Academic Sciences International Journal of Pharmacy and Pharmaceutical Sciences

ISSN- 0975-1491 Vol 4, Suppl 5, 2012

Research Article

PROTECTIVE ROLE OF TRACE ELEMENTS AGAINST CADMIUM INDUCED ALTERATIONS IN THE SELECTED OXIDATIVE STRESS ENZYMES IN LIVER AND KIDNEY OF FRESH WATER TELEOST, *OREOCHROMIS MOSSAMBICUS* (TILAPIA)

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Received: 28 July 2012, Revised and Accepted:15 Sep 2012

ABSTRACT

Cadmium (Cd) is a non essential heavy metal that enters human and animal bodies via different industrial products, environmental pollution and different contaminated foods. The present study is carried out to investigate Cd induced alterations in the lipid peroxidation (LPO) and antioxidant enzymes such as superoxide dismutase (SOD) and catalase (CAT) in liver and kidney of fresh water teleost, *Oreochromis mossambicus* (Tilapia) exposed to Cd before and after supplementation with trace elements such as calcium (Ca) and zinc (Zn) either individually or in combination. The fish were exposed to cadmium chloride ($CdCl_2$) at a dose of $1/10^{th}$ LC_{50} i.e. 5ppm for 7, 15 and 30 days (d) time intervals. After 15d Cd exposure, the fish were then supplemented with trace elements like Ca (1ppm) and Zn (1ppm) either individually or in combination for again 7, 15 and 30d time intervals. After the specified time intervals, liver and kidney tissues were isolated and used for assay of antioxidant enzymes as well as LPO. Results revealed significant elevation of LPO during Cd exposure for all the time durations. Maximum LPO level was found in 30d Cd exposed fish liver tissue (26.415 ± 0.286 µ moles of MDA formed / gm wet wt. of the tissue) than kidney (21.692 ± 0.193 µ moles of MDA formed / gm wet wt. of the tissue). Both SOD and CAT activity levels were markedly inhibited at all the time intervals of Cd exposure. After supplementation with trace elements Ca and / or Zn, the LPO levels were significantly decreased. Maximum decrease in LPO levels were found in kidney and liver under Ca alone supplementation followed by combination of Ca + Zn and Zn alone supplementation. Maximum SOD activity levels were found in 30d Zn supplemented kidney tissue (0.628 ± 0.212 superoxide anion reduced / mg protein / min) followed by 30d combined supplementation of Ca and Zn (0.621 ± 0.201 superoxide anion reduced / mg protein / min). Whereas Maximum CAT activity levels were found in 30d Ca supplemented kidney tissue (0.605 ± 0.261 µ moles of H_2O_2 / mg protein / min) followed by 30d combined supplementation of Ca and Zn (0.583 ± 0.219 µ moles of H_2O_2 / mg protein / min). Our findings clearly evidenced that the Ca alone supplementation is very effective in reducing the Cd toxicity when compared to other modes of supplementation in the teleostean fish *Oreochromis mossambicus*.

Keywords: Cadmium, Trace elements supplementation, Oxidative stress enzymes, Tilapia

INTRODUCTION

Heavy metals like Cd, Pb and Hg have no known biological functions and consequently detrimental to essential life processes. These metals in the form of inorganic compounds from natural and anthropogenic sources continuously enter the aquatic ecosystem where they pose a serious threat because of their toxicity.

Among the heavy metals, Cd is one of the most toxic, non-essential heavy metal; known for its corrosive nature and is widely used in paints and dyes, cement and phosphate fertilizers[1]. Cd occurs naturally in the environment in significant amounts but its release in the recent past is steadily increasing due to human activities causing pollution at considerably toxic amounts was reported by earlier workers in various aquatic ecosystems[2]. Bioenhancement of Cd transfer along a food chain was studied by Seebaugh[3] and fish were reported to be used as biological indicators to assess water pollution[4]. In aquatic systems, as fish occupy the upper trophic level, there are greater chances of transferring Cd to higher organisms particularly to man.

Cd has an extremely long half-life (20-30 Years) in the human body[5] and is highly cumulative, especially in the liver and kidney[6,7,8,9]. It is a ubiquitous toxic metal and induce oxidative damage by disturbing the prooxidant – antioxidant balance in the tissues[10]. Cd inhibits oxidative stress enzymes which protect tissues by either binding to sulfhydryl groups essential for the enzymes, replace the bivalent metals like zinc (Zn), copper (Cu), iron (Fe) and manganese (Mn) required for the enzymes or decreases the bioavailability of selenium (Se) required for the enzymes[11]. Cd like many other heavy metals is antagonistic to essential trace elements like Zn, Fe, Cu, Ca etc.,[12] and competes with these trace elements for binding sites as transport and storage proteins, metalloenzymes and receptors.

Zn is a ubiquitous essential trace element with numerous functions in biological systems. It occurs in all living cells as a constituent of metallo enzymes involved in major metabolic pathways. It plays a catalytic, inhibitory or accessory role in the regulatory enzymes such as kinases or phosphatases. Zn controls several enzymes of intermediary metabolism, DNA and RNA synthesis, gene expression, immunocompetence and plays a significant role in homeostasis of hormones[13]. It has been noted that Zn is a constituent of several enzymes (more than 300 enzymes) in the body and can prevent cell damage through activation of the antioxidant defense system[14,15].

Ca plays diverse role in the living organisms. In most of the vertebrates it is a major component of the skeleton but it also has vital functions in the body fluids and soft tissues. It acts as a cofactor in various enzymatic processes and couples stimulus excitation reactions, as in muscle contraction or the secretion of exocrine and endocrine glands. Both Ca and Cd are divalents and they use the same transitional channel interacting with each other antagonistically. Zohouri[16] have been reported that high concentrations of Ca either in water or diet clearly envisages ameliorating effects on water borne Cd toxicity in fish *Oreochromis mossambicus*.

Hence, an attempt is made in the present investigation on the interactions of Ca and / or Zn against Cd induced toxicity in liver and kidney of teleostean fish *Oreochromis mossambicus*.

MATERIALS AND METHODS

Chemicals: Cadmium as cadmium chloride ($CdCl_2$), calcium as calcium chloride ($CaCl_2$) and zinc as zinc chloride ($ZnCl_2$) were purchased from Merck (Dormstadt, Germany). All other chemicals which were used in the present study were obtained from the standard chemical companies like Sigma Chemical Co. (St Louis, Mo, USA) and SD Fine Chemicals. The chemicals used in this study were of the highest purity.

Animals: Fish *Oreochromis mossambicus* (Tilapia) weighing 10 ± 2 gm were collected from the local fresh water ponds and acclimatized to laboratory conditions for a week in separate troughs. The laboratory temperature was maintained at 28°C ± 2°C. The fish were