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INTERNATIONAL RICE RESEARCH INSTITUTE

Rice Grain Quality

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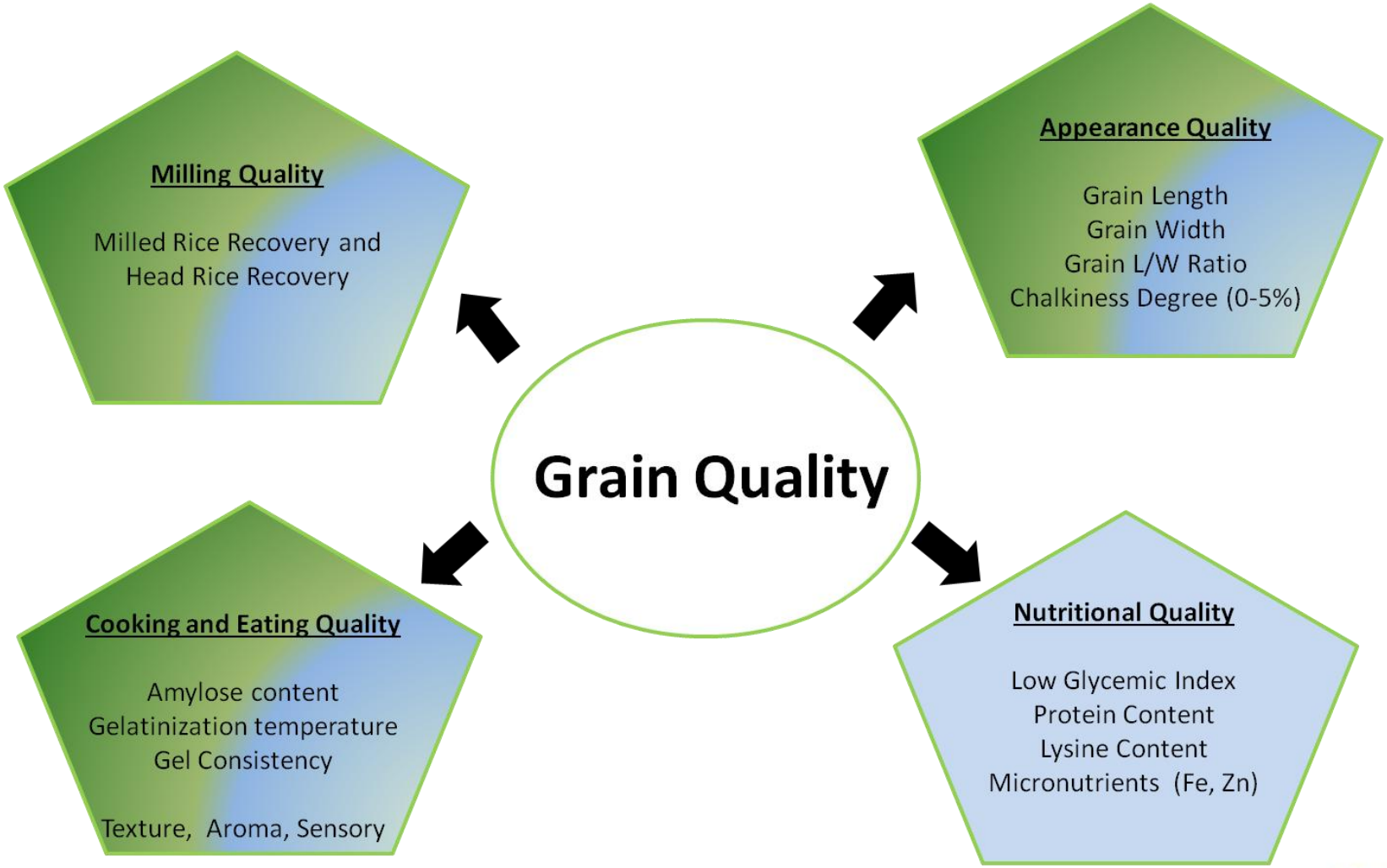
IRRI, Los Banos, March 26th, 2015

Rice Science for a Better World

Market opportunities for grain quality classes:



Seed Industry

Public inerest (academic)

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Hybrid rice and grain quality

Hybrid rice is an important market segment in seed industry grown from 1% in 2003 to 40% in 2012 in USA alone. Trend is similarly overwhelming in developing countries too.

Key benefits of hybrid rice is substantial elevation of yield by 15-20% not only under ambient conditions but also under challenging environments and thus good economic returns.

Yield advantage has to be met with acceptable grain quality – a key to ensure success.

Farmers has to meet higher price tag for hybrid rice and thus demands better revenues and one major avenue is improving grain quality with high yield stability.

Hybrid rice and grain quality

The major challenge we observe in hybrids is reduced head rice recovery (HRR) and enhancement of chalk

In F1 hybrids we have to deal with segregation in filial endosperm where key grain quality parameters such as HRR, as well amylose and cooking quality is highly variable.

Consumption of whole grain in rice need to deal with genetic segregation of endosperm for grain quality attributes.

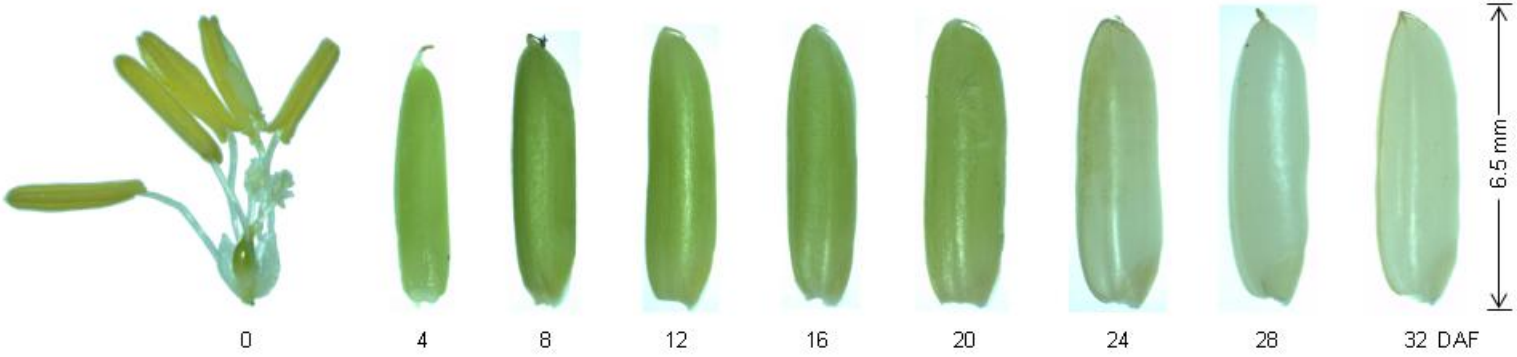
How can we overcome the problems ?

- Uniform amylose for improving cooking quality
- Reducing chalk and improving head rice recovery

Grain quality parameters are affected by environment during seed development

Control

0-8 DAF	12-28 DAF	29-32 DAF
Determines grain length mainly by pericarp growth	Determines storage efficiency of endosperm (starch and storage proteins) Role of aleurone in accumulating lipids, antioxidants, and micronutrients	Embryo desiccation
4-8 DAF		
Determines endosperm sink strength		



Under stress

0-8 DAF	9-16 DAF	17-22 DAF	23-30 DAF
No prominent evidence of grain length impact under stress Endosperm cellularization is affected, and thus reducing grain width	Chalk formation is triggered Impairment in starch (amylose) accumulation	Alteration in starch structure (amylose-amylopectin ratio) Storage proteins are affected	Early trigger of embryo desiccation Early trigger of programmed cell death in endosperm

Reduced sink strength (lowered endosperm cells)	Reduced seed filling duration (altered storage composition)	Impact on dormancy

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Grain quality:

Physical traits role in breeding

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Food security in rice: How can we improve head rice yield recovery through genetics ?

Post harvest loss prevention + Grain Quality = Milled rice yield

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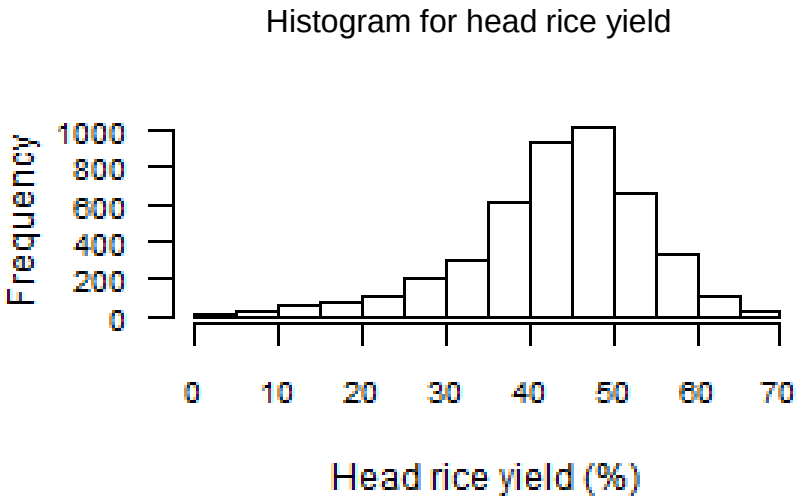
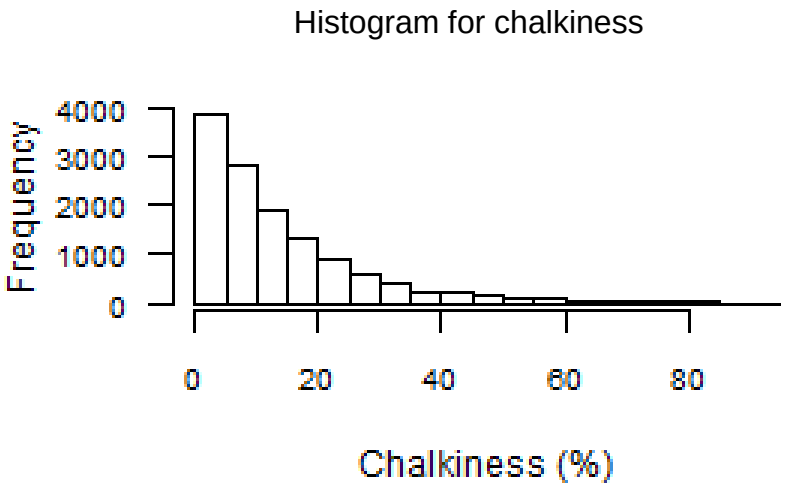
Grain quality diversity in the breeding pool

Grain quality repository from 100,000 lines: represent huge Genetic diversity





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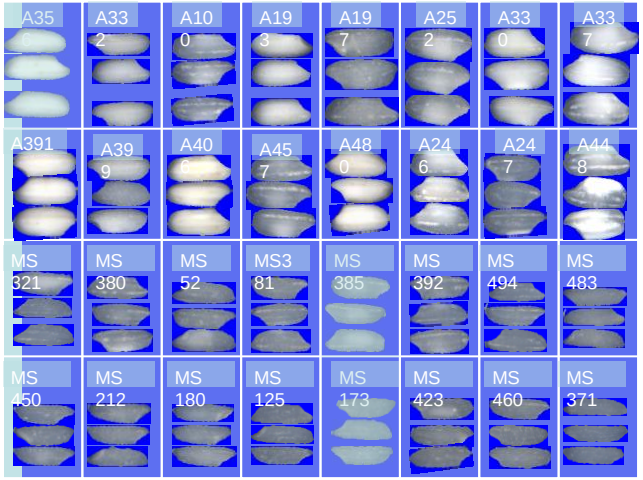
What we know about chalk ?



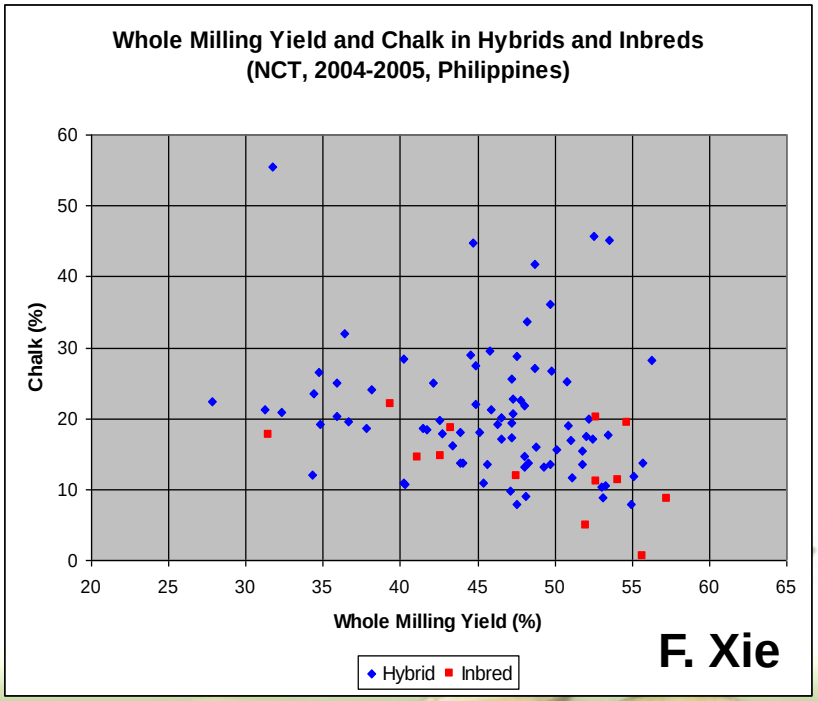
Chalkiness is the opaque portion of the white endosperm that is associated with loose packing of starch. Chalk is associated with high levels of damage to the kernel and hence results in low milling yields

chalk relevance in hybrid rice ?

We need to work towards reducing Chalk in hybrids.

•Select better germplasm with reduced chalk under multi-environments as source of inbreds for creating hybrids

•Utilize functional markers to reduce chalk



Genetic basis of chalk

Chalk phenotype is induced by abiotic stress impact, all of those traits impose direct consequence on chalk trait.

More than 140 QTLs were reported for the character chalkiness on chromosomes 1, 2, 4, 5, 8, 10 and 11, mostly among Asian cultivars (Tan et al. 2000, Li et al. 2003a, Wan et al. 2005).

M**any of them are not reproducible** either due to

(i) environmental influences and/or

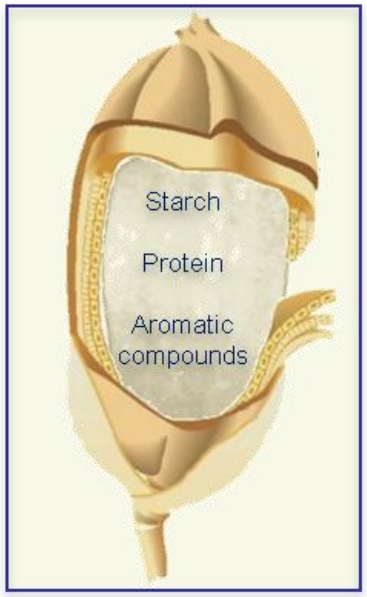
(ii) specialized genetic background used in bi-parental mapping population.

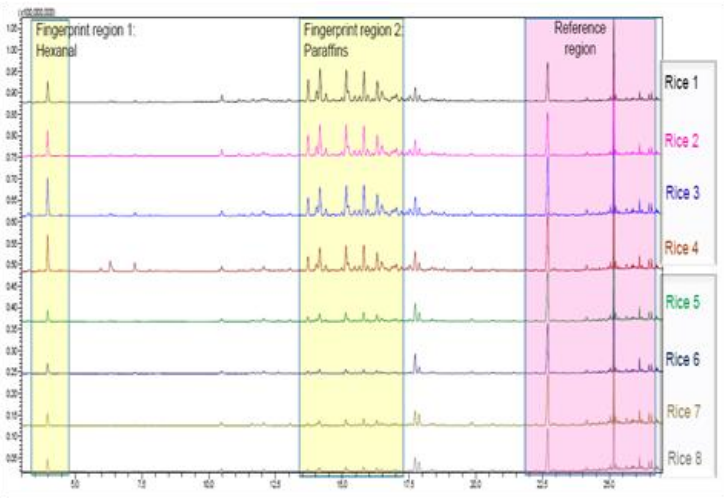
IRRI is using GWAS strategies to identify diagnostic markers to reduce chalk in rice breeding programs.

Grain quality:

Cooking quality role in breeding

Phenotyping platforms for evaluating grain quality @ IRRI





Physical quality

- Chalk
- Head rice yield
- Size and shape

Biochemical composition

- Amylose content
- Gel temperature
- Gel consistency
- Viscosity
- Aroma

- Primary metabolic signatures
- Aromatic profiling

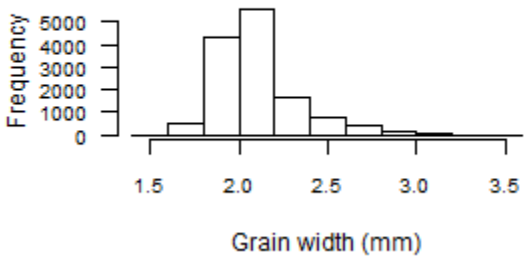
Cooking quality

- Sensory panelists
- Rheology & texture
- Exploring high-throughput technology-based sensory profiling

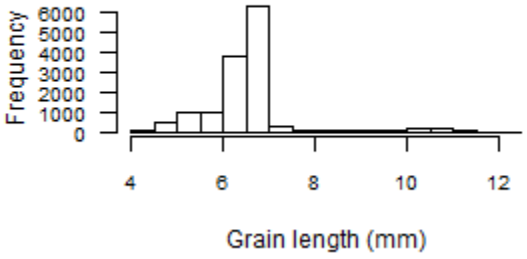
Grain quality diversity in the breeding pool

Grain quality repository from 100,000 lines: represent huge Genetic diversity

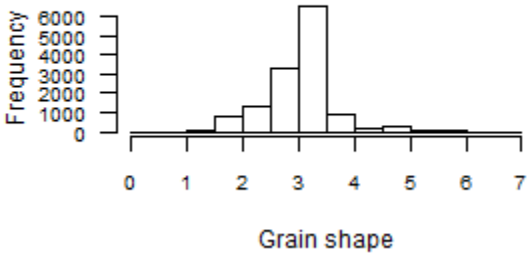
Histogram for grain width



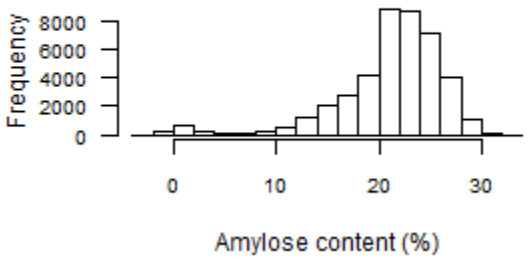
Histogram for grain length



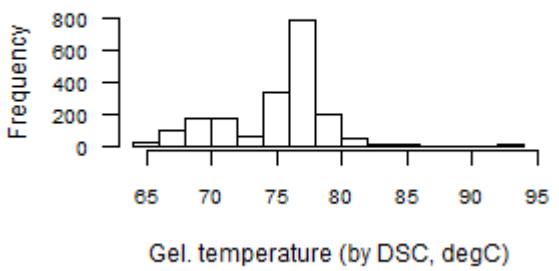
Histogram for grain shape



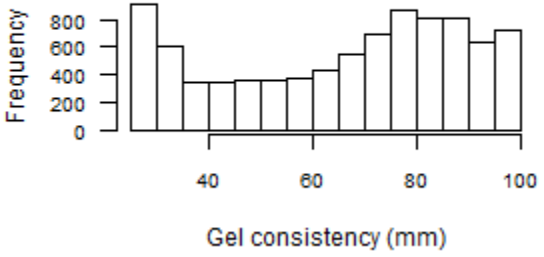
Histogram for amylose content



Histogram for gelatinization temperature (by differential scanning calorimetry)



Histogram for gel consistency



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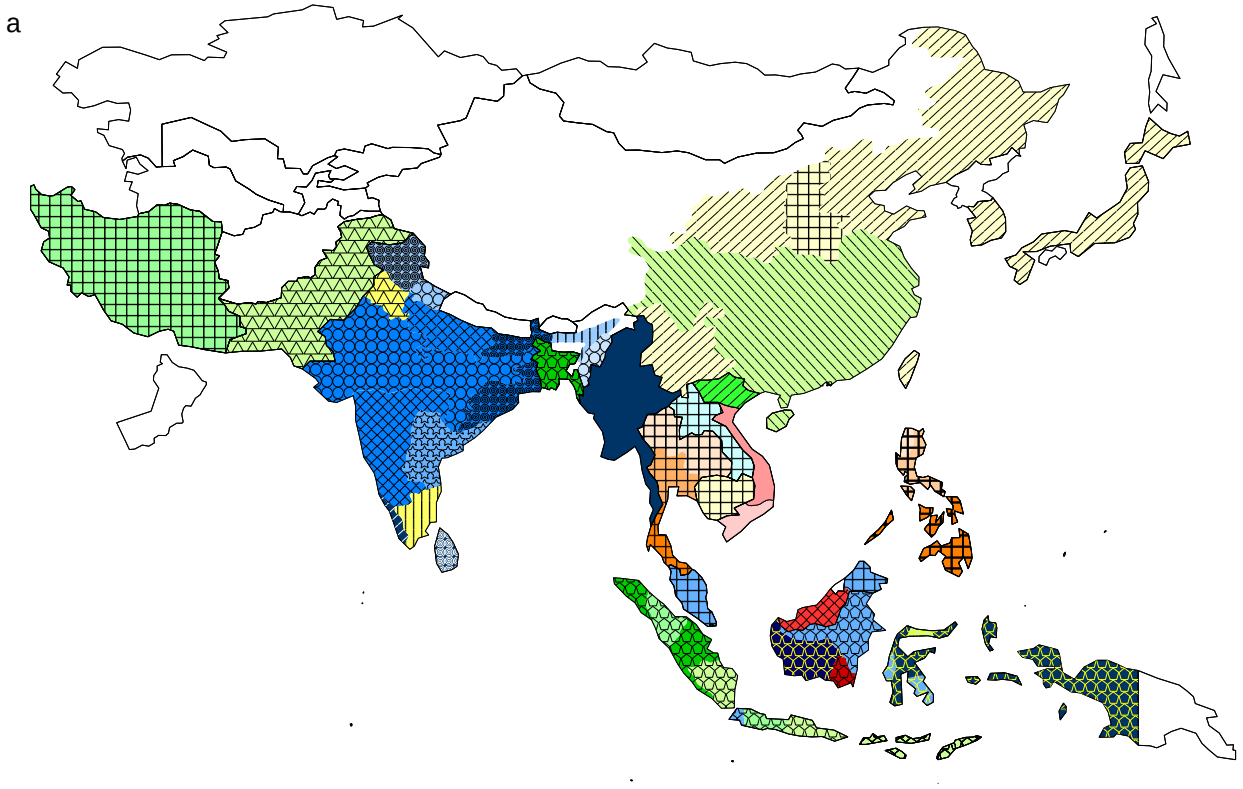
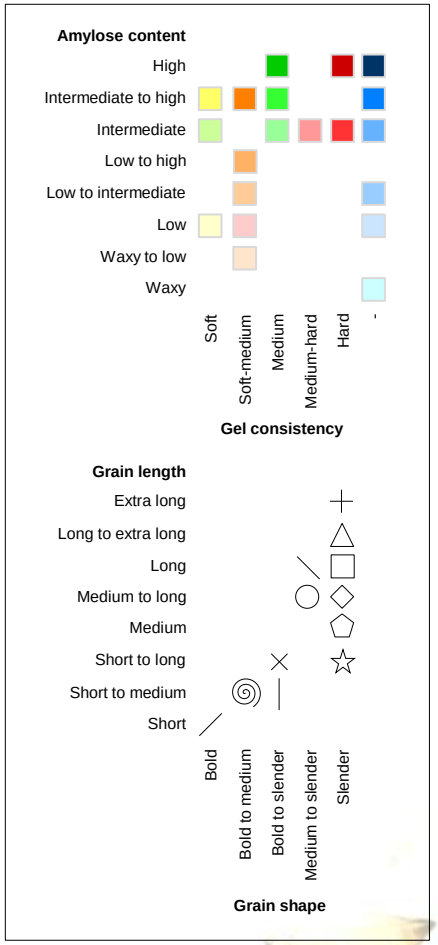
IRRI‘s Breeding material matching regional quality preferences





Modified from Calingacion et al.,
Plos One 2014

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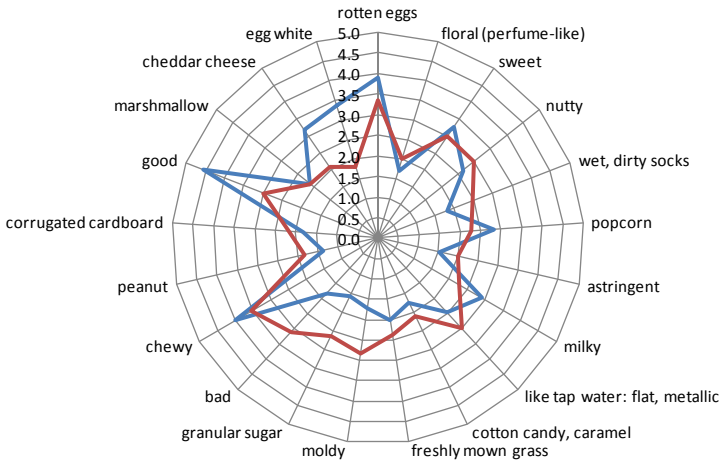
How to bridge grain quality measures with Sensory preferences ?



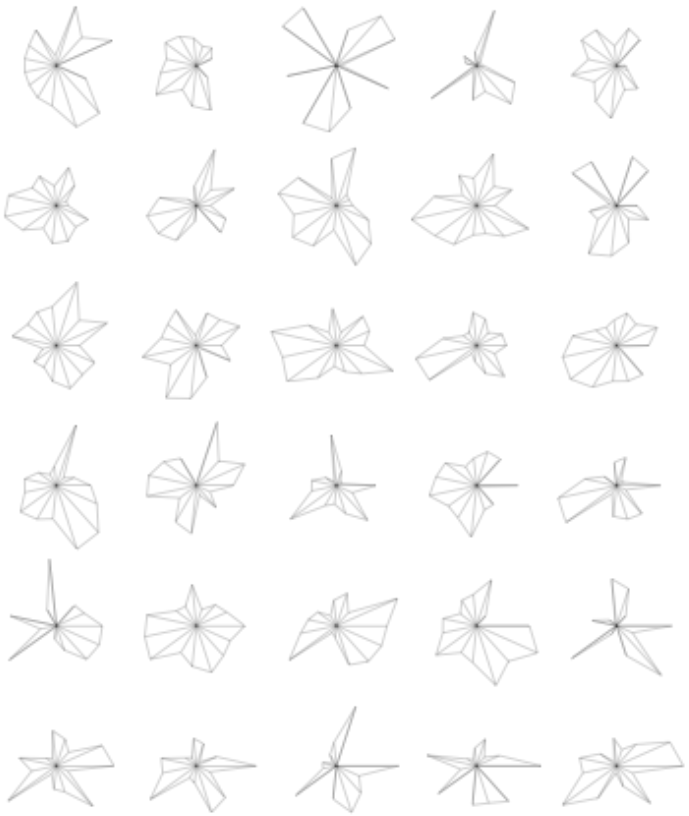
What distinguishes these two mega varieties

Quality Parameter	 Samba Mahsuri	 Swarna
AAC (%)	24.0	24.2
GT (°C)	75	75

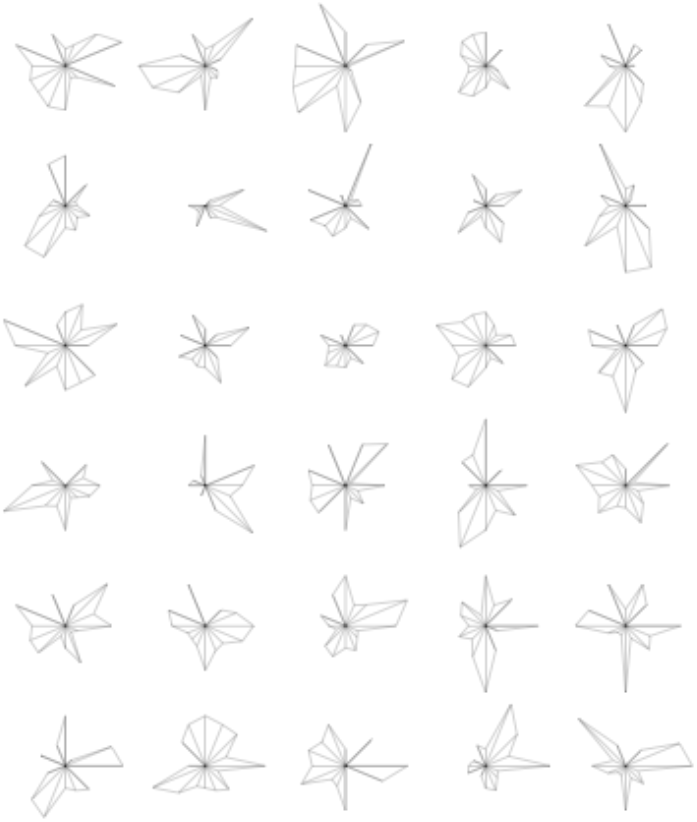
13/16 panelists were able to differentiate the two varieties in a sensory.

Sensory preferences

Sensory profiles of 30 rice varieties representing diversity for quality



(Aroma and taste)

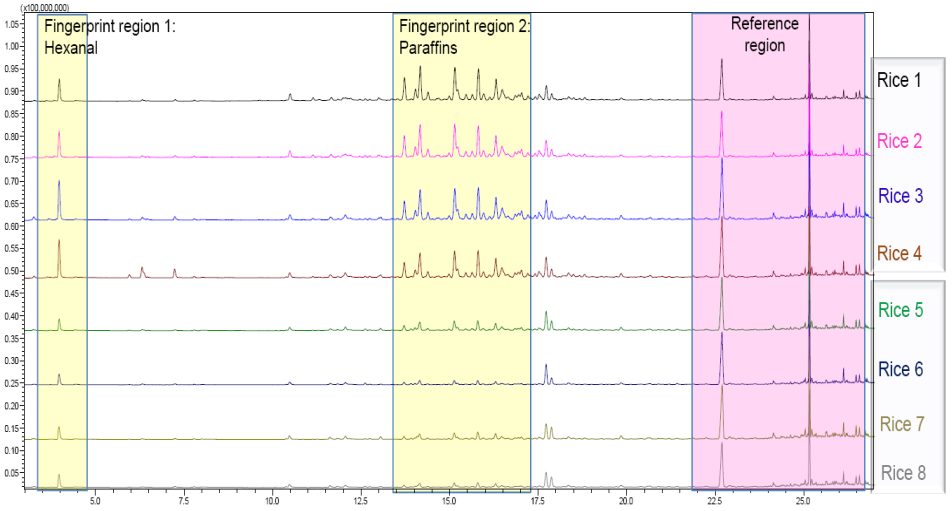


(Texture)

Aroma profiling

Gc-MS/MS platform

Sniffing aroma released from uncooked milled rice treated with KOH.



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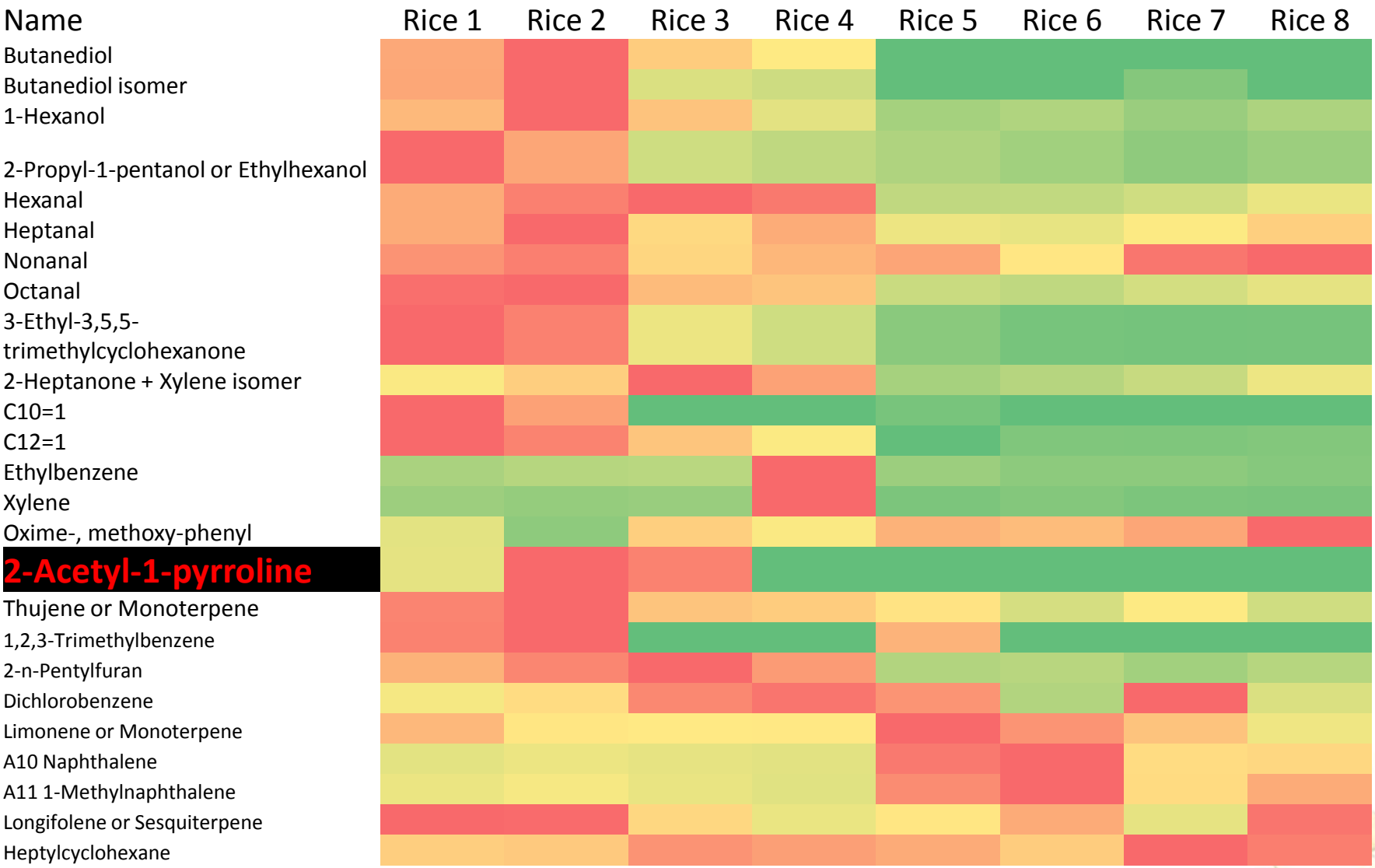
Aroma-inducing compounds differentiating aromatic rice from non-aromatic rice



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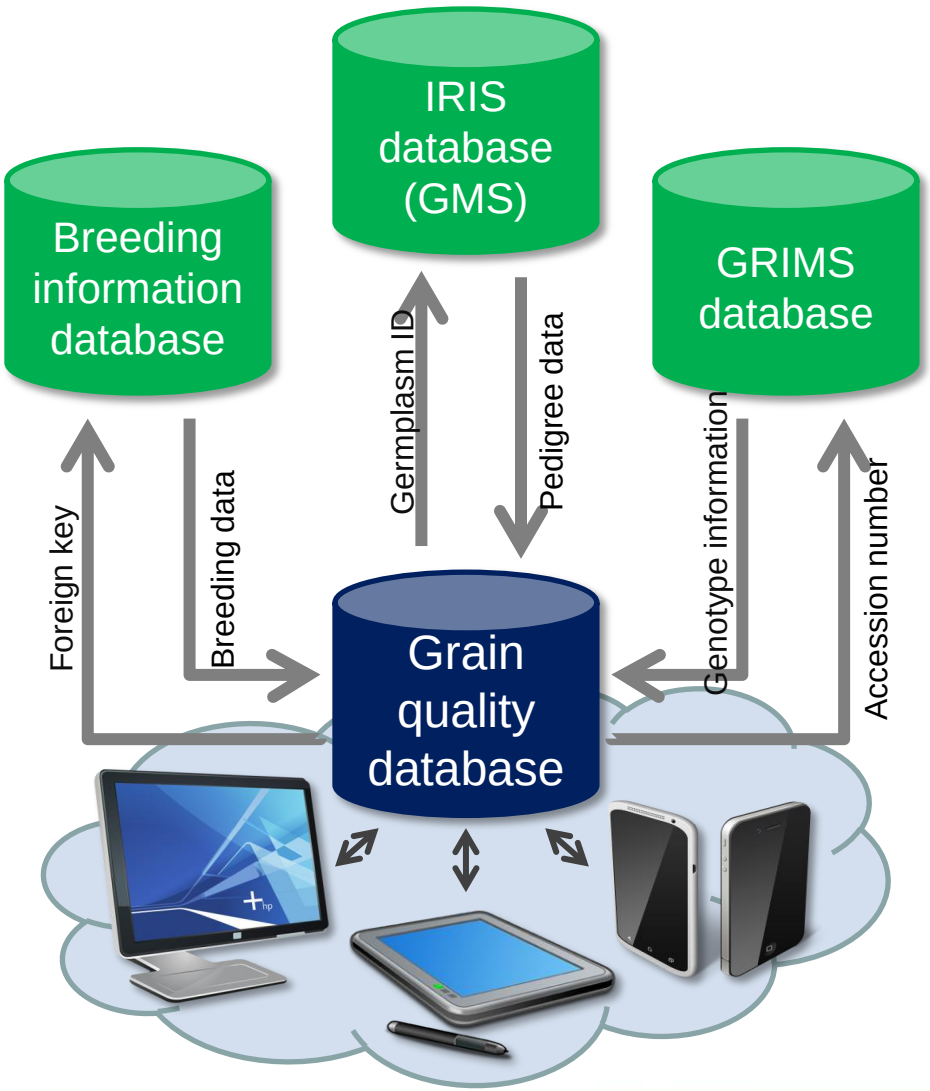
How can we breed diffferent quality classes using post-genomic resources?

Specialty rice with health and nutritional benefits with good eating quality for high-value markets



Genetic basis of grain quality

- Repository contains ~150,000 phenotypic data
- Ideal data-mining resource for multi-discipline research at IRRI
- Mining initial data, we captured 3000 core collection (1000 gene bank + 2000 breeding lines) representing maximum variation among grain quality traits (premium as well health and nutritional attributes)
- Comprehensive grain quality phenotyping for 26 traits done from multi-seasons
- Genome wide association studies to define the genetic basis of grain quality for health and nutritional attributes

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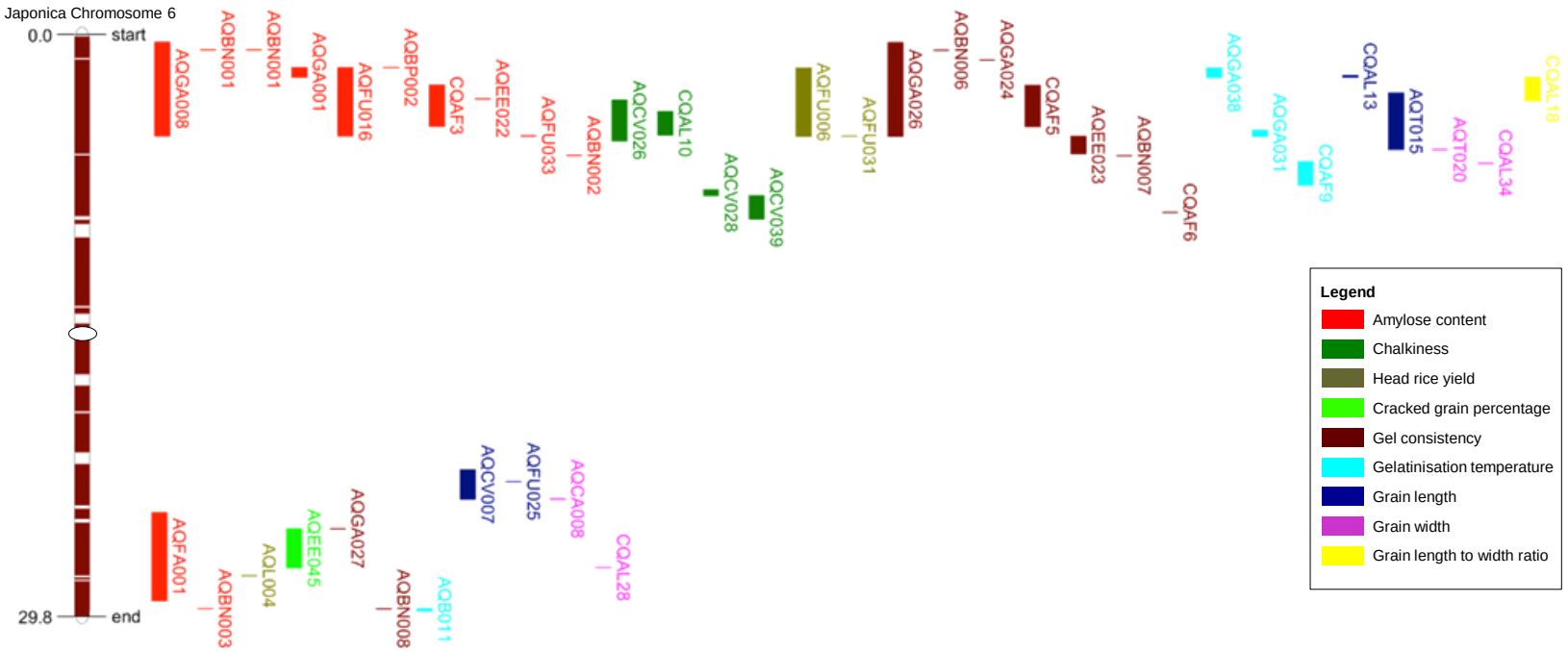
Multiple grain quality QTLs overlap in the hot-spot region



Research Focus to restructure rice breeding for quality segments

Capturing quality oriented market demand

- Market survey of consumer preferences: emphasizing the importance of grain quality segment
- Define country/zone based mega varieties profiling on quality parameters
- Deriving strategies to restructure breeding programs – quality focus

Grain Quality Relevance to Rice Breeding

- Genetic diversity within the IRRI developed breeding material for identifying superior lines for grain quality fitting to various market niches
- Validate grain quality measures through sensory profiling – driving indicators of consumer preferences
- Phenotypic assessments of grain quality preferences through metabolic signatures
- Identification of diagnostic markers reflecting quality segments using 3K genomes (**medium quality and premium quality with emphasis on consumer preferences**)
- Incorporating integrative knowledge in marker assisted selection and genomic selection technologies to hasten the progress in rice breeding pipelines and fine tune premium quality in high yielding background

Sensory evaluation as a tool in understanding rice grain quality (Move beyond amylose)

- Utilizing objective sensory evaluation approaches to establish descriptive profiles of rice for eating quality and to provide more comprehensive definition of grain quality

Platform to address grain quality issues in rice

Diagnostic germplasm kit

- **Right set of breeding material targeting medium to superior quality**
  - Already screened lines of grain quality for immediate usage in the breeding program (Market niches)
  - Value added pre breeding material with increased head rice yield, minimum chalkiness
  - Value added pre breeding material with superior taste validated based on sensory
  - Value added pre breeding material for aroma (validated based on metabolomics profiling)

Breeder's infinium chip

- **Diagnostic marker system/ chip for improvement of hybrid breeding program to identify superior grain quality material**
  - Identification and deployment of molecular markers based on genome wide association studies to identify QTLs of grain quality traits (physical, biochemical and cooking quality)
  - MetaboliteQTL based validated markers of aroma
  - Diagnostic markers for texture and taste

Capacity building

- **Platform to standardize grain quality measurements across member research institutes**
  - standardization of protocols for grain quality testing as per universal/ trade standard of ISO benchmark
  - Training on sampling and quality analysis
  - Grain quality profiling of hybrid and parents: services on exclusive materials of MNCs
  - molecular breeding for grain quality

Services

- **Service Labs for grain quality analysis:**
  - At regional level
  - At country level
- **Screening of hybrid and inbred material**
- Undertake specific project
- Data analysis and decision making
- Consultancy

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