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Fenvalerate-induced oxidative damage in rat tissues and its attenuation by dietary sesame oil

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Abstract

The primary objective of this study was to investigate the propensity of Fenvalerate (FEN), a synthetic pyrethroid to induce oxidative stress (OS) in various tissues of growing male rats following a short-term (28 days) dietary regimen and its possible attenuation by dietary (10%) sesame oil (SO). FEN incorporated diet was fed to weanling male rats at the dosages of 0, 250, 500 and 1000 ppm. Terminally, significant induction of OS in liver, thymus, spleen and erythrocytes was noticed at higher doses as evidenced by the elevated levels of lipid peroxidation (LPO). Significant dose-dependent depletion of GSH levels, perturbations in antioxidant enzymes, and enhanced protein carbonyls further confirmed the potential of FEN to induce OS in hepatic tissue. In addition, FEN also caused significant increases in activities of hepatic transaminases, ALP and LDH. Interestingly, dietary SO significantly attenuated FEN-induced oxidative damage in liver and other tissues. The degree of protection was remarkably high, since LPO and GSH status, protein carbonyl content and antioxidant defenses in liver and other tissues were brought down to basal levels in the SO + FEN_{1000} group. These results clearly indicate the potential of FEN to induce oxidative damage in vivo and also suggest the ability of SO, a dietary fat to significantly offset the oxidative damage which may related to the presence of antioxidant compounds in the oil.

Keywords: Fenvalerate; Pyrethroid; Oxidative damage; Rat tissues; Dietary sesame oil; Attenuation

1. Introduction

Synthetic pyrethroids constitute a unique group of insecticides having pyrethrum like structures with better performance characteristics and account for over 30% of insecticides used globally (Soderlund and Bloomquist, 1989; Vijverberg and van den Bercker, 1982). An important characteristic of pyrethroids is their differential potency in insects and mammals (Casida et al., 1983). Synthetic pyrethroids are generally viewed as safe insecticides available due to their low acute toxicity to mammals (Elliott, 1977). Based on the symptoms produced in animals, pyrethroids fall into two distinct classes—Type I and Type II (Ecobichon, 1991). While Type I

Abbreviations: LPO, lipid peroxidation; OS, oxidative stress; ROS, reactive oxygen species; SOD, superoxide dismutase; GPX, glutathione peroxidase; GR, glutathione reductase; GSH, glutathione-reduced; GSSG, glutathione-oxidized; GOT, glutamate oxaloacetate transaminase; GPT, glutamate pyruvate transaminase; MDA, malondialdehyde; TBARS, thiobarbituric acid reactive substances; CDNB, 1,chloro-2,4-dinitrobenzene; DNPH, dinitrophenylhydrazine; SO, sesame oil; AIN, American Institute of Nutrition; FEN, fenvalerate

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pyrethroids affect sodium channels in nerve membranes, producing repetitive neuronal discharge and prolonged negative after-potential, Type II pyrethroids produce even longer delay in sodium channel inactivation leading to a persistent depolarization of the nerve membrane without repetitive discharge. They are more hydrophobic in nature (Michelangeli et al., 1990) and their target site is biological membrane. Studies describing the oxidative stress mechanisms in pyrethroid-induced toxicity are limited. Few recent reports (Giray et al., 2001; Gupta et al., 1999) have demonstrated the induction of oxidative stress by pyrethroids such as Cypermethrin.

Fenvalerate, (cyano (3-phenoxyphenyl)2-(4-chlorophenyl)-3-methylbutyrate) is a relatively recently developed type II synthetic pyrethroid that has replaced other groups of insecticides due to its improved insecticidal potency (WHO, 1990). Exposure of the general population to this pyrethroid is mainly via dietary residues. Significant FEN residues have been detected in vegetables and fruits (Boyer et al., 1992; Patel et al., 1990). FEN displays moderate toxicity in mammals (Ecobichon, 1991; WHO, 1990) and is rapidly hydrolysed in experimental animals to yield fenvaleric acid as a major metabolite (Kaneko et al., 1981). Recently, FEN was shown to inhibit the activity of mitochondrial enzymes in rats (Gassner et al., 1997). However, to the best of our knowledge, the potential of FEN to induce oxidative damage in various mammalian tissues in vivo has not been comprehensively investigated. Earlier, we have demonstrated the induction of oxidative stress in various tissues of rats following administration of single and multiple sublethal oral doses (Prasanthi, 2001). In this communication, we describe our attempts to assess FEN-induced oxidative damage in various tissues of growing male rats and its attenuation by sesame oil, a dietary fat.

Currently, there is an increasing interest in identifying the potential of various plant products as antioxidants, antimutagens/anticarcinogens and as dietary modulators of toxicity (Verhagen et al., 2003; Wattenberg, 1990). Several plant products exert antioxidative effects and many of these are widely used in different parts of the world (Ahmed et al., 2000; Khan et al., 1997). Sesame seed oil (SO) is a component of the traditional health food in India as well as in oriental countries and has long been thought to possess the ability to prevent various diseases including atherosclerosis, hypertension and to retard aging (Fukuda et al., 1994, 1985; Namiki, 1995). While sesaminol is the principal antioxidative component in SO (Osawa et al., 1990), the lignans present are also speculated to contribute towards its unique chemical/physiologic properties, including its antioxidant and antimutagenic properties (Kang et al., 1998a). However, data on the potency of SO to offset pyrethroid-induced oxidative damage in vivo are limited (Kang et al., 1998b). Hence, we also examined whether dietary SO has the potential to significantly attenuate FEN-induced oxidative damage.

2. Materials and methods

2.1. Chemicals

Technical grade Fenvalerate (FEN; 95% pure) was a gift from M/S Searle India (Mumbai, India.). Thiobarbituric acid, xanthine oxidase, cytochrome 'c' and NADH were obtained from M/s Sigma Chemical Co., St. Louis, MO, USA. GSH, GSSG, CDNB, DNPH, NADPH, mineral mix and vitamins were purchased from M/s SISCO Research Laboratories, Mumbai, India. Casein was obtained from M/s Hi-Media, Mumbai, India. Cellulose was procured from M/s Loba Chemie, Mumbai, India. Sesame oil was purchased from the local market. All other reagents used were of analytical reagent grade.

2.2. Physico-chemical characteristics of sesame oil

The physico-chemical characteristics of sesame oil were analysed (Table 1). Refractive index was determined according to the method described in the Manual of methods and tests and analysis for food (1972). Free fatty acids were determined according to the method of Kates (1972). Sesamin and sesamolin content were determined as per the method of Budowski et al. (1950).

2.3. Preparation of basal diet

The purified diet (basal diet) was prepared in the laboratory as per the composition of AIN-76 (AIN, 1977). Composition of the diet was: Casein—20%; Corn starch—10%; Sucrose—50%; Cellulose—5%; Groundnut oil—10%; AIN Mineral mix—3.5%; AIN vitamin mix— 1%; Choline bitartrate—0.2%; DL-methionine—0.3%. All the diets were prepared thrice a week. Sesame

Table 1
Physico-chemical characteristics and fatty acid profile of sesame oil

Parameters	
Density at 15 °C	0.915
Refractive index	1.465
Free fatty acids (as % oleic acid)	0.6
Fatty acids (%)	
Myristic acid C14:0	0.5 ± 0.1
Palmitic acid C16:0	11.2 ± 0.4
Stearic acid C18:0	3.4 ± 0.1
Arachidic acid C20:0	0.2 ± 0.02
Oleic acid C18:1	42.4 ± 0.8
Linoleic acid C18:2	42.1 ± 0.6
Linolenic acid C18:3	0.20 ± 0.3
Sesamin (g/100 g)	0.6 ± 0.07
Sesamolin (g/100 g)	0.4 ± 0.03