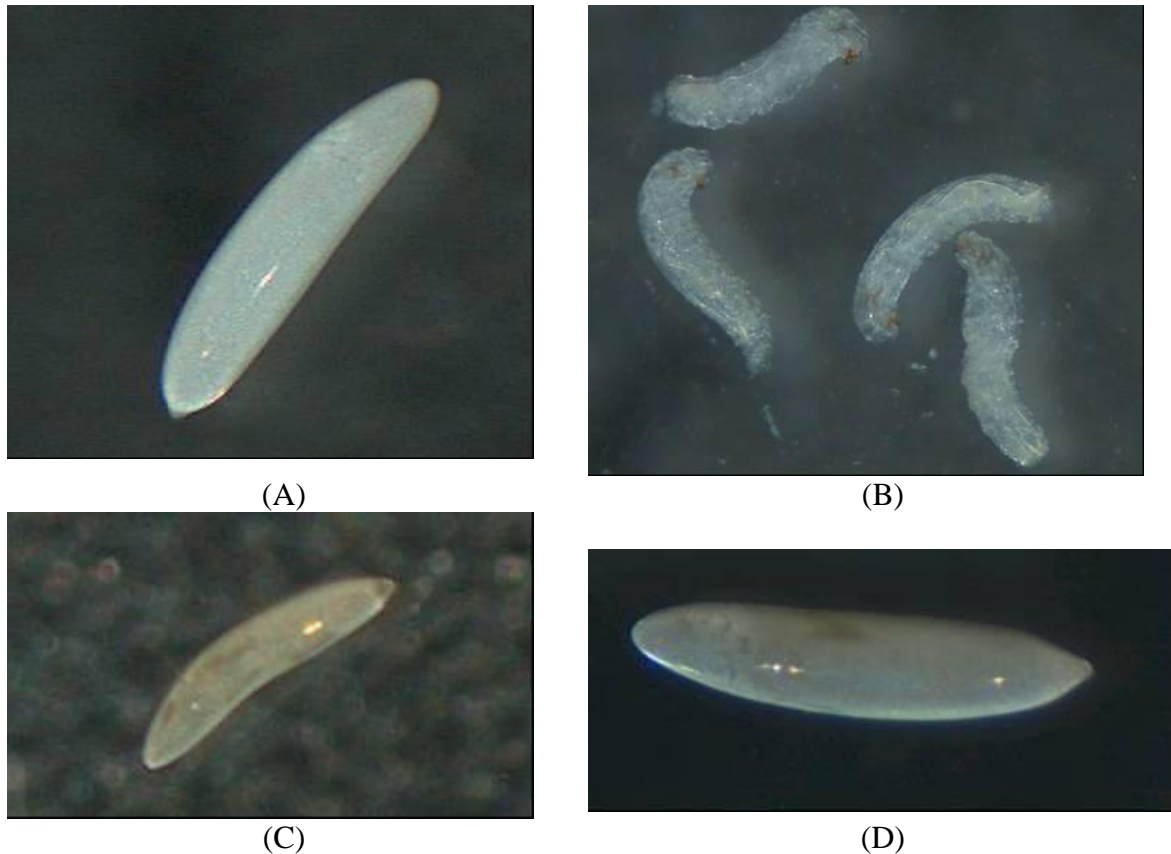


Figure 2. A - healthy eggs (before UV-C treatments); B - emerged larvae from T1 (control); C and D - dead eggs after 24 h of  $1.384 \text{ kJm}^{-2}$  UV-C radiation in the light storage.

#### 4. CONCLUSIONS

The UV-C radiation at  $1.384 \text{ kJm}^{-2}$  or higher was a very efficient treatment to destroy *Ceratitis capitata* eggs incubated in an aqueous media. The use of UV-C light could be an economically viable promising technique for avoiding at 100% *C capitata* viability, and very probably for other fruit flies. When compared to other quarantine treatments UV-C light could be considered as more efficient and environmentally safer. Further studies should be conducted in order to evaluate mortality of the fly eggs in infested fruits, for demonstrating the *in vivo* efficacy of UV-C radiation at low levels as a quarantine treatment.

## 5. ACKNOWLEDGEMENTS

Thanks are due to V. Quinto (IMIDA, La Alberca, Murcia, Spain), to Profs. Pablo Bielza and Dina Cifuentes (Crop Protection Group, Technical University of Cartagena), and to Mariano Otón and Pedro Robles (Postharvest and Refrigeration Group, Technical University of Cartagena).

## 6. REFERENCES

- AGUAYO, E.; ESCALONA, V.H.; GÓMEZ, P.; ARTÉS-HERNÁNDEZ, F.; ARTÉS, F. Técnicas Emergentes y Sostenibles para la Desinfección de Frutas y Hortalizas Mínimamente procesadas. *Phytoma*. n.189, p.138-146, 2007.
- ALLENDE, A.; ARTÉS, F. Combined ultraviolet-C and modified atmosphere packaging treatments for reducing microbial growth of fresh processed lettuce. *Food Research Internat.*, n.36, p. 779-786, 2003.
- ARTÉS, F.; GÓMEZ, P.; ARTÉS-HERNÁNDEZ, F.; AGUAYO, E.; ESCALONA, V.H. Sustainable sanitation techniques for keeping quality and safety of fresh-cut plant commodities. *Postharvest Biol. Technol.* n. 51. p. 287–296, 2009.
- ARTÉS-HERNÁNDEZ, F.; ESCALONA, V.H.; ROBLES P.A.; MARTÍNEZ-HERNÁNDEZ, G.B.; ARTÉS, F. Effect of UV-C radiation on Quality of Minimally Processed Spinach Leaves. *J. Sci. Food Agric.* n.89, p. 414-421, 2008.
- ARTHUR, V.; WIENDL, F.M. Desinfestação de *Averrhoa carambola* (Macquart, 1835) (Diptera, Thphridae) a través de Radiação Gama. *Scientia Agrícola* v.51, n.2, p. 216-221, 1994.
- ARRUDA, M.C. de; JACOMINO, A.P. SPOTO, M.H.F. Conservação de Melão Rendilhado Minimamente Processado Sob Atmosfera Modificada Ativa. *Ciência e Tecnologia de Alimentos*, v. 24, n. 1, p. 53-58, 2004.
- CORCORAN, R.J. Heat-Mortality Relationships for Eggs of *Bactrocera Tryoni* (FROGGATT) (Diptera, Thphridae) at Varying Ages. *J. Aust. Ent. Soc.* v.32, p.307-310, 1993.
- DÓRIA, H.O.S.; BORTOLI, S.A.de; ALBERGARIA, N.M.S de. Influência de Tratamentos Térmicos na Eliminação de *Ceratitis capitata* em Frutos de Goiaba (*Psidium guajava* L.). *Acta Scientiarum Agronomy*, Maringá, v.26, n.1, p.107-111, 2004.
- GUERRERO-BELTRÁN, J.A.; BARBOSA-CÁNOVAS, G.V. Review: Advantages and Limitations on Processing Foods by UV Light. *Food Sci. Technol. Int.*, v.10, p.137-147, 2004.
- LOPES, E.B.; BRITO, C.H.de; BATISTA, J. de L.; ALBUQUERQUE, I.C. Tratamento Hidrotérmico no Controle de Larvas de *Ceratitis capitata* em frutos de Tangerina. *Tecnol. & Ciên. Agropec.*, João Pessoa – PB, v.2, n.2, p.23-28, jun., 2008.
- LURIE, S.; JEMRIC, T.; WEKSLER, A.; AKIVA, R.; GAZIT, Y. Heat Treatment of ‘Oroblanco’ Citrus Fruit to Control Insect Infestation. *Postharvest Biol. Technol.* v.34, p. 321-329, 2004.
- MENDONÇA, M. da C.; NASCIMENTO, A.S.; CALDAS, R.C.; PEREIRA-FILHO, C.A. Efeito do Tratamento Hidrotérmico de Mangas na Mortalidade de Larvas de *Ceratitis capitata* (WIEDL.) (Diptera, Thphridae). *Soc. Entomol. Brasil.* v.29, n.1, 139-145 mar., 2000.

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- PINHEIRO, A.C.M.; VILAS BOAS, E.V. de B.; MESQUITA, C.T. Ação do 1-metilciclopropeno (1-MCP) na Vida-de-Prateleira da Banana ‘Maçã’. Rev. Brasileira de Fruticultura, v.27, n.1, p.25-28, 2005.
- RAGA, A. Sensibilidade de Ovos de *Ceratitis capitata* (WIED., 1824) Irradiados em Dieta Artificial e em frutos de manga (*mangifera indica* L.). Scientia Agrícola, v.53, n.1, jan/abr., 1996.
- RODRÍGUEZ-HIDALGO, S.; GÓMEZ, P.; BOLUDA, M.; ARTÉS-HERNÁNDEZ, F.; ARTÉS, f. Ozono y Radiación UV-C como Alternativas al Cloro para desinfectar Espinaca “Baby” Mínimamente Processada Cultivada en Bandejas Flotantes con dos Abonados. Actas IX Simposio Nacional y VI Ibérico sobre Maduración y Poscosecha, Zaragoza. Editorial Acribia, S.A. Royo, n. 23, sept., 2008.
- SILVA, A.B. da; BATISTA, J. de L. Mosca-das-Frutas: Uma Ameaça a Fruticultura. Artigo Técnico- Grupo Cultivar de Publicações LTDA.  
<<http://www.grupocultivar.com.br/artigos/artigo.asp?id=796>>> acesso em: 05/12/2008.
- THOMAS, D.B.; MANGAN, R.L. Morbidity of the Pupal Stage of the Mexican and West Indian Fruit Flies (DIPTERA: THPHRIDAE) Induced by Hot-Water Immersion in the Larval Stage. Florida Entomologist, v.78, n.2, p. 235-246, 1995.
- WALDER, J.M.M. Effects of gamma Radiation on the Sterility and behavioral Quality of the Caribbean Fruit Fly, *Anastrepha suspensa* (LOEW) (Diptera, Thphridae). Scientia Agrícola, v.50, n.2, 1993.
- VICENTE, A.R.; MARTÍNEZ, G.A.; CHAVES, A.R.; CIVELLO, P.M. Effect of Heat Treatment on Strawberry Fruit Damage and Oxidative Metabolism During Storage. Postharvest Biol. Technol, n.40, p.116-122, 2006.
- VIEIRA, S.M.J. Qualidade Pós-Colheita de Goiaba Submetida ao Tratamento Hidrotérmico. 39p. Dissertação (Mestrado em Engenharia Agrícola) – Universidade Federal de Viçosa, 2004.

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