



Survival of Queensland fruit fly *Bactrocera tryoni* (Froggatt) (Diptera: Tephritidae) in apples treated with essential oils and cold storage



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ABSTRACT

Little is known on the fumigant effects of essential oils on the immature stages of fruit flies (eggs and larvae). The present study aimed to investigate effects of fumigation with essential oil alone or followed by cold storage on the survival of Queensland fruit fly *Bactrocera tryoni* in Gala apples. Efficacy was based on the number of pupae recovered from treated and untreated fruits and on phytotoxic effects. In a 24 h fruit fumigation test, peppermint oil applied at 100 and 200 $\mu\text{L/L}$ air was found to be active against *B. tryoni* eggs, whereas broad-leaved peppermint oil was active against both eggs and larvae but only at the highest dose tested (200 $\mu\text{L/L}$ air). However, both peppermint and broad-leaved peppermint oils sometimes had a phytotoxic effect on the apples. In a 6 h fruit fumigation test, an equal mixture of peppermint and broad-leaved peppermint oil (100 $\mu\text{L/L}$ air) did not cause phytotoxic effect but had only a slight effect on *B. tryoni* eggs and no effect on the larvae. There was no synergism or additive effect when this essential oil mixture was applied in combination with subsequent cold storage. These results indicate that peppermint oil and broad-leaved peppermint oil have little potency for Gala apple fumigation since they were only effective at doses and durations of exposure which were phytotoxic to fruit. On the other hand, cold storage (4 ± 1 °C) alone was confirmed to be a very effective treatment against *B. tryoni* larvae and eggs in Gala apple without causing fruit damage and was not enhanced by prior fumigation with these oils.

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1. Introduction

Plant essential oils are among natural products that have potential to be developed as fumigants. They have been reported to have fumigant effects on a number of postharvest as well as preharvest insect pests (Yi et al., 2006; Rajendran and Sriranjini, 2008; Kimbaris et al., 2010). In direct exposure (in vitro) testing of eight potentially active essential oils, peppermint (*Mentha piperita*) was the most efficacious on eggs whereas broad-leaved peppermint (*Eucalyptus dives*) was the most efficacious on larvae of Queensland fruit fly *Bactrocera tryoni* (Froggatt) (Hidayat et al., 2013). However, the fumigant effect of an essential oil on fruit fly eggs and larvae in the infested fruits is apparently untested.

Peppermint, *M. piperita* is a herb plant belonging to the family Labiatae (Small, 2006). Its essential oil, which is rich in menthol, is a popular flavouring agent for foods such as sweets and chewing gum and for oral health care products such as toothpaste and

mouthwashes. This essential oil is also used in alternative medicines (Keifer et al., 2007). Broad-leaved peppermint, *E. dives* is a medium sized tree (Boland et al., 2006) with a strong peppermint odour from the crushed leaves (Brooker and Kleinig, 2006). The essential oil of this Australian native plant contains large amount of piperitone (Bignell et al., 1998; Delaquis et al., 2002; Weber et al., 2006; Gilles et al., 2010), which is a raw material in the production of synthetic menthol (Leffingwell and Shackelford, 1974). Not much is known of the medicinal properties of this essential oil, but there have been reports on its antimicrobial activities (Delaquis et al., 2002; Gilles et al., 2010).

Methyl bromide is currently the most widely used fumigant for phytosanitary purposes (Heather and Hallman, 2008) including disinfestation of tephritid fruit flies in fresh fruits (Armstrong, 1992; Hallman and Thomas, 2011; Dominiak and Ekman, 2013). Methyl bromide is known to have strong penetrative ability and to be tolerated by many commodities (Follett and Neven, 2006). However, under the Montreal protocol due to its ozone depleting effects, the production and usage of methyl bromide has been scheduled to be phased out in developed countries (with few exemptions) by 1 January 2005 and by 1 January 2015 in

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