Biological Trace Element Research
https://doi.org/10.1007/s12011-024-04487-9

RESEARCH

Zinc-Biofortified Rice Improves Growth in Zinc-Deficient Rats

Venu Konda[1] · Ravindranadh Palika[1] · Ananthan Rajendran[1] · C. N. Neeraja[2] · R. M. Sundaram[1] · Raghu Pullakhandam[1]

Received: 25 September 2024 / Accepted: 8 December 2024

Abstract

Biofortification of staple food crops with zinc (Zn) is considered a sustainable strategy to prevent deficiency, but evidence on their health impact is awaited. The weaning Wistar/Kyoto male rats were fed on a Zn-deficient diet (ZDD, < 0.1 ppm) for 4 weeks followed by repletion (pair feeding) with control rice diet without (CRD; 5.0 ± 0.23 ppm) or with additional Zn (CRD + Zn, 30.3 ± 0.60 ppm) or biofortified rice diet (BRD; 8.54 ± 0.51 ppm) for 3 weeks. Body weights, plasma, liver, pancreatic, fecal Zn levels, and intestinal ZIP4 and ZnT1 mRNA expression were measured at the end of the experiment. The body weight of rats fed on CRD or CRD + Zn or BRD significantly increased ($p < 0.01$) compared to rats fed on ZDD. The body weight BRD was significantly higher compared to CRD ($P < 0.01$), both of which remained lower compared to CRD + Zn ($p < 0.03$). Repletion of Zn through either CRD or BRD significantly increased the plasma Zn concentration (PZC), tissue, and fecal Zn excretion compared to ZDD, without significant between-group differences. However, PZC, tissue, and fecal Zn of CRD + Zn was significantly higher compared to the rest of the groups. The intestinal ZIP4 and ZnT1 mRNA expressions are consistent with Zn status and/or dietary Zn exposure. A similar PZC, tissue, and fecal Zn in CRD compared to BRD, despite higher Zn intakes in the latter, could be due to preferential shuttling of Zn for growth. Together, these results indicate that Zn from biofortified rice is efficiently utilized for promoting the growth in Zn-deficient rats.

Keywords Zinc · Biofortification · Rice · Bioavailability · Growth · Zinc status · Efficacy

Introduction

Zinc (Zn) is ubiquitous in biological systems and is essential for normal growth and immune function. In humans, the Zn status is homeostatically regulated primarily through intestinal absorption and endogenous pancreatic Zn excretion, such that the plasma Zn concentrations (PZCs) remain resistant to changes in dietary Zn intakes [1]. Studies in adult human volunteers showed that chronic lower dietary intakes (< 1 mg/day) rapidly (4–9 weeks) reduce the PZCs, and manifest in clinical symptoms such as diarrhea and dermatitis [2–4]; this could possibly be due to absence of readily available Zn stores in the body. Although there are no established biomarkers to assess the diagnosis of Zn deficiency in individual subjects, low dietary Zn intakes against its requirements (> 25%), high prevalence of stunting, and high prevalence (> 20%) of low serum or plasma Zn concentrations (P(S)ZCs) are suggested for assessing the risk of population Zn status [5, 6].

Although population-based serum Zn estimates are limited, based on lower dietary intakes and high prevalence of stunting, the risk of Zn deficiency is reported to be higher in many developing countries [5], which in turn led to advocacy of increasing the Zn intakes through food fortification. Biofortification entails screening for nutrient-dense germplasm and transfer of this trait to agronomically elite varieties through either conventional or marker-assisted selection breeding [7, 8]. The higher nutrient density in biofortified staple crops is expected to reduce the dietary inadequacy of nutrients in all population groups. The other advantage of biofortification is that, unlike chemical fortification, it does not require centralized production and

✉ Ravindranadh Palika
nadh.palika@gmail.com

✉ Raghu Pullakhandam
raghu_nin2000@yahoo.com

1 ICMR-National Institute of Nutrition, Hyderabad 500007, Telangana, India

2 ICAR-Indian Institute of Rice Research, Hyderabad, Telangana, India

Published online: 16 December 2024