

Parboiled Germinated Brown Rice Decreases Inflammatory Cytokines Levels in Various Regions of Brain in Rats Induced by Carbon Tetrachloride

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ABSTRACT

Parboiled germinated brown rice (PGBR) from the Khao Dawk Mali 105 (KDML 105) Thai rice strain is well-known for its nutrients and bioactive compounds. This research was conducted to determine the protective effect of PGBR on carbon tetrachloride (CCl₄)-induced brain inflammation. Thirty-five male Sprague-Dawley rats were randomly divided into five groups: (I) control group (basal diet); (II) CCl₄ group (basal diet); (III) white rice + CCl₄ group; (IV) brown rice + CCl₄ group, and (V) PGBR + CCl₄ group. PGBR, brown rice and white rice diets were produced by replacing cornstarch in basal diet with cooked PGBR, brown rice, and white rice, respectively. Twice weekly, each rat was orally administrated with 1 mL/kg of CCl₄ in olive oil (1:1, v/v). After eight weeks, all rats were subjected to carbon dioxide euthanasia. The cerebral cortex, hippocampus and cerebellum were dissected and homogenised to evaluate the levels of tumour necrosis factor α (TNF- α), interleukin 1 β (IL-1 β), and interleukin 6 (IL-6). It was observed that the administration of CCl₄ induced the elevation of the TNF- α and IL-1 β levels in all brain tissues, as well as the blood ammonia and serum liver functions also rose. However, there was a significant reduction in the levels of TNF- α and IL-1 β in the cerebral cortex, hippocampus and cerebellum in the PGBR + CCl₄ group compared to the CCl₄ group ($P < 0.05$), whereas the blood ammonia and serum liver functions were also decreased. These findings suggest that regular consumption of PGBR may prevent CCl₄-induced brain inflammation.

Keywords: Brain inflammation, Parboiled germinated brown rice, Carbon tetrachloride, Khao Dawk Mali 105, KDML 105

INTRODUCTION

Carbon tetrachloride (CCl₄) is a well-known model for detecting hepatoprotective properties of natural components. In addition, CCl₄ causes free radical generation in many bodily tissues; such as the liver, kidney, heart, lung, testis, blood and brain (Dashti et al., 1989). Yamamoto and Sugihara (1987) reported that hyperammonaemia occurred after inducing rats with CCl₄ (1.0 mL/kg three times per week for 10 weeks), which was produced by the decrease in the hepatic content and by the inhibition of carbamoyl-phosphate synthetase and arginine-succinate synthetase, important enzymes of the urea cycle. Elevated concentrations of ammonia in the brain as a result of hyperammonaemia resulted in the activation of astrocytes, which stimulated a number of inflammatory signalling systems; such as nitric oxide synthase (NOS), nuclear factor kappa B (NF-κB), and cyclooxygenase-2 (COX-2) (Jayakumar et al., 2006). Additionally, ammonia activates brain microglia, which can release the pro-inflammatory cytokines; such as IL-1α, IL-1β and TNF-α (Atanassov et al., 1994; Rao et al., 2013). Moreover, the hippocampus plays a key role in memory function, particularly the transference from short- to long-term memory and control of spatial memory and behaviour. The cerebral cortex is also a major component of the brain for memory function, as well as attention, perceptual awareness, thought, language and consciousness, while the cerebellum is essential for balance and motor control functions (Preston and Eichenbaum, 2013). Therefore, inflammation in the brain, particularly the hippocampus, cerebral cortex and cerebellum, plays a crucial role in neurodegenerative disorders (Cagnin et al., 2006; Rovira et al., 2007; García Martínez et al., 2010).

Germinated brown rice has numerous bioactive compounds and is renowned for its nutritional components. Several valuable nutrients were remarkably increased after germination, especially increasing 13-fold γ-oryzanol, 10-fold γ-aminobutyric acid (GABA), about fourfold dietary fibre, vitamin E, niacin and lysine, and nearly threefold vitamins B1, B6 and magnesium (Kayahara and Tsukahara, 2000). Furthermore, previous studies have shown the anti-oxidant, anti-inflammatory, anti-diabetic and anti-cancer properties in germinated brown rice (Latifah et al., 2010; Zhang et al., 2010; Imam et al., 2012; Soiapornkul et al., 2012). Recently, parboiled germinated brown rice (PGBR) was produced from the Khao Dawk Mali 105 (KDML 105) rice strain, which is the most famous Thai rice, and is known for its texture and aroma. PGBR was produced by steaming germinated paddy rice. During parboiling, starch granules of rice were gelatinised, which improves stability and lessens the rupture