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GENETIC IMPROVEMENT OF RICE QUALITY THROUGH MARKER ASSISTED BREEDING —AN OVERVIEW

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Improving rice nutritional value is important since rice feeds nearly a half of the world's population.Rice is the main component of diets in many parts of the world, including Asia. In these regions, widespread malnutrition occurs. High protein rice can be used as a vehicle to remediate malnutrition problems worldwide. Grain protein content is an important component that determines a nutritional value of rice. Improving protein content in rice will help enhance its nutritional profile. The availability of high protein rice varieties will provide a solid bottom line that can be used to help solve the worldwide malnutrition problem across social, cultural, and economic issues. The bran layer of the whole-grain rice contained various health-beneficial component. Genetic enhancement for oryzanol is very important to increase the nutritional value of rice. Therefore, acquiring knowledge of the genetic diversity and relationships among landraces germplasm is very important. Studies of genetic diversity using molecular markers are necessary to understand the genetic relationships and structures of populations and to orientate effective strategies of landraces germplasm conservation. Whole-grain rice cereals are examples of potential markets that emphasize the nutritional quality of rice. Because rice is the staple food of diverse populations from various cultures and religious backgrounds, it can be used to reach to almost any target population.Rice is acceptable in any religious belief or vegetarian population. Rice provides a source of carbohydrates. It is also a natural source of dietary fiber, vitamins, minerals, specific oils and other disease-fighting phyto-compounds. Continuing advancements in nutrigenomics and nutrigenetics will help improve public knowledge of the importance of specific aspects of food nutrition for optimum fitness and health. Improving the nutritional values of rice becomes increasingly important. Through a better understanding of the molecular breeding approaches rice genetic improvement is becoming more attainable.

DNA-based molecular markers : DNA marker is a small region of DNA sequence showing polymorphism between different individuals. They arise from different classes of DNA mutations such as substitution mutations (point mutations), rearrangements (insertions or deletions) or errors in replication of tandemly repeated DNA. These markers are selectively neutral because they are usually located in non-coding regions of DNA. DNA markers are the most widely used type of marker predominantly due to their abundance. Unlike morphological and biochemical markers, DNA markers are practically unlimited in number and are not affected by environmental factors and/or the developmental stage of the plant. The DNA markers are PCR based and non PCR based. PCR-based markers are more attractive for MAS, due to the small amount of template required and more efficient handling of large population sizes. AFLP, RAPD and Sequence tagged site (STS) are dominant markers, which limits its application for differentiation of homozygous and heterozygous individuals in segregating progenies. Among the DNA markers, the most widely used markers in major cereal crops are SSRs or microsatellites and SNPs.

Marker Assisted Breeding : Marker assisted evaluation of breeding materials involves cultivar identity, assessment of purity and genetic diversity, parental selection, study of heterosis and identification of genomic regions under selection. MAS refer to the use of DNA markers that are tightly-linked to target loci as a substitute for or to assist phenotypic screening. These DNA markers should reliably predict phenotype. By determining the allele of a DNA marker, plants that possess particular genes or quantitative trait loci (QTLs) may be identified based on their genotype rather than their phenotype. A marker can either be located within the gene of interest or be linked to a gene determining a trait of interest, which is the most common case. Thus MAS can be defined as selection for a trait based on genotype using associated markers rather than the phenotype of the trait.

Molecular markers can be used in many steps of a rice breeding program, e.g. germplasm characterization, pedigree and evolution studies, parental selection for crossing, test for F_1 hybrid confirmation, test for genetic purity of seeds, cultivar protection, breeding strategies establishment, linkage map construction, and mapping of genes and QTLs associated with biological processes. Marker assisted breeding play an important role in rice quality improvement.

Rice Grain Quality : Grain quality of rice is the totality of features and characteristics of rice or rice product that meets the demand of end-user. The concept of grain quality covers many features ranging from physical to biochemical properties, and includes milling efficiency, grain shape and appearance, cooking easiness, eating palatability, and nutrition. Thus, rice grain quality generally includes four classes, i.e. milling quality, appearance quality, cooking and eating quality, and nutritional quality. Grain quality and its assessment are not only important to consumers, end-users, processors, but also to rice breeders who are engaged in creating rice varieties haboring new features such as high quality, high yield potential, highly resistant to abiotic or biotic stresses. It is necessary for rice breeders to understand how the quality traits are inherited from their parents. Genetic studies have revealed many genes and quantitative trait loci (QTL) for grain quality, though the grain quality traits are complex. Furthermore, rice quality affects the market value, given that better quality rice is able to fetch a higher premium. Indian basmati rice and Thai jasmine rice are highly priced due to their distinctive aroma when cooked. The growing income and food diversification in Asian countries such as China (Summer *et al.,* 2001) and some European countries (Ferrero and Nguyen 2004) have led consumers to prefer better quality rice.

Milling Quality : Milling quality is assessed by brown rice recovery, milled rice recovery and head rice recovery, which is one kind of complex quantitative trait whose genetic control is poorly understood. Up to date, no major gene has been genetically identified and functionally characterized. However, many studies have been carried out to search quantitative trait locus (QTL) for the milling quality (Tan *et al.* 2001, Jiang *et al.* 2005, Lou *et al.* 2009, Nelson *et al.* 2012). These researches improve our understanding of the genetic control of milling quality, and provide molecular markers that are useful in breeding for improvement of milling quality in rice.

Grain size and shape : Grain shape is not only key determinant of grain quality but also of grain yield potential. A long, slender grain of rice is generally preferred by consumers in Northern India, USA, and South and Southeast Asian countries, whereas consumers in Japan, Korea, and Northern China prefer short or round grain of rice.

Grain Chalkiness : Chalkiness is a major concern in rice breeding because it is one of the key factors in determining quality and price. The chalky endosperm consists of loosely packed, round and large compound starch granules while the translucent endosperm comprises tightly packed, polyhedral and small single starch granules. The chalky grains show significantly different physicochemical, morphological, thermal, cooking and textural properties from translucent grains.

Cooking and eating quality : Cooking and eating quality is the easiness of cooking as well as texture, springiness, stickiness and chewiness of cooked rice. These characteristics are controlled by starch physicochemical properties comprising of apparent amylose content (AAC), gelatinization temperature (GT), gel consistency (GC) and paste viscosity properties. Starch makes up about 90% of the rice grain.

Amylose content and gel consistency : Amylose content is usually referred to as apparent amylose content (AAC) in literature because the iodine-based assay used for measuring it often detects long-chain amylopectin in addition to the “true” amylose. AAC is the most important element influencing the cooking, eating and processing characteristics of rice. The AAC of rice is known to play a crucial role in determining its cooked texture. It is directly related to water absorption, volume expansion, fluffiness and separability of cooked grains and inversely related to cohesiveness, tenderness and glossiness. Typically, cereal grains contains 20–30% amylose with the remainder (70–80%) being amylopectin. Rice can be classified based on its amylose content: waxy rice (0–2% amylose), very low amylose (3–9%), low amylose (10–18%), intermediate amylose (19–23%) and high amylose (>23%). Synthesis of amylose is catalyzed by the granule-bound starch synthase (GBSS) protein which is encoded by the*waxy* gene *(Wx)*.

Gelatinization Temperature : Gelatinization temperature (GT) is the range of temperature wherein at least 90% of starch granules swell irreversibly in hot water with loss of crystallinity and birefringence. GT ranges from 55 to 85°C and determines the cooking time of rice. According to Tian et al., “GT is a physical-chemical property which directly reflects the cooking quality of rice grain in terms of energy and time needed for cooking”. Cooking time for rice can be reduced by up to four minutes by lowering the GT of the grain. GT of rice can be classified as low (55–69°C), intermediate (70–74°C) or high (75–79°C). GT also plays an important role in water uptake, volume expansion and kernel elongation of cooked rice. For example, high GT rice elongates less and is likely to be undercooked when standard cooking procedure is applied but its texture could be softened through overcooking. Although rice grain quality preferences differ around the world, varieties with intermediate GT are generally preferred. GT is predominantly determined by amylopectin structure. Three classes of enzymes including starch synthase, starch branching and starch de-branching enzymes have been implicated in the synthesis of amylopectin. The gene, Starch synthase II (*SSIIa*) has been found to be the major determinant of GT.

Protein content and amino acid : Grain protein content is an important component that determines a nutritional value of rice. And, Protein deficient rice increase malnutrition where their dietary intake is mainly on rice and these staple crops have low levels of essential amino acids. Improving protein content in rice will help enhance its nutritional profile. Recent trends indicate that developing healthy lifestyles is an increasingly important goal for many. High-protein grains can provide the base for developing novel foods and fibers or nutrient-dense food products that can be tailored as functional foods to meet the needs for individuals with specific genetic traits. Grain amino acid content protein is made of amino acids. Similar to other cereals, rice has imbalanced amino acid profiles, lacking a few essential amino acids. Lysine, threonine and methionine are among the most critical and are limiting factors in rice grain for human nutrition.

Breeding for fragrance : Fragrant rice varieties, such as basmati and jasmine, are of great interest to consumers due to their distinctive flavor. Researchers have identified many chemical compounds that contribute to the fragrance of fragrant rice of the identified chemical compounds, 2-acetyl-1-pyrroline (2AP) has been found to be the most significant compound in conferring fragrance to fragrant rice. The elevated levels of 2AP in fragrant rice are thought to be due to a deletion within exon 7 (Bradbury *et al*., 2005a; Amarawathi *et al.,* 2008 or exon 2 of the gene encoding the enzyme betaine aldehyde dehydrogenase (BADH2), which is located on chromosome 8. These mutations render BADH2 non-functional, resulting in the accumulation of 2AP (Bradbury, *et al.,* 2005a, b, 2008).

Combining grain quality with other traits : Breeding is working for not only one trait, but all the traits for the formation of a new variety. In addition to grain quality traits, yield and other agronomic or resistance traits are also very important. For those rice cultivars already have good quality, the objective of MAS is to combine the important quality traits with other traits. There are special cases for basmati and jasmine rice which have premium grain quality, and have been widely accepted by consumers worldwide. MAS has been carried out to introduce bacterial blight resistance, blast resistance, brown planthopper resistance tolerance and plant stature genes into the basmati or jasmine rice.

REFERENCES

1. Wendy, C.P. Lau; Mohd. Y. Rafil; Mohd. R. Ismail, Adam Puteh, Mohammad A. Latif and Asfaliza Ramli (2015). Review of functional markers for improving cooking, eating, and the nutritional qualities of rice. *Front. Plant Sci.*
2. Kumar, P., Gupta, V.K.; Misra, A.K.; Modi, D.R.; Pandey, B.K. (2009).
3. Tautz, D.; Trick, M.; Dover, G. (1986). Cryptic simplicity in DNA is a major source of genetic variation. *Nature 322 :* 652–656.
4. Maxwell Darko Asante https://www.intechopen.com/books/advances-in-international-rice-research/breeding-rice-for-improved-grain-quality
5. Sumner, D.A.; Rozelle, S.D.; Huang, J. and Lee, H. (2001). The China Market for Rice: Current Status, Recent Trends, and Projections, with Emphasis on the Potential for Imports from the United States and Potential for External Competition with U.S. Rice. Davis, CA: A Research Study for the USA Rice Federation
6. Ferrero, A. and Nguyen, N. (2004). Constraints and opportunities for the sustainable development of rice-based production systems in Europe. *FAO Rice Conf.* 43, 12–13.
7. Bradbury, L.M.T.; Fitzgerald, T.L.; Henry, R.J.; Jin, Q. and Waters, D.L.E. (2005a). The gene for fragrance in rice. *Plant Biotechnol. J.* 3, 363–370.
8. Bradbury, L.M.T.; Henry, R.J.; Jin, Q.; Reinke, R.F. and Waters, D.L.E. (2005b). A perfect marker for fragrance genotyping in rice. *Mol. Breed. 16,* 279–283.
9. Bradbury, L.M.T.; Gillies, S.A.; Brushett, D.J.; Waters, D.L.E. and Henry, R.J. (2008). Inactivation of an aminoaldehyde dehydrogenase is responsible for fragrance in rice. *Plant Mol. Biol. 68,* 439–449. doi: 10.1007/s11103-008-9381-x

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