Industrial Crops and Products 81 (2016) 147–151

Contents lists available at ScienceDirect

Industrial Crops and Products

journal homepage: www.elsevier.com/locate/indcrop

Short communication

Fumigant toxicity of monoterpenes against fruitfly, *Drosophila melanogaster*

Zhilin Zhang[a], Ting Yang[a], Yike Zhang[b], Lihua Wang[a], Yongjian Xie[b,*]

[a] Hubei Key Laboratory of Quality Control of Characteristic Fruits and Vegetables, Hubei Engineering University, Xiaogan 432000, Hubei, PR China
[b] The Key Laboratory for Quality Improvement of Agricultural Products of Zhejiang Province, School of Agricultural and Food Science, Zhejiang A&F University, Linan 311300, Zhejiang, PR China

ARTICLE INFO

Article history:
Received 27 August 2015
Received in revised form 25 October 2015
Accepted 27 November 2015
Available online 10 December 2015

Keywords:
Drosophila melanogaster
Monoterpenes
Fumigant
Essential oils
(±)-Citronellal
(+)-Pulegone

ABSTRACT

Monoterpenes are the major components of essential oils from many aromatic plants, partly contributed to the insecticidal properties of essential oils. In this study, the fumigation activity of 40 pure monoterpenes against fruitfly, *Drosophila melanogaster*, were evaluated. Results from fumigation tests revealed that terpinolene, 3-carene, eugenol, thymol, carvacrol, isoeugenol, citral, (±)-citronellal, cuminaldehyde, (−)-verbenone, and (+)-pulegone exhibited strong fumigation activity against *D. melanogaster*. In addition, the (±)-citronellal and (+)-pulegone (aldehydes and ketones) were the most toxic monoterpenes to *D. melanogaster* with LC_{50} values of 0.015 and 0.02 μl/L, respectively. Oxygenated monoterpenes were found to be with higher toxicity as compared with monoterpene hydrocarbons. The present results indicated that (±)-citronellal and (+)-pulegone exhibit a potential for the development of new botanical insecticides against the *D. melanogaster*, suggesting that further studies of a number of medically important dipterans might be warranted.

1. Introduction

Due to essential oils with low mammalian toxicity, fully biodegradable, multifunctional and environmentally safe, there is increasing interest in research concerning with the naturally occurring toxicants from plants as new alternative pesticides. Insecticidal properties of numerous essential oils and some monoterpenes have been extensively studied against various insect species (Kordali et al., 2006, 2007; Abdelgaleil et al., 2009; Abdelgaleil, 2010; Santos et al., 2011; Zahran and Abdelgaleil, 2011; Xie et al., 2014; Bougherra et al., 2015; Mansoura et al., 2015; Peixoto et al., 2015).

Dipteran pests (mosquitoes and flies), one of the most common insects in human settlements, play a predominant role in the transmission of some important diseases which are today among the greatest health problems in the world (Hemingway, 2004; Malik et al., 2007; Kumar et al., 2012a). In recent years, due to global warming, populations of mosquitoes and flies have increased significantly, and much effort has been focused on exploring bioactive chemical compounds from plants for mosquitoes and flies control (Prajapati et al., 2005; Omena et al., 2007; Cheng et al., 2008, 2009; Garcez et al., 2009; Pavela, 2009, 2013; Kumar et al., 2012a,b,c; 2013, 2014). Despite a large number of studies on the insecticidal activity of essential oils against mosquitoes and flies, but the monoterpenes compounds, as one component of essential oil, had been less explored against mosquitoes and flies.

This research examined passively volatile monoterpenes hydrocarbons and oxygenated monoterpenes using the model insect *Drosophila melanogaster* Meig. It is typically used because it is easy to care for, has four pairs of chromosomes which had been well-defined, breeds quickly, and lays many eggs. *Drosophila* is also highly amenable to large-scale insecticide screening operations; it is physiologically, biochemically and genetically similar to mosquitoes and flies of medical importance. Thereby *Drosophila* is suitable for screening of volatile insecticides for activity against pests, such as those that pose a threat to public health (e.g., dipterans such as flies and mosquitoes) (Constant et al., 2004; Scharf et al., 2006). Therefore, *Drosophila* provides an excellent model system with which to assess experimental fumigant insecticides for their potential to control and medically important dipterans.

This study investigated the toxicity 40 monoterpenes from six families against mosquitoes and flies, obtained using a novel *D. melanogaster* testing system. The objectives of this research were: (1) to identify compounds with high toxicity against the *D. melanogaster*, (2) to assess structure-activity relationships among the chemicals. In this paper, several highly effective monoterpenes were identified, and provided a rationale for pursuing further stud-

* Corresponding author.
E-mail address: yjxie@zafu.edu.cn (Y. Xie).

http://dx.doi.org/10.1016/j.indcrop.2015.11.076
0926-6690/

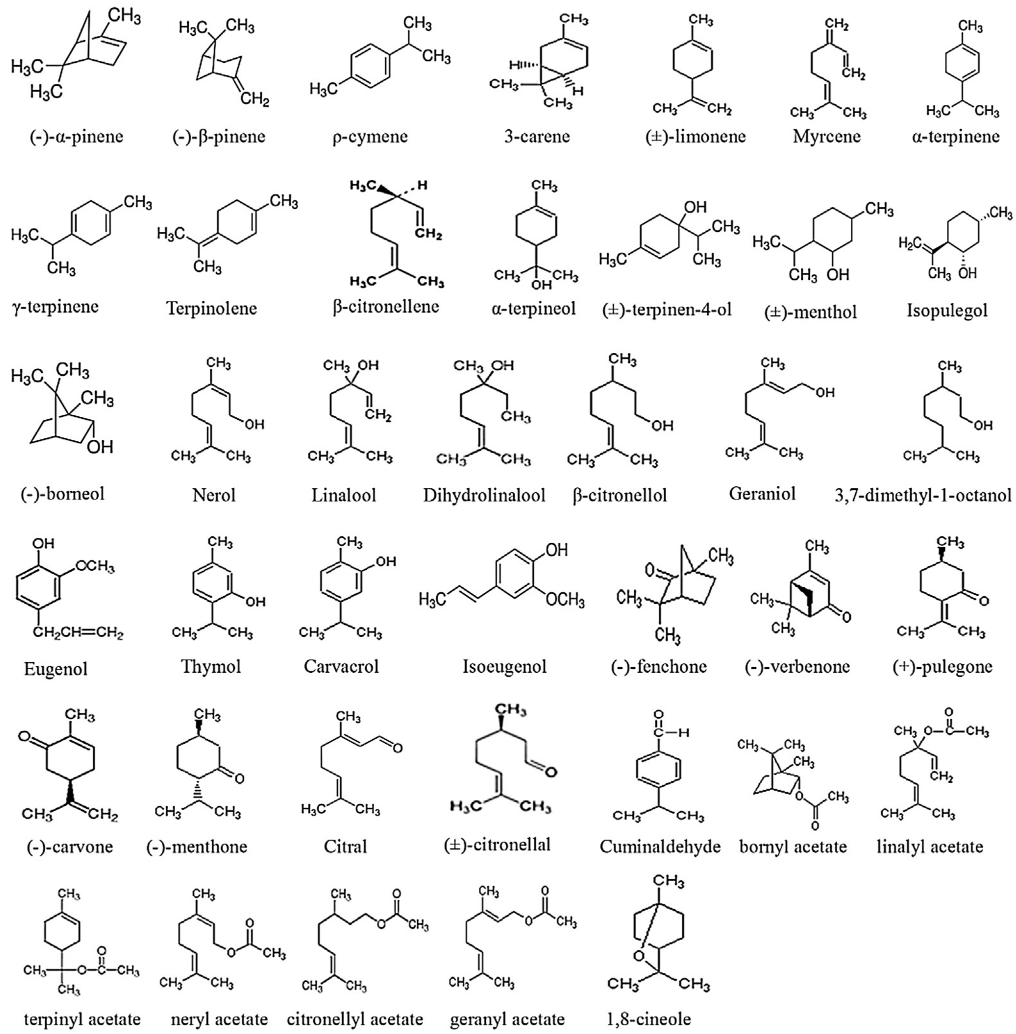

Fig. 1. The chemical structures of the tested monoterpenes.

ies on these insecticides and other related insecticides that are yet to be synthesized.

2. Materials and methods

2.1. Fly strain and rearing

The insecticide-susceptible strain of fruit fly, *D. melanogaster*, was obtained from the college of life science, Hubei Engineering University and used exclusively in all studies. Flies were reared in 50 ml vials capped with cotton plugs on a commercial diet. Flies were reared on a 12:12 h photocycle at 24 °C and ambient relative humidity. Mixed-sex adults, less than 1 week old, were used in bioassays.

2.2. Chemicals and dilutions

Forty monoterpene compounds (Fig. 1) with suspected insecticidal activity were identified, and purchased from commercial sources, part of compounds were purchased from Sigma–Aldrich Chemical (Shanghai, China) and the other part were purchased from Tokyo chemical Industry Co., Ltd. (Shanghai, China), and were of at least 95% purity. The positive control insecticides dichlorvos (DDVP) was purchased from LHDUBANG Agrochemicals Co., Ltd. (Shanghai, China). Insecticide stock solutions were prepared at a standard concentration of 100 mg/mL in analytical-grade acetone. For liquid monoterpenes compounds, directly took a certain amount for experimental study. Stock solutions were stored at −20 °C in sealed amber-colored vials.

2.3. Bioassays

The fumigation bioassay method of Scharf et al. (2006) was employed to assess the insecticide activity of 40 volatile compounds. A filter paper (Whatman no 1 cut into 2 cm diameter pieces) was impregnated with respective dosages of compounds and then attached to the undersurface of the 1000 ml glass jar's (10 cm diameter × 12.5 cm) screw cap, respectively. The cap was tightly screwed onto the jar, which contained 20 fruit flies. Adults used in all experiments were of unknown age. Jars containing the untreated filter paper (containing acetone) were considered as controls. Three replicates of each control and treatment were set up. After 24 h, mortality was scored with the aid of a magnifying glass. Flies were considered dead only when they showed a complete lack of movement. All bioassays were conducted at room temperature (23–25 °C) under atmospheric pressure conditions.

2.4. Statistical analyses

Probit analysis of concentration-mortality data were performed using PROC PROBIT in the SPSS version 19.0 software package (SPSS