Rethinking Rice: Low-GI Rice and Challenges Ahead

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India is home to the second-largest number of people with diabetes in the world, following China. The increasing risk of diabetes is often seen as a "ticking time bomb" due to its rapid global rise and severe long-term health impacts. According to the International Diabetes Federation (IDF), India had an estimated 77 million diabetics in 2019, which is expected to rise to 101 million by 2030 and 134 million by 2045. Urbanization has led to greater consumption of processed foods high in sugars and unhealthy fats. Upon digestion, a diet that is rich in carbohydrates tends to cause a rapid and pronounced increase in blood glucose levels (hyperglycemia). The glycaemic index (GI) is a measure of the effect of food on blood glucose levels upon digestion. Alternatively, GI is also defined as the ratio of the incremental areas under the glucose response curve after the standard amount of glucose from the test food relative to that of control food (glucose or white bread) is consumed (Venn & Green, 2007). It ranks foods on a scale from 0 to 100, with lower numbers indicating a slower release of glucose into the bloodstream. Foods with a low GI, typically 55 or less, cause a gradual rise in blood sugar, while medium GI foods, with scores between 56 and 69, have a moderate effect. High GI foods, scoring 70 or above, lead to a rapid spike in blood sugar. Factors such as the type of carbohydrate, fiber content, fat, protein, and food preparation methods can influence a food's glycaemic index. Low GI foods are proven and often recommended for sustained energy and better blood sugar control, especially for individuals with type-2 diabetes or those aiming for long-term health benefits (Zafar *et al.*, 2019).

Starch Composition and Its Impact on Blood Glucose

Rice grain with 70-80% of it is starch composed of amylose and amylopectin which are linear and branched polysaccharides respectively. Amylopectin is digested more quickly because its branched structure offers multiple points where enzymes like amylase can attack, breaking down both α (1→4) and α (1→6) bonds. Hence, it causes a quicker and larger spike in blood glucose compared to amylose, which leads to a slower, more sustained release of glucose. South Asian and Middle Eastern cultivars are rich in amylose whereas Japanese and Chinese populations prefer to use sticky rice which is low in amylose. Sticky rice rich in amylopectin gets digested faster and raises blood sugar levels swiftly hence has a higher GI value of 80 or more, whereas most Indian cultivars have between 50 and 70 (moderate to low GI) which greatly varies with the cultivar, the extent of processing and many more other factors. Starch is also classified as: rapidly digestible starch (RDS), slowly digestible starch (SDS), and resistant starch (RS). RDS, which is digested within 20 minutes, leads to a rapid rise in blood glucose levels. SDS takes 20 to 120 minutes to digest, resulting in a slower release of glucose. RS, the indigestible part of starch, is fermented in the large intestine after more than 120 minutes and can aid in managing diabetes by regulating the GI.

Polished Rice and the Quest for Low-GI Varieties

More than 99% of the rice consumed in India is white or polished rice because of its greater palatability and storability but it usually comes under the high GI range. RDS typically makes up a significant portion of starch in polished rice followed by SDS and RS. Polished rice will have a higher GI compared to parboiled rice and brown rice as the removal of the bran layer makes starch easily accessible for the enzymes. The parboiling process leads to gelatinization and starch retrogradation which increase the RS content. Similarly, brown rice retains its bran layer, which is rich in dietary fiber which slows down the digestion and absorption of carbohydrates. If one can develop varieties that exhibit low GI even after polishing, it can reach a huge population in less time. Increasing the amylose content and/or the chain length of amylose and/or amylopectin may increase the RS content and lower the GI (Sivakamasundari *et al.*, 2022). In relation to this, several high amylose mutants, and floury mutants have been characterized already but unfortunately, their pleiotropic effect leads to reduced yield (lower grain weight), increase in chalkiness, increased gelatinization temperature, and increased hardness which has made them difficult to utilize for low GI breeding. Recently, scientists identified significant QTLs *qGI2.1/qAC2.1* and *qPC2.1* contributing to ultralow to low GI and high protein content respectively. The QTL *qGI2.1/qAC2.1* comprised many candidate genes out of which *OsSBEIIb* explained about 57.8% of phenotypic variance towards GI which was then confirmed by CRISPR/Cas9-

Mediated *OsSBEIIb* mutagenesis. The research also identified a significant difference in amino acid and lipid accumulation in high and low GI lines which probably indicates the involvement of these pathways. The High amylose-high protein RILs developed contained high amylose and RS content and surprisingly had yields comparable to high-yielding varieties (Badoni *et al*., 2024). So, these lines could be utilized to integrate the trait into some of the popular varieties cultivated widely in different countries.

Conclusion

The development and introduction of low-GI rice varieties hold significant promise in combating the rising incidence of diabetes, especially in regions where rice is a staple food. By modifying the starch composition to increase amylose content and resistant starch, these varieties can slow down the digestion process, resulting in a more gradual release of glucose into the bloodstream. This helps in managing postprandial blood sugar spikes, a crucial factor in diabetes control. As part of nutrition therapy, low glycemic index (GI) foods, particularly rice, which is a widely consumed staple, play a significant role in both the prevention and management of diabetes. If 50% of at-risk individuals in India were to adopt low and ultra-low GI rice, it could prevent up to 20 million new cases of diabetes in the next ten years. The widespread use of low-GI rice has the potential to reduce the prevalence of diabetes by 25-40% by 2035. However, the challenge lies in maintaining yield, grain quality, and palatability. Recent advances, such as the identification of key QTLs and successful CRISPR/Cas9 interventions, have paved the way for creating high-amylose, low-GI rice without compromising yield. Scaling these innovations can provide a sustainable dietary intervention to reduce diabetes risk in high-consumption areas and can definitely has the potential to become the next big thing after Basmati.

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