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Multi-omics deciphered the role of OsPPDK in reprogramming metabolism and enhancing resistant starch in whole grain rice

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Abstract

Resistant starch (RS) is a unique dietary fiber with significant functional properties, offering multiple health benefits, including improved gut microbiota health and a reduced risk of diet-related non-communicable diseases—particularly in rice-consuming populations. However, the genetic regulation of RS in whole-grain rice remains largely unexplored. In this study, we screened a genetically diverse collection of whole-grain red, purple, variable purple, and brown rice varieties to assess their RS content. Genome-wide association studies (GWAS) identified key genes regulating RS, primarily within starch biosynthetic pathways, as well as pathways linked to protein and lipid metabolism. Among these, OsPPDK exhibited a high percentage of phenotypic variance explained (PVE = 56 %) and demonstrated epistatic interactions with genes involved in protein metabolism, turnover, and other regulatory networks influencing RS accumulation. Marker-trait associations (TGTAGGAACT) revealed that high RS content was predominantly found in red rice, was rare in black rice, and was completely absent in Japonica varieties. Interestingly, rice lines with elevated RS levels displayed a floury endosperm phenotype, attributed to OsPPDK. To validate the role of OsPPDK in metabolic reprogramming, near-isogenic lines (NILs) carrying the gene were developed. Further metabolic profiling of the flo4 mutant—harboring a defective OsPPDK gene—revealed a shift from starch metabolism toward amino acid, phospholipid, and phenylpropanoid pathways, coinciding with increased RS accumulation. Additionally, retrogradation further enhanced RS levels by up to 10 % in high-RS rice lines. These findings provide valuable genetic and metabolic insights that can facilitate breeding strategies to develop rice varieties with enhanced RS content, ultimately promoting better health outcomes.

Keywords: Amino acids, lipids, metabolism, resistant starch, rice

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