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RESEARCH PAPER

Effect of Silymarin Supplementation on Nickel Oxide Nanoparticle Toxicity to Rainbow Trout (*Oncorhynchus mykiss*) Fingerlings: Pancreas Tissue Histopathology and Alkaline Protease Activity

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Abstract The effects of dietary nickel oxide nanoparticles (NiO-NPs) contamination along with silymarin supplementation on pancreatic tissue of rainbow trout fingerlings were investigated. Five treatments including different levels of NiO-NPs (0, 100 and 500 mg kg^{-1} feed) and silymarin (0 and 1 g kg^{-1} feed) in three respective replicates were designed. The trial was conducted under 12L:12D photoperiod condition for 60 days. Tissue samples for histological and enzymatic studies were taken on days 30 and 60. The results from day 30 indicated that the highest and lowest alkaline protease activities were belonged to fish fed diet without any nanoparticles (T1) and those fed 100 or 500 mg kg^{-1} feed (T4 and T5), respectively. Dietary silymarin could to some extent prevent toxic effects of NiO-NPs on enzyme activity (T2 vs. T3). Acinar cells necrosis, edema of connective tissue and cellular shrinkage were observed in NiO-NPs received groups (T4 and T5). At the end of the trial, T2 and T3 could regain their digestive capacity after removal of nanoparticles and those groups continued to receive nanoparticles until the end of the trial (T4 and T5) showed the lowest alkaline protease activity. Moreover, the histological observations revealed pancreas tissue necrosis, nuclear degeneration and vascular dilation in the latter groups. In conclusion, NiO-NPs affected pancreatic tissue and its function in a dose-dependent manner, while dietary silymarin helped fish to sustain digestive capacity. Future researches should focus on the ecological outcomes of pollutants induced toxicity.

Keywords Pancreas · Alkaline protease · Nickel oxide nanoparticles · Rainbow trout

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1 Introduction

During the recent years, nanomaterials has been considerably developed and marketed to the extent that it is predicted to reach more than trillion dollars by 2015. The market also includes animal feed industry and agricultural activities, namely aquaculture (Rather et al. 2011). Nanoparticles could reach and affect an organism via different ways; however, determining their physiological importance and subsequent associated risks would be difficult. There is plethora of information regarding the direct animal exposure (skin and respiratory organ/gill direct contact) to nanoparticles in the literatures. Despite its importance in nutrient provision for individual growth and survival, information regarding the effects of nanoparticles on gastrointestinal tract, especially via food/feed, cosmetics and drug delivery systems is inconclusive (Agarwal et al. 2013).

Different mechanisms of action have been proposed for the toxic effects of nanoparticles; among them, free radical production beyond the anti-oxidative capability of an organism to prevent the deteriorative effects of nanoparticles has gained more interest (Kim et al. 2009; Tee et al. 2015). Highly reactive free radicals cause deteriorative and most of the time irreversible damage to biomolecules such as structural proteins, lipids and nucleic acids following with loss of cell/organ function and subsequent cell death

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