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Thermal resistance of fifth-instar *Cydia pomonella* (L.) (Lepidoptera: Tortricidae) as affected by pretreatment conditioning

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Abstract

Codling moth (*Cydia pomonella* (L.)) is targeted for postharvest control by quarantine regulations in Japan and South Korea and by phytosanitation concerns in Europe. Heat treatments may be used to control *C. pomonella*. But possible increase of heat resistance in insect pests, caused by pretreatment thermal conditions during harvest and storage periods, may compromise the efficacy of subsequent thermal treatments. A heating block system was used to determine the effect of pretreatment conditioning on the thermal resistance of the fifth-instar *C. pomonella*. Results showed that pretreatment conditioning at 35 °C for 40, 120, 360 or 1080 min significantly increased the thermal resistance of *C. pomonella*. Among the above conditions 35 °C for 360 min resulted in the highest heat resistance for fifth-instars. The minimum treatment times required to reach 100% mortality for 300 larvae that went through thermal conditioning at 35 °C for 360 min were 30, 7 and 3 min at 48, 50 and 52 °C, respectively, as compared with 15, 5 and 2 min at those temperatures without pretreatment conditioning. After a pretreatment at 35 °C for 360 min followed by a period of at least 120 min at 22 °C, fifth-instar thermal resistance returned to the level that had existed before pretreatment conditioning.

Keywords: Codling moth; Heating block; Pretreatment conditioning; Quarantine; Thermal death resistance; Recovery

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1. Introduction

Heat treatments are increasingly used or are being considered as an alternative control measure to provide quarantine security against insect pests in fresh and stored agricultural commodities in the wake of consumer concerns over the use of chemical treatments. The heating methods include forced hot air (Armstrong et al., 1989; Sharp, 1992), hot water (Yokoyama et al., 1991; Jones and Waddell, 1997), vapour heat (Hansen et al., 1992; Shellie and Mangan, 1994), microwaves (Ikediala et al., 1999), and radio frequency (RF) energy (Tang et al., 2000; Wang et al., 2001, 2002c). The most important variables for heating methods are target temperature and exposure time, which are predetermined in efficacy tests defining insect thermal resistance and thermal death kinetics under laboratory conditions. However, test insects are usually maintained at room temperature (20–25 °C) for at least 12 h before mortality studies. This general base-line information on insect mortality is widely used in developing thermal treatment protocols. Deviation of harvest and storage conditions from 20 to 25 °C prior to treatments may alter the efficacy of the treatments because the minimum time-temperature combinations required to kill certain insect populations may change with pretreatment conditions at sub-lethal warm temperatures (Jang, 1992; Waddell et al., 2000).

Codling moth larvae, *Cydia pomonella* (L.) (Lepidoptera: Tortricidae), are important cosmopolitan insect pests, and feed on many nuts and fruits (Barnes, 1991; Wearing et al., 2001; Hansen et al., 2002). *Cydia pomonella* is also an important target of quarantine regulations in Japan and South Korea and of phytosanitation concerns in Europe. To meet the quarantine requirements, all development stages of *C. pomonella* need to be killed by the thermal treatments. Based on previous studies (Wang et al., 2002a, 2004) on thermal lethality of *C. pomonella* using the heating block system, fifth-instars are the most heat tolerant stage, as also found by Yokoyama et al. (1991).

Increased heat resistance following exposure to sub-lethal temperatures between 32 and 42 °C, has been observed in *Drosophila* sp. (Feder et al., 1996), tephretid fruit flies (Jang, 1992; Beckett and Evans, 1997; Waddell et al., 2000), flesh flies (Yocum and Denlinger, 1992), and lightbrown apple moths, *Epiphyas postvittana* (Walker) (Lepidoptera: Tortricidae), (Lester and Greenwood, 1997). Hallman (1994) observed that third instars of the Caribbean fruit fly, *Anastrepha suspensa* (Loew) (Diptera: Tephritidae), reared at 30 °C, were significantly more heat tolerant than those reared at 20 °C. Lester and Greenwood (1997) reported that the lethal time for 99% mortality for fifth-instar lightbrown apple moths increased from 23 min without pretreatment thermal conditioning to 37 min after 8 h at 35 °C. Hallman and Mangan (1997) cautioned that field temperatures of infested fruits might alter the efficacy of quarantine heat treatments, which were developed using laboratory insects reared at constant temperatures. As a result, thermal conditioning of insects caused by warm weather may compromise the effectiveness of the treatment because of the increased insect heat resistance. It is important to determine the enhanced heat resistance of targeted insects as affected by various pretreatment conditions. Currently, there are no reported data about the effect of pretreatment conditions on heat resistance of *C. pomonella*.

Heat resistance of thermally conditioned fruit flies reverted to the level that existed before pretreatment conditioning within 2–3 h after return to 26 °C (Jang, 1992). If applicable to *C.*