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Superior breadmaking quality of the rice flour of PDI (protein disulfide isomerase) mutant

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Rice consumption has gradually declined to about 60kg per capita from more than 100kg 40 years ago. In recent years, rice flour has received attention as an alternative to wheat flour owing to technological innovations for making fine flour from rice. However, there has been little effort aimed at breeding cultivars with superior milling or end-use qualities. Seed protein is a major determinant of end-use properties for processing in the food industries. The *esp2* mutant [MNU-treated knockout mutant of a protein disulfide isomerase (*PDIL1-1*)], accumulates a large amount of proglutelins, the precursor of the major seed storage protein glutelin. *PDIL1-1* is abundantly expressed in the developing endosperm and is involved in both oxidative protein folding and sorting of glutelins. Rice endosperm develops two types of protein bodies (PB-I containing prolamins and PB-II containing glutelins), whereas *esp2* forms small particles containing both prolamins and proglutelins (Fig. 1). In a recent study, we demonstrated that the proglutelins in *esp2* accumulate as large protein complexes through inter-molecular disulfide bonds (Onda et al. 2009). In addition, some starch granules purified from *esp2* were much larger than those of wild-type (Fig. 2).

Having identified unique phenotypes of the *esp2* seeds, we compared breadmaking quality of the rice flour of wild type and *esp2*. We consistently recognized three superior qualities in the *esp2* flour: the first quality is that the *esp2* flour was easier to knead because it was not as sticky as that of wild-type; the second is an improved extensibility of the dough during fermentation; and the third quality is higher plasticity of the dough. Baking tests showed that the bread of *esp2* resulted in a larger volume than the control. The bread also was less prone to collapse during the cooling time after baking (Fig. 3). We speculate that storage proteins of *esp2* form gluten-like protein complexes in the ER, which probably improves the extensibility and plasticity of the dough. We plan to evaluate further the characteristics of *esp2* flour on a commercial scale.

Reference

Onda Y, Kumamaru T, Kawagoe Y (2009) ER membrane-localized oxidoreductase Ero1 is required for disulfide bond formation in the rice endosperm. *Proceedings of the National Academy of Sciences of the United States of America,* **106**: 14156–14161.

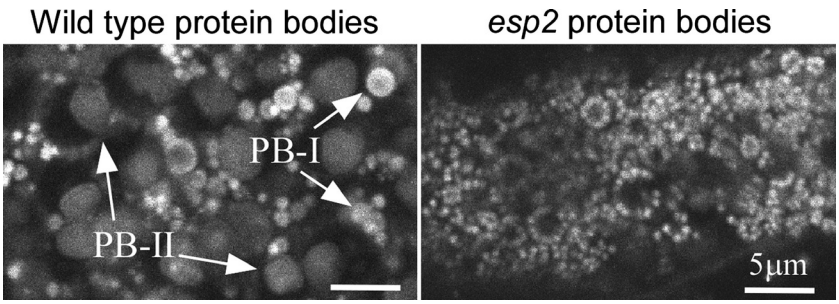

Fig. 1 The *esp2* endosperm develops small particles containing storage proteins.
The wild-type endosperm develops two types of protein bodies: PB-I contains prolamins and PB-II stores glutelins and γ-globulin. In contrast, the *esp2* endosperm develops small particles.

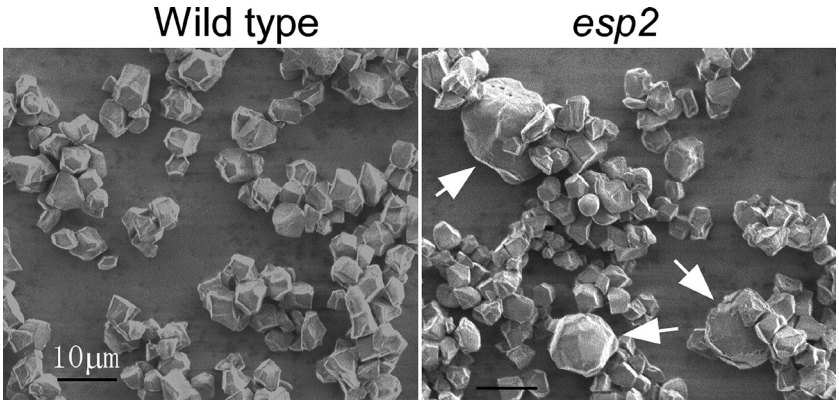

Fig. 2 Starch granules purified from wild-type and *esp2*
Wild type rice synthesizes compound granules consisting of up to several dozens of sharp-edged granules. In contrast, some, but not all, starch granules purified from *esp2* are much larger than those of wild type (arrows).

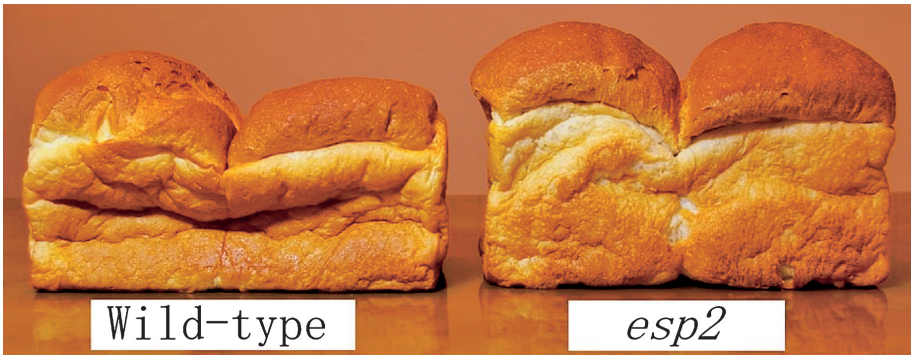

Fig. 3 Superior breadmaking quality of the *esp2* flour
Rice flour (70%) of wild type or *esp2* were mixed with wheat gluten (30%), and compared for breadmaking quality. The bread made from wild type flour (left) showed a prominent hollow region during the cooling time after baking, whereas the *esp2* bread (right) did not collapse, indicating that the *esp2* dough has a high plasticity.