BMC Microbiology

RESEARCH

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Lactobacillus protects against lead-induced hepatotoxicity by preserving the gut barrier and microbiota remodeling

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Abstract

Lead (Pb) toxicity is a global health concern that primarily affects the liver. This study explored the protective effects of lactobacilli against Pb(II)-induced hepatotoxicity in mice. Three strains of lactobacilli—*Lacticaseibacillus paracasei* GMNL-32, *Limosilactobacillus fermentum* GMNL-93, and *Lacticaseibacillus casei* GMNL-277—were evaluated for Pb adsorption and antioxidant activity. In a chronic Pb(II) exposure mouse model, GMNL-93 and GMNL-277 more effectively mitigated Pb(II)-associated liver damage, and upregulated RNA expression of gut function-associated proteins (e.g., *Cldn3*, *Cldn5*, and *Muc5*). Microbiome and functional pathway analyses suggested strain-specific modes of action: GMNL-93 was associated with shifts in microbial composition and enrichment of pathways linked to redox balance and bile acid metabolism, whereas GMNL-277 was linked to enhanced thiamine-related metabolism; GMNL-32 showed comparatively limited protective. Overall, lactobacilli are promising candidates for reducing lead toxicity through directly interaction and microbiome-dependent host protection.

Keywords Lead toxicity, *Lacticaseibacillus paracasei*, *Limosilactobacillus fermentum*, *Lacticaseibacillus casei*, Hepatotoxicity, Gut microbiota, Intestinal barrier

Introduction

Heavy metals are naturally occurring elements with high atomic weights and densities at least five times greater than that of water. Some heavy metals, such as iron and zinc, serve as essential nutrients at low concentrations. Other heavy metals, such as lead (Pb), mercury, and arsenic, have no known biological function and can be toxic even in trace amounts [1]. Heavy metal toxicity occurs when these metals accumulate in the body to levels that impair physiological function and cause harm. Since 2017, public health and ecological concerns regarding heavy metal toxicity have increased as a result of the global increase in environmental pollution and industrial activity [2].

Pb, one of the most dangerous heavy metals, poses major risks to human and animal health and the

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