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Using vitamin E to prevent the impairment in behavioral test, cell loss and dendrite changes in medial prefrontal cortex induced by tartrazine in rats

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ABSTRACT

Tartrazine is a food color that may adversely affect the nervous system. Vitamin E is a neuro-protective agent. This study aimed to evaluate the effects of tartrazine and vitamin E on the performance of rats in memory and learning tests as well as the structure of medial Prefrontal Cortex (mPFC). The rats were first divided into seven groups which received the followings for a period of seven weeks: distilled water, corn oil, vitamin E (100 mg/kg/day), a low dose (50 mg/kg/day) and a high dose (50 mg/kg/day) of tartrazine with and without vitamin E. Behavioral tests were conducted and the brain was extracted for stereological methods The high dose of tartrazine decreased the exploration time of novel objects ($P < 0.01$). The low and high doses of tartrazine led into an increase in working and reference memory errors in acquisition and retention phases (eight-arm radial maze) compared to distilled water group ($P < 0.01$). Additionally, the high dose of tartrazine induced a reduction in the volume of mPFC (~13%) and its subdivision. Not only that, but the number of neurons and glial cells (~14%) as well as the mushroom and thin spines per dendrite length declined. The length of dendrites per neuron also reduced in comparison to the distilled water group ($P < 0.01$). Nonetheless, concomitant treatment of the rats with vitamin E plus tartrazine prevented the above-mentioned changes. An acceptable daily dose of tartrazine could induce impairment in spatial memory and dendrite structure. Moreover, a high dose of tartrazine may defect the visual memory, mPFC structure, the spatial memory and also cause dendrite changes. Vitamin E could prevent the behavioral and structural changes.

1. Introduction

For a long time, chemical additives have been an option for human beings intended to cover the improper quality of blemished food. However, a wide range of food colors used today are synthetic because they are produced easily and provide cheaper and better coloration (Mohamed et al., 2015). Tartrazine (E 102, FD, and C Yellow) is an orange-colored powder, which is widely applied to products to yield a lemon yellow color. It is a water soluble artificial azo color obtained from coal tar. Drinks and beverages contain a maximum amount of tartrazine (Gao et al., 2011; Saxena and Sharma, 2015). Furthermore, tartrazine has been illegally used as an alternative to saffron for cooking in some countries. Its application has not been confined to food industry; rather, it has been widely used to color some pharmaceutical products, such as capsules of vitamins, antacids, cosmetics, and hair products (Mohamed et al., 2015). As for its side effects, it has been found that different doses of tartrazine in the diet of mice caused adverse effects leading to hepatocellular damage, reproductive alterations, genotoxicity of lymphocytes and inflammation of the stomach lining (Mohamed et al., 2015; Tanaka, 2006; Moutinho et al., 2007). In addition, a number of undesirable effects on nervous system, including anxiety, migraines, clinical depression, blurred vision, and sleep disturbance have been observed following tartrazine ingestion (Rowe and Rowe, 1994). Gao et al. (2011) also indicated that tartrazine could cause learning and memory deficits in mice and rats.

Prefrontal cortex and hippocampus are the essential parts of the brain that play important roles in learning and memory. Park et al. (2009) showed that a variety of food colors can adversely affect on both hippocampal cells and prefrontal cortex.

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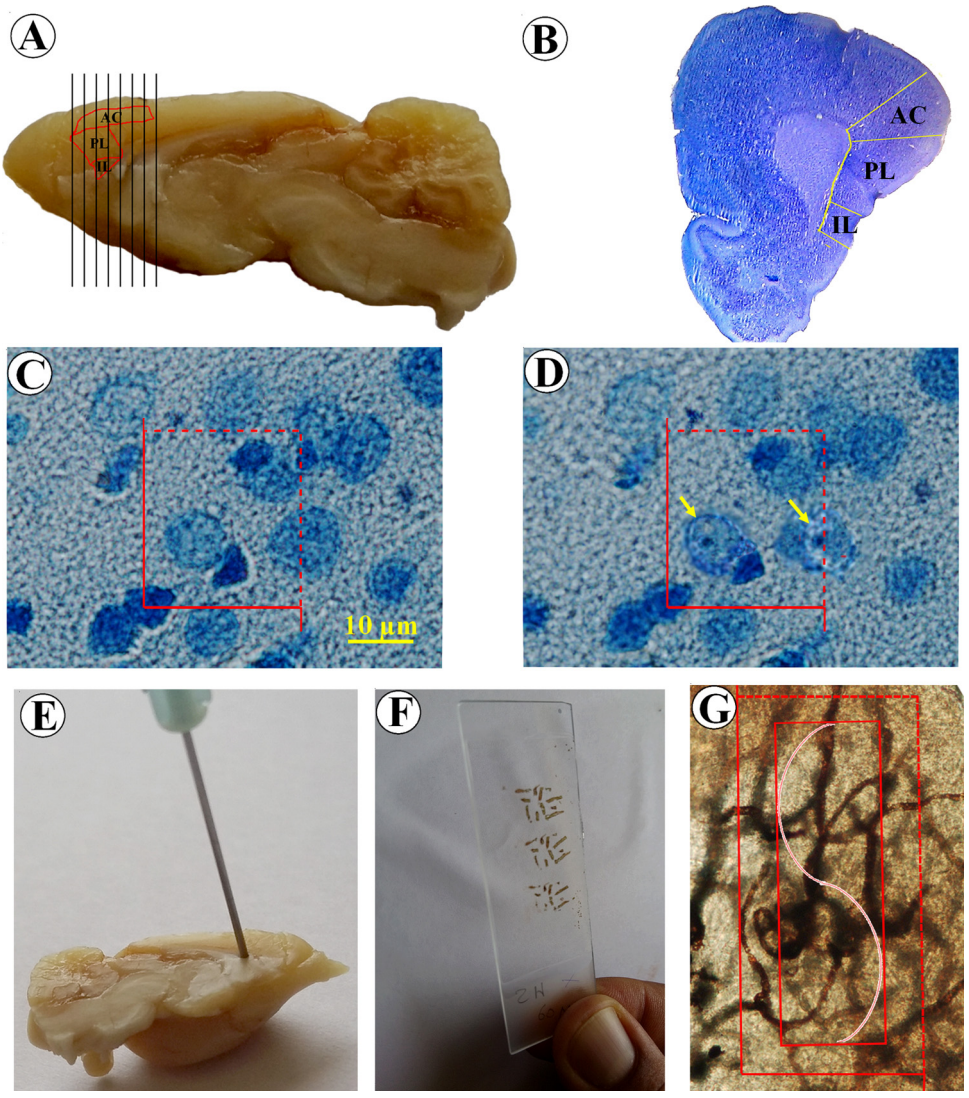

Fig. 1. Stereological estimation of the mPFC volume, cells number, and dendrites length. A. The design of sectioning used to estimate the volume of the mPFC using Cavalieri's method. Different parts of mPFC (AC: anterior cingulate, PL; prelimbic, IL: infralimbic) are indicated. B. The area of each part was determined using the software. C&D. An unbiased counting frame was superimposed on the images of the mPFC sections stained with Giemsa. The cells'nuclei appearing during scanning of the height of the "optical disector" were counted using the unbiased counting frame (arrow). E. The vertical cylinders were punched out from the mPFC perpendicular to its pial surface using a trocar. F. The cylinder was randomly rotated along its vertical axis, sectioned using a microtome, and mounted on a slide. G. Four cycloids were placed at a rectangle. The number of the cell bodies of the neurons was counted using the unbiased counting frame while the sections were scanned. The total number of the intersections between the dendrites axes and the cycloids were counted.

Therefore, the present study was conducted to fulfill two main purposes. The first aim of the present study was to evaluate the effects of tartrazine on the medial Prefrontal Cortex (mPFC), which plays a vital role in memory and learning. Further, it intended to find a protective agent to be consumed in the case of exposure to tartrazine. The main mechanism of the side effects of tartrazine has been proposed by Gao et al. (2011). They showed that after exposure to tartrazine the actions of antioxidant enzymes (catalase, glutathione peroxidase, and superoxide dismutase) would decrease as well as the level of malonaldehyde (as a marker of oxidative stress) increase in the brain of rats. Therefore, it seems to be rational to use an anti-oxidant compound to protect the side effects of tartrazine.

Vitamin E, a group of fat-soluble compounds with prominent antioxidant activities, is a well-known agent considered to fulfill the aforementioned purpose (Nuoya et al., 2015; Sakr et al., 2015). Vitamin E serves as a neuro-protective agent and is considered to be a therapeutic agent in neurodegenerative diseases (Sakr et al., 2015). It was considered to be evaluated in this survey because it can be found naturally in some foods and is also available as a nutritional supplement. In this study, a low and a high dose of tartrazine were defined as 5 and 50 mg/kg/day respectively. Five mg/kg body weight lies in the range of Acceptable Daily Intake (ADI) for tartrazine (Moutinho et al., 2007). The high dose was selected considering the fact that individuals' exact intakes during the day and in different dietary habits are hard to record. The dose of vitamin E was also selected according to its suggested neuro-protective effects in previous surveys (Nuoya et al., 2015; Sakr et al., 2015). Therefore, the present survey was performed using a rat model with the consumption of tartrazine to answer the following questions:

1. Does the exposure to tartrazine (low and high doses) influence the rats' memory and learning (visual and spatial)?
2. Does the tartrazine exposure have any effects on the volume of the mPFC (anterior cingulated, PL, and IL cortices)?
3. Does the exposure to tartrazine cause any changes in the number of neurons and glial cells in the mPFC?

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