The Journal of Basic & Applied Zoology (2016) 77, 56–68

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The Journal of Basic & Applied Zoology

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Reversal of deltamethrin-induced oxidative damage in rat neural tissues by *turmeric-diet*: Fourier transform-infrared and biochemical investigation

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Received 6 September 2014; revised 4 September 2016; accepted 1 October 2016

KEYWORDS

FT-IR;
Neural tissues;
Oxidative stress;
Antioxidant enzymes;
Deltamethrin;
Turmeric-diet

Abstract The present study is designed to determine the protective effect of turmeric (TMR) against neural oxidative damage caused by deltamethrin (DLM). Here we have employed mainly Fourier transform-infrared (FT-IR) spectroscopy to understand this event, in addition to biochemical analysis. For this purpose, rats were randomly divided into four groups ($n = 6$); control, TMR (1% *turmeric-diet*), DLM-treated (41 ppm) and TMR co-administrated with DLM for 48 days. The FT-IR spectra of brain tissues reflect the significant changes in the area values of macromolecules including proteins, lipids and nucleic acids in DLM-treated rats compared to control. In addition, DLM caused increase in the malondialdehyde (MDA) level accompanied by decrease in antioxidant enzymes activity such as superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx) and glutathione reductase (GR). However, the TMR co-administered with DLM group, exhibits appreciable restoration in area values and peaks of IR spectra and also the restoration of the mentioned antioxidant enzyme activities. The group merely fed with TMR showed insignificant changes in all investigated parameters. Therefore, the results reveal that, 1% of turmeric has a protective effect against deltamethrin caused neural oxidative damage.

Introduction

For the sake of more food production and domestic pest control number of pesticides and insecticides have been used in the agricultural and non agricultural practices. Deltamethrin (DLM) (Fig. 1) is fast acting neurotoxic pyrethroid obtained from natural toxin pyrethrin (Aksakal et al., 2010; Guardiola et al., 2014; Mani et al., 2014). It is chemically designed to be more toxic to insects nervous system for the slow break down and formulated with synergists increasing potency and compromising the body's ability of detoxification (Thatheyus and Selvam, 2013; Haverinen and Vornanen, 2014). Lozowickaa et al. (2014) have reported that, the residues of DLM were detected on cereals at the range of 0.02–0.88 mg kg^{-1}. Owing to the extensive use of pyrethroids in agriculture and domestic activities, there are more chances of

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Peer review under responsibility of The Egyptian German Society for Zoology.

http://dx.doi.org/10.1016/j.jobaz.2016.10.003
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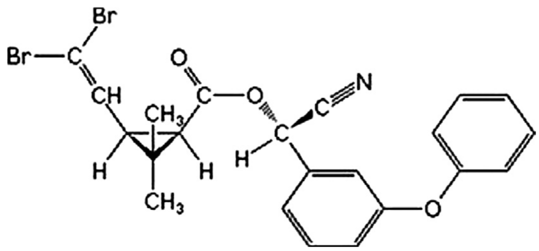

Fig. 1 Molecular structure of deltamethrin.

exposure to these chemicals, leading to neurodegenerative diseases (Baltazar et al., 2014). Such exposures have been observed more frequently in developing countries (Rother, 2014).

Although, DLM exhibits, relatively low mammalian and avian toxicity (Haverinen and Vornanen, 2014). Several studies were demonstrated that DLM is one of the most neurotoxic pyrethroids to insect and mammals too (Shafer et al., 2005; Kim et al., 2006; Gullick et al., 2014; Olsvik et al., 2014). It makes conformal changes in the structure of α- and β-subunits of the sodium channels (Ding et al., 2004) which lead to delayed closure of ion channels, resulting in a slow influx of sodium, hence slow depolarization (Ding et al., 2004; Chinn and Narahashi, 1985). Consequently, Shafer et al. (2005) and Eriksson and Fredriksson (1991) have reported that DLM is potential neurotoxicant, particularly in developmental stages of infants and children. Poisoning of pyrethroid induces some neurotoxic symptoms which include hyperexcitation, convulsions, seizures, and paralysis in rats (Symington et al., 2007). DLM also causes cerebrovascular and neurodegenerative disorders in humans (Godin, 2007). Neurodegenerative disease caused by DLM was shown to be exerted through oxidative stress (Hossain et al., 2005). It enhances the production of reactive oxygen species (ROS), including superoxide anion ($O_2^{\cdot-}$), hydrogen peroxide ($H_2O_2^{\cdot}$) and hydroxyl radical ($^{\cdot}OH$) thereby causing DNA damage in rats (Roszczenko et al., 2013; Abdul-Hamid and Salah, 2013).

Indeed body has its own endogenous antioxidant mechanism to scavenge the produced ROS in the metabolism. However, the brain is an important, vital and delicate organ having more demand for oxygen and contains relatively low antioxidant enzymes. Studies demonstrated that, DLM induces oxidative stress in functionally different tissues. It is evidenced by increased MDA level, accompanied by the simultaneous decrease in the levels of antioxidant enzymes, including SOD, CAT, GPx and GR (Mazmanc et al., 2011; Shivanoor and David, 2014). The SOD converts $O_2^{\cdot-}$ into $H_2O_2^{\cdot}$, further, $H_2O_2^{\cdot}$ metabolism by peroxidases that include CAT and GPx yields H_2O (Wilcox, 2002). In addition to this, GPx plays a major role in the neutralization of H_2O_2, and OH to non-toxic products (Salvi et al., 2007). Thus, decreased activity of these enzymes may lead to an enhanced generation of ROS in the cells. Hence, measuring these enzyme activities and by-products of lipid and protein oxidation can provide evidence for oxidative damage (Ishrat et al., 2009). There are several investigations demonstrating that, the increased ROS causes oxidative damage to the macromolecules including proteins, lipids, carbohydrates and nucleic acids (Shivanoor and David, 2014; Bishnoi et al., 2008), consequently, oxidative stress in neural tissue leads to neurodegenerative diseases (Carloni et al., 2012).

In many situations exogenous antioxidant/s proved to reduce the damage caused by the ROS either by scavenging them or by enhancing the activity of endogenous antioxidant enzymes. Therefore, extensive research was carried out to find efficient natural herbal products to protect cells from damages caused by ROS. On the other hand use of phytochemicals as a therapy in diseases related to oxidative stress has gained immense interest for their ability to scavenge free radicals and their capability to protect body tissues against oxidative stress (Nabavi et al., 2012).

The herbal powder of *Curcuma longa* L. is well known as turmeric (TMR), has been traditionally used all over Asia to prepare curries and also as a preservative (Gilda et al., 2010; Prasad and Muralidhara, 2014; Mangolim et al., 2014). TMR has been used extensively as an effective therapeutic agent in an Ayurvedic and Chinese medicinal system (Sethi et al., 2009; Mendonça et al., 2013). Therefore, attention was paid on whole turmeric (*C. longa* L.), however curcumin is an active ingredient of turmeric, a naturally occurring phenolic phytochemical compound (Haiyee et al., 2009; Fu et al., 2014, 2015). It possesses anti-carcinogenic property in animal model (Yanyan and Zhang, 2014), anti-HIV (Fu et al., 2014) antioxidant (Yang et al., 2014), anti-inflammatory (Aggarwal et al., 2013; Antonyan et al., 2014) and anti-Alzheimer (Naksuriya et al., 2010 a). Curcumin has been reported to possess strong antioxidant properties that can inhibit the oxidative stress further the brain damage (Ataie et al., 2010; Samini et al., 2013). Recently, Yang et al. (2014) and Naksuriya et al. 2010 have reported that curcumin is found to be neuroprotective. There are few studies demonstrating that curcumin can be made effective and bioavailable by the *turmeric-diet* and also exhibits prevention to oxidative damage (El-Ashmawy et al., 2006; Martin et al., 2012). Furthermore, Thapliyal et al. (2002, 2003) and El-Shahat et al. (2012) found that *turmeric-diet* acts as an antioxidant by improving antioxidant enzyme activity in rat and mice.

In the present study, FT-IR spectroscopic technique was employed in addition to biochemical analysis; to evaluate the protective effect of TMR against the DLM caused oxidative damage in the brain. FT-IR spectroscopy is one of the vibrational spectroscopic techniques, which has been widely used as a quantitative and qualitative tool (Xiaonan et al., 2011; Ozek et al., 2014; Shivanoor and David, 2015) to detect and quantify the macromolecules in any biological samples (Xiaonan et al., 2011; Krishnakumar et al., 2012). Therefore, the present study uses this molecular fingerprinting approach in addition to biochemical analysis to investigate the protective effects of turmeric on DLM induced oxidative damage in rat brain tissues.

Materials and methods

Chemicals

Deltamethrin (Fig. 1)-DECIS 2.5 EC is an insecticide purchased from Bayer Pvt. Ltd, India. All other chemicals were of analytical grade, purchased from commercial vendors' in India.