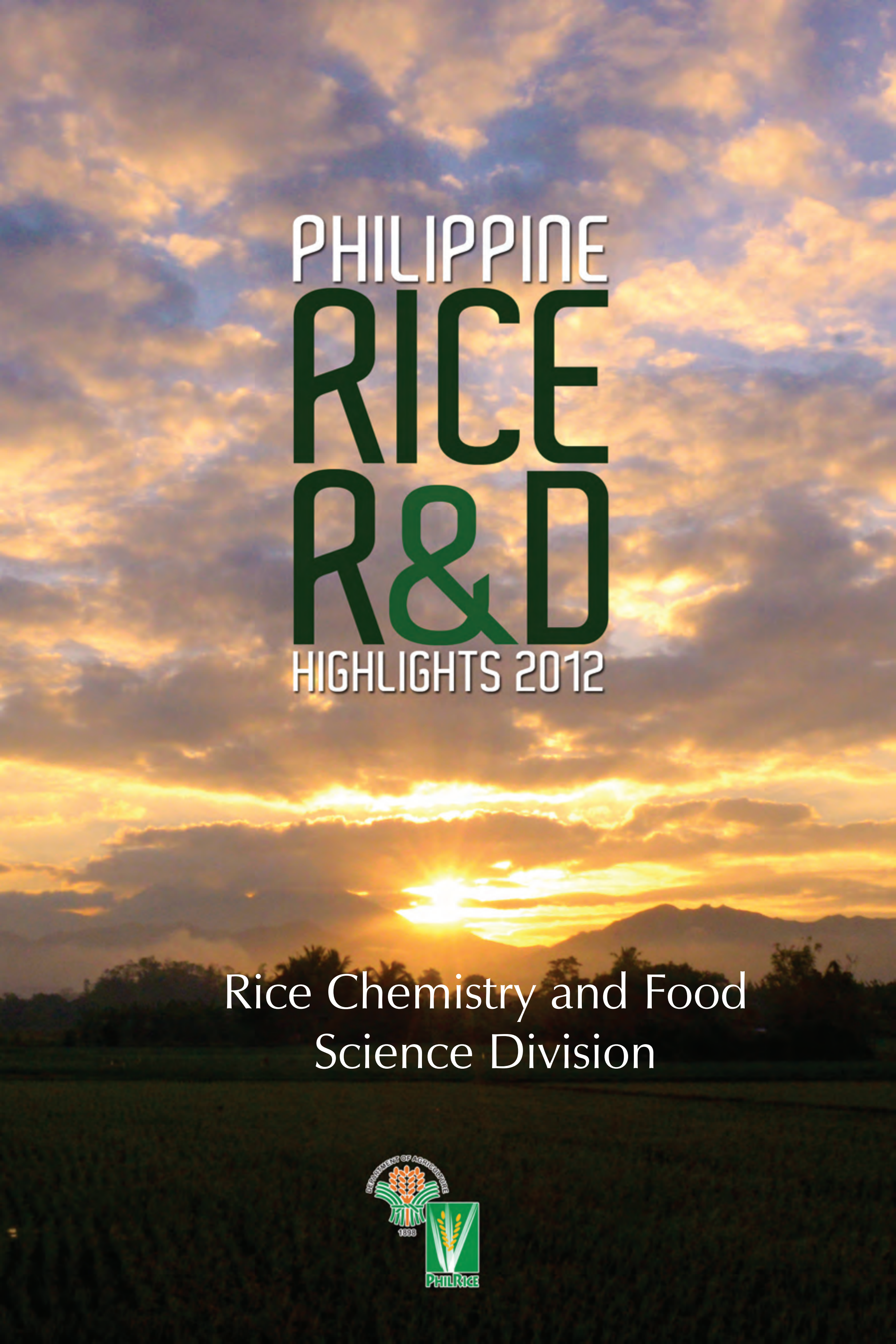

PHILIPPINE RICE R&D HIGHLIGHTS 2012

Rice Chemistry and Food Science Division

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Rice Chemistry and Food Science
Division Head: Rizza Abilgos-Ramos

The team primarily focused on conducting grain quality evaluation (GQ) of rice lines and varieties to assist breeders in identifying promising rice lines for entry into the National Cooperative Test and to advance the GQ assessment methods. The upgrading of methods will not only ensure better accuracy of data but also fast-track varietal screening. Current developments in analytical assessment of quality characteristics of rice and the demand for reliable data by heightened breeding activities further necessitate an immediate updating of grain quality techniques.

The following were our specific tasks and objectives:

- Evaluate early generation rice lines to select promising entries to expedite the screening, thereby reducing cost and maximizing resources
- Identify an ideal amylose content and gelatinization temperature combination for a variety to retain the quality of freshly cooked grain and to remain acceptable even in staled and reheated form
- Study the interrelation of grain dimensions and shape to milling and head rice recovery. It is premised on the possibility of breeding for a specific grain dimension to improve milling and head rice recovery
- Improve amylose determination method for rice and development of an amylose field test kit
- Validate molecular markers for rice eating quality

The accomplishments of the projects showed that most of the targets were achieved. The routine grain quality analyses were all completed and methods were validated.

I. Grain Quality Assessment of Rice Lines and Varieties
JBA Duldulao

Grain quality (GQ) evaluation is the final hurdle rice lines undergo after their yield, disease and insect resistance, agronomic, and other traits have passed set standards. Study 1 of this project covered GQ evaluation of early generation rice lines to select promising entries to expedite the screening, thereby reducing cost and maximizing resources. GQ analysis of lines for irrigated (transplanted and direct seeded), hybrid, and adverse ecosystems was centralized, with a few personnel strictly focused on the task to ensure repeatability and reliability of results.

The project, through Study 2, sought for an ideal amylose content and gelatinization temperature combination for a variety to retain the quality of freshly cooked grain and to remain acceptable even in staled and reheated form.

Study 3 looked into the interrelation of grain dimensions and shape to milling and head rice recovery. It was premised on the possibility of breeding for a specific grain dimension to improve milling and head rice recovery.

Centralized grain quality screening

JBA Duldulao, KB Bergonio, CT Estonilo, and JD Adriano

Grain quality screening (GQS) plays an important role in the rice breeding program of PhilRice. Aside from yield, resistance to pests and diseases, and agro-morphologic qualities, grain quality, which includes milling recovery, physical attributes, and eating properties complete the traits of a rice entry. Integration of GQS in the early rice breeding stages is essential as it trims down the number of lines advanced for further trials, thus reducing cost and maximizing resources. Furthermore, early generation screening may also allow the identification of entries with properties suited for special purposes.

This year, entries from 2011 WS and 2012 DS and WS season in the ultra-early maturing (UEM), direct-seeded (DS), mutant (MUT), advance observational nursery (AON), preliminary yield trial (PYT), drought, and multi-environment trial (MET) were screened for grain quality. The milling quality and apparent eating quality as predicted by the starch properties of the milled rice were evaluated.

Highlights:

- Six hundred sixty four entries from UEM, DS, MUT, AON, PYT, and MET were processed and analyzed for milling recovery and physicochemical properties. Eating quality of the samples was categorized based on apparent cooked rice texture using grain quality clustering of amylose-gelatinization temperature (GT) type by Juliano, BO (2010).

- Out of 664 entries, 602 met the total milled rice recovery standard of grade 1 to premium, but only 51% (308 entries) of these passed the head rice recovery requirement of at least 48% (grade 1 to premium). From each varietal development stage, one entry each from UEM and MUT 2011 WS, 35 from DS 2011 WS and 2012 DS, 53 from AON 2011 WS and 2012 DS, 206 from PYT 2011 WS and 2012 DS, and 12 from drought 2012 DS passed the standards for milling quality (Table 1).

- Most entries (533) met the preferred low to intermediate amylose content of 12-25%. Twenty nine entries from AON 2011 WS were identified as glutinous. Majority of the entries were of low to high intermediate GT type (<70°C -74°C GT).

- Grain quality clustering showed that 95% of the entries (629) are presumably soft to intermediate/medium–textured upon cooking. This indicates good eating quality and acceptability of most of the entries evaluated. Only 36 entries (12 from EUM 2011WS, three from DS 2012 DS, one from AON 2012 DS, 18 from PYT 2012 DS, and two from drought 2012 DS) are presumably hard-textured upon cooking.

- Overall, grain quality screening revealed that one out of 73 entries from AON 2011WS, 17 out of 190 entries from PYT 2011WS, nine out of 29 entries from DS 2012 DS, 41 out of 78 entries from AON 2012 DS, 46 out of 151 entries from PYT 2012 DS, and four out of 32 drought 2012 WS entries satisfied all the requirements for milling, physical, and (apparent) eating qualities as set by the National Seed Industry Council. No entry from UEM 2011 WS, DS 2011 WS, and MUT 2011 WS satisfied the grain quality requirements. MET entries were noted to have acceptable (apparent) eating quality, but the milling and physical qualities should further be determined.

Table 1. Classification of 2011 WS and 2012 DS and WS season early generation rice lines based on milling properties.

lo. of ntries	No. of entries by Brown Rice			No. of entries by Milled Rice					No. of entries by Head Rice				
	Poor (<75%)	Fair (75.1-79.9%)	Good (>80%)	Below Standard (<55%)	Grade 3 (55.5-60.0%)	Grade 2 (60.1-65.0%)	Grade 1 (65.1-70.0%)	Premium (>70.1%)	Below Standard (<30.0%)	Grade 3 (30.0-38.9%)	Grade 2 (39.0-47.9%)	Grade 1 (48.0-56.9%)	Premium (>57%)
42	1	38	3	0	0	1	13	28	1	20	20	1	0
24	9	15	0	0	0	0	17	7	1	0	6	9	8
20	20	0	0	0	6	10	4	0	1	7	11	1	0
73	28	45	0	0	1	1	71	0	2	35	32	3	1
190	12	168	10	0	0	2	66	122	3	16	40	69	62
26	-	-	-	-	-	-	-	-	-	-	-	-	-
29	1	28	0	0	0	0	25	4	2	3	6	11	7
77	1	76	0	0	0	1	71	5	0	9	19	33	16
151	3	148	0	0	0	13	134	4	3	25	48	64	11
32	3	29	0	0	0	1	27	4	12	1	7	7	5
664	**78**	**547**	**13**	**0**	**7**	**29**	**428**	**174**	**25**	**116**	**189**	**198**	**110**

Note: -, data not available as samples are submitted sample in milled rice form.

Table 2. Classification of 2011 WS and 2012 DS and WS season early generation rice lines based on physicochemical properties and apparent cooked texture.

of ies	No. of entries by Amylose Class					No. of entries by Gelatinization Temp. Type				No. of entries by Grain Quality Cluster		
	Waxy (0-2.0%)	Very low (2.1-10.0%)	Low (10.1-18.0%)	Intermediate (18.1-25.0%)	High (>25%)	Low (<70°C)	Intermediate (70-74°C)	High-Intermediate (70-74°C)	High (74.5-80°C)	Cluster 1 (Soft Texture)	Cluster 2 (Intermediate Texture)	Cluster 3 (Hard Texture)
[illegible]	0	0	0	28	14	4	32	6	0	22	8	12
[illegible]	0	0	6	18	0	11	12	1	0	24	0	0
[illegible]	0	3	10	7	0	15	4	1	0	20	0	0
[illegible]	29	10	29	5	0	32	12	29	0	73	0	0
0	0	10	105	74	0	56	93	40	1	190	0	0
[illegible]	0	0	11	15	0	1	11	14	0	26	0	0
[illegible]	0	0	5	20	4	9	20	0	0	19	7	3
[illegible]	0	0	17	49	12	29	48	0	0	51	26	1
1	0	0	15	102	34	54	97	0	0	91	42	18
[illegible]	0	0	1	16	15	3	27	2	0	17	13	2
4	**29**	**23**	**199**	**334**	**79**	**214**	**356**	**93**	**1**	**533**	**96**	**36**

Consumer acceptability and quality of freshly cooked, staled, and reheated rice

EH Bandonill, GG Corpuz, MJC Ablaza, PA Tibayan, and OC Soco

Rice is preferably served and consumed in freshly cooked form. However, there are instances when leftover rice stored at ambient temperature is served in the next meal. It is also a common practice to refrigerate unconsumed rice and reheat the following day. Such practices result in staling of rice characterized by a hard texture.

Texture of staled and reheated rice has been measured using Instron by Juliano, et al (2007). Consumer scores of freshly cooked rice were regularly determined, but the acceptability of staled and reheated rice has not yet been scored by a consumer panel. This study aimed to compare the acceptability of freshly cooked, staled, and reheated rice and to determine the types of rice that remain acceptable to consumers even in staled and reheated forms.

The physicochemical properties, Instron hardness, and sensory scores of 2011 DS rice varieties were previously determined. Varieties of different amylose content (AC) and gelatinization temperature (GT) combinations were used namely, Improved Malagkit Sungsong (IMS2) (waxy-low GT); NSIC Rc160 (low AC-low GT); PSB Rc72H (intermediate AC-low GT); PSB Rc82, NSIC Rc222, and IR64 (control) with intermediate AC-intermediate GT; NSIC Rc122 (intermediate AC-high GT); NSIC Rc152 (high AC-low GT); and PSB Rc68 (high AC-intermediate GT). Results presented herein were from the same varieties from the 2011 WS and 2012 DS. Freshly cooked, staled [at ambient (28-30oC), and refrigerated (4-8oC) temperatures] and reheated samples were evaluated using an Instron texture meter and by a consumer panel.

Highlights:

- Freshly cooked IMS2 showed the lowest Instron hardness (0.76-0.94 kg/cm2) while PSB Rc68 staled at refrigerated temperature (4-8oC) and reheated showed the highest (2.92-4.00 kg/cm2) as shown in Figure 1.

- Increase in Instron hardness was noted in intermediate AC-low/ intermediate GT (1.77-3.64 kg/cm2) and high AC-low/intermediate GT (2.74-4.00 kg/cm2) rice varieties upon staling at ambient and refrigerated temperatures while waxy-low GT (0.67-0.99 kg/cm2) and low AC-low GT (1.25-1.75 kg/cm2) varieties remained soft.

- Low AC-low GT NSIC Rc160 remained highly acceptable (86.7 to 96.7%) and had the highest mean rating (3.5-3.8) even with ambient and refrigerated staling (Figure 2). It was consistently preferred over other samples evaluated. High AC-low/int/high GT NSIC Rc152 and NSIC Rc68, which had hard texture and separated cooked grains, were least liked (20.0 to 63.3%) either freshly cooked or staled.

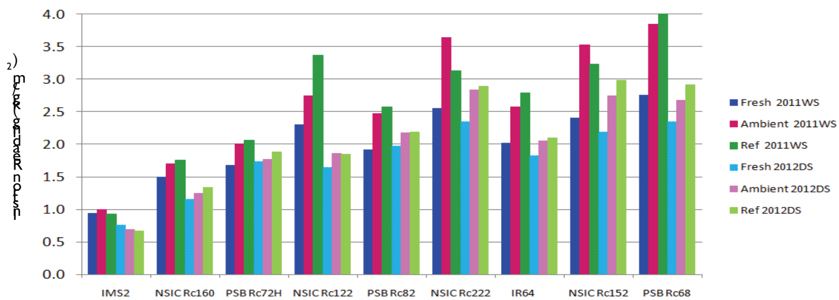

Figure 1. Instron hardness of freshly cooked and staled rice.

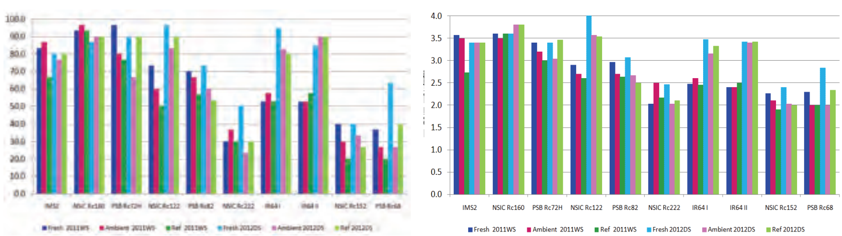

Figure 2. Percent acceptability and mean rating of freshly cooked and staled rice.

Effect of rice grain dimensions and shape on milling and head rice recovery

EH Bandonill, TF Padolina, KB Bergonio, PA Tibayan, J delaCruz, MJC Regalado

Milling quality is determined by the quantity of total milled rice and the percentage of head rice that can be produced from a given amount of rough rice. Head rice is a major price determinant in many countries. Thus, improvement in head rice recovery is essential to meet consumer demand and increase farmers' profitability.

Reports claim that long and slender rice is more prone to breakage than the short grain type, and therefore has lower milling yield. To validate this, varieties of different lengths and shapes from the 2011 DS and WS were analyzed for milling and head rice quality. These varieties were represented by Basmati for extra long (>7.5 mm) and slender (length-to-width ratio >3.0), NSIC Rc160 for long (6.6-7.4 mm) and slender, NSIC Rc9 for medium (5.5-6.5 mm) and intermediate (2.0-3.0), and NSIC Rc170 for short (<5.4 mm) and bold (<2.0). Laboratory (LM) and commercial (CM) milling machines were used for milling recovery determination (Figure 3). Physical attributes and physicochemical properties of the samples were also analyzed.

Highlights:

- The short-grained NSIC Rc170 (5.2-5.4 mm) consistently had high milling [69.9-74.5 (LM), 72.1-72.5% (CM)] and head rice [63.5-65.0, 63.1-63.7%] recoveries (Table 3).

- Low milling (61.5-65.5, 58.7-61.2%) and head rice (41.2-48.8, 33.2-43.2%) recoveries were recorded for the long-grained (7.5-7.7 mm) Basmati rice.

- Percent chalkiness, amylose content, crude protein content, and gelatinization temperature had no effect on milling yield of the representative varieties (Tables 3 and 4).

- Results indicated that long and slender rice is more prone to breakage than short grain types, and therefore has lower milling yield.

Figure 3. Laboratory (a) and commercial (b) grading of rice samples.

Table 3. Physical attributes and milling recovery of rice with different grain dimensions.

ariety	Physical Attributes														Milling Recovery									
	Length (mm)				Shape				Thickness (mm)				Chalky Grains (%)		Brown Rice (%)				Total Milled Rice (%)				Head Rice (%)			
	LM		CM		LM		CM		LM		CM		LM		CM		LM		CM		LM		CM		LM	
	2011 DS	2011 WS	2011 DS	2011 WS	2011 DS	2011 WS	2011 DS	2011 WS	2011 DS	2011 WS	2011 DS	2011 WS	2011 DS	2011 WS	2011 DS	2011 WS	2011 DS	2011 WS	2011 DS	2011 WS	2011 DS	2011 WS	2011 DS	2011 WS	2011 DS	2011 WS
C Rc170	5.2	5.4	5.2	5.3	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	3.3	4.7	78.5	77.3	80.4	75.2	72.5	72.1	74.5	69.9	63.1	63.7	65.0	63.5
C Rc9	5.8	5.9	5.9	6.1	2.4	2.4	2.5	2.5	1.6	1.7	1.6	1.7	10.1	11.8	70.4	75.1	73.4	71.6	63.7	64.4	65.9	66.7	59.5	43.7	53.5	47.2
C Rc160	7.1	7.2	7.0	7.3	3.2	3.3	3.2	3.3	1.7	1.7	1.7	1.7	3.1	4.0	74.6	79.0	76.7	75.1	65.0	62.3	68.2	68.5	44.7	51.2	49.5	52.9
nati	7.5	7.7	7.3	7.6	3.8	4.0	3.8	4.0	1.6	1.7	1.6	1.6	1.8	5.3	73.6	75.6	75.5	70.0	61.2	58.7	65.5	61.5	43.2	33.2	48.8	41.2

Table 4. Physicochemical properties of rice with different grain dimensions

Variety	Physicochemical Properties					
	Amylose Content %)		Crude Protein (%)		GT Score	
	LM		LM		LM	
	2011 DS	2011 WS	2011 DS	2011 WS	2011 DS	2011 WS
NSIC Rc170	17.0	10.5	6.5	6.2	7.0	7.0
NSIC Rc9	18.1	14.6	9.6	6.9	3.5	3.6
NSIC Rc160	15.5	10.3	8.6	7.1	7.0	7.0
Basmati	18.3	13.6	8.1	6.1	6.4	6.5

LM – Laboratory mill

CM – Commercial mill

II. Advancing Rice Grain Quality Assessment Methods

JBA Duldulao

Grain quality is one of the major selection criteria in rice breeding programs. At the marketplace, how the grains appear dictates the price of rice. Millers prefer rice with good milling recovery while consumers favor rice with little chalk and brokens.

Grain quality evaluation at PhilRice is handled by staff of the Rice Chemistry and Food Science Division (RCFS). They assist breeders in identifying promising rice lines for entry into the National Cooperative Test.

Through time the tools for grain quality evaluation tools have apparently become tedious, cumbersome, and outdated. For instance, determination of amylose content for the past years saw some significant variations, even from the same check varieties. Determination of chalkiness by manual separation of chalky grain from translucent grains takes so much time and easily strains the eyes. Gel temperature as determined from the degree of disintegration of rice grains in alkali has the tendency to be scored differently by one analyst from another. Even the same sample can show a wide range of dispersion per grain. These experiences stress the need for improved tools or adoption of new ones upon revalidation in the PhilRice laboratories. The upgrading of methods will not only ensure better accuracy of data but also fast-track varietal screening.

Current developments in analytical assessment of quality characteristics of rice as well as the demand for reliable data by heightened breeding activities further necessitate an immediate updating of grain quality techniques at PhilRice.

Improving amylose determination method for rice: Development of an amylose field test kit

JBA Duldulao, KB Bergonio, CT Estonilo

The effect of amylose content (AC) on the cooking and eating quality and processing behavior of rice makes it a critical parameter in the rice breeding program. To expedite screening of early generation line numbering to hundreds, an amylose field test kit must be made available to breeders.

There have been a few reported amylose test kits. The amylose field test of Kongseree et al. (2002) is based on iodine staining using milled rice sample (3 g), with defatting (70% isopropanol or ethanol rubbing alcohol) and staining (0.01% I_2 in 0.1% KI) in 0.05N sodium acetate buffer (pH 8). They applied this to detect contamination of low AC Khao Dawk Mali 105 rice with high-AC rice. Juliano et al. (2009) adapted and modified the former for the Philippines using the same iodine staining reagent but with a different buffer (sodium phosphate, pH 8) to differentiate milled rice into waxy, low AC, intermediate AC, and high AC. The kit takes 30-35 minutes to simultaneously differentiate four to six rice samples and 25 minutes for a single sample.

Both kits were based on the conventional method of Juliano at alkaline pH (1971). The method suffered from interferences from amylopectin and lipids, leading to variability of measures, even with check varieties. We recently reported an ammonium-based amylose determination method which gave a distinct and stable blue color, minimal interference from amylopectin and lipids, and with an improved accuracy across amylose classes (from waxy to high amylose) (Juliano et al., 2012).

We previously came up with a moderately accurate (85%) one-step amylose staining field test using only five milled rice grains and mixed reagent (borate buffer and I2 in NH4I solution) without defatting. Color must be scored within five to seven minutes as staining tends to fade upon drying. It takes about three to five minutes only to simultaneously differentiate five to 10 samples. Validation of our rapid field test at the RCFS Division of PhilRice Los Baños using select NCT 2009 DS and WS entries revealed accuracy of 70% and 80% and intermediate precision of 80%.

This study aimed to reevaluate and optimize our rapid amylose test referenced on the ammonium-based colorimetric method.

Highlights:

- A rapid amylose test kit and protocol composed of a spot plate, a coloring reagent, and a color stabilizer that can differentiate AC class of 6 samples simultaneously for only four to five minutes was developed.

- The rapid amylose test followed this protocol: (1) Place seven whole milled rice grains on a spot plate and stain with 0.5 mL of coloring reagent mix by swirling for about 10-15 seconds. (2) Aspirate off the coloring reagent solution using Pasteur pipette. (3) Add 0.5 mL of color stabilizer and swirl for about 10 seconds. (4) Aspirate off the color stabilizer solution using Pasteur pipet (optional). (5) Classify the AC class of the samples based on the color produced. The resulting colors were white (no stain) to light violet for waxy to very low-AC, light violet to light gray for low-AC, violet to gray for intermediate-AC, and dark violet to black for high-AC (Figure 4).

Figure 4. Iodine staining for (L to R) waxy, low-AC, intermediate-AC and high-AC varieties.

- Overall AC class differentiation accuracy based on iodine colorimetry AC data by two analysts on 25 selected varieties was 76% and 80%, while intermediate precision between analysts was 96% (Table 5). For 150 test samples (NCT 2011WS entries), AC class differentiation accuracy was 73%. Differentiation accuracy for each AC class was 100% for waxy, 25-31% for low-AC, 80-87% for intermediate-AC, and 42-100% to high-AC rice samples.
- The developed rapid amylose test kit protocol will be further refined to improve accuracy to at least 85%.

Table 5. AC class differentiation accuracy of rapid amylose test kit on check varieties (N=25) and NCT 2011WS entries (N=150)

AC Class by Iodine Colorimetry	Rapid Amylose Test Kit Accuracy		
	Check Varieties (N=25)		NCT 2011WS Entries (N=150)
	Analyst 1	Analyst 2	
Amylose Classification			
Waxy-Very low (0-10.0%)	100%	100%	100%
Low (10.1-18.0%)	25%	25%	31%
Intermediate (18.1-25.0%)	80%	87%	84%
High (>25.0%)	100%	100%	42%
Overall Accuracy (%)	76%	80%	73%
Intermediate precision between 2 analysts	96%		Not applicable

Validation of molecular markers for rice eating quality

KB Bergonio, JBA Duldulao, DJS Timbol, CT Estonilo

Accurate screening and selection of parent germplasm and early generation lines with good eating quality is critical in rice breeding. Physicochemical and sensory analyses are the methods of choice, but these have limitations. Sensory methods require large quantities of samples and only a few samples can be analyzed per day. Moreover, results are sometimes inconsistent even for the same sample, presumably due to the physical and emotional condition of evaluation panel or subtle differences in sample preparation (Lestari et al., 2009).

On the other hand, methods to determine physicochemical properties of rice such as amylose content, gelatinization temperature, gel consistency, and fragrance are relatively accurate and reproducible. However, they also require large quantities of samples and are tedious, expensive, and time-consuming. Consequently, these factors slow down the screening process as breeders need to immediately know the physicochemical and sensory properties of progeny across multiple years and locations.

Molecular techniques based on the polymerase chain reaction (PCR) have been employed in rice grain quality studies as physicochemical properties such as amylose content, gelatinization temperature, and gel consistency are controlled by one to three major genes with one or more modifiers (Lestari et al., 2009). Molecular assessment by PCR is simple, efficient, cost-effective, and allows for early growth stage evaluation unlike the conventional methods. Hence, it can complement or completely replace conventional methods for physicochemical and sensory assessment.

This study aimed to validate previously reported PCR-based markers for rice eating quality against conventional assessment methods, to subsequently formulate a marker-based assessment and prediction method of eating quality of rice, and to generate molecular descriptors of the accessions of the PhilRice Genebank.

Highlights:

- Four PCR-based markers [three single nucleotide polymorphisms (SNP) and one simple sequence repeats (SSR)] were tested for their association with each of the rice eating quality parameter and special trait, namely (CT)n microsatellite (or SSR) in the Waxy (Wx) gene for amylose class (Ayres et al., 1997), GC/TT SNP in the starch synthase IIa (SSIIa) gene for gelatinization temperature type (Jin et al., 2010), C/T polymorphism in Ex10 of the Wx gene for gel consistency (Tran et al., 2011), and 8-bp del and 3 SNP in Ex7 of the gene encoding the putative betaine aldehyde dehydrogenase 2 (badh2) for fragrance detection (Bradbury et al., 2005). PCR conditions for each of the DNA markers were optimized prior to use.

- Eighty four validation samples, composed of selected varieties representing all eating quality types, and 215 test samples from the PhilRice Genebank were used. These were processed and prepared for genotypic analyses to determine the accuracy and repeatability of each molecular marker versus conventional sensory and chemical analyses. Correspondence between each molecular marker and conventional methods were also evaluated by Pearson regression and correlation analysis. Sixty two out of 84 validation samples and 213 out of 215 test samples successfully germinated and grew under conventional practices at the PBBD screen house. DNA from two-week old leaf tissue samples were collected by the CTAB method. DNA quality and quantity were checked using agarose gel electrophoresis and Nanodrop® spectroscopy.

- Amylose classification by the (CT)n microsatellite marker showed an average overall prediction accuracy of 77% using the validation set. Prediction accuracy for high amylose content samples (N=14) was 42.9%, while 78.9% for waxy-low-intermediate amylose content (N=38). Repeatability between two separate analyses of the same validation samples was 100%. For test samples, overall prediction accuracy was 70.0%. Genotypic amylose classification (Table 6) for waxy-low-intermediate samples (N=167) obtained 79.0% accuracy, while 40.0% accuracy for high-amylose content samples (N=46).

- Gelatinization temperature type by the GC/TT SNP marker showed an average overall prediction accuracy of 91.3% with the validation set. Prediction accuracy for high intermediate gelatinization temperature samples (N=30) was 93.3%, while 88.6% for low gelatinization temperature samples (N=22). Repeatability between two separate analyses of the same validation samples was 98.1%. On the other hand, overall prediction accuracy obtained with test set was 89.2. High intermediate gelatinization temperature type (N=142) obtained 93.7% prediction accuracy, whereas for low gelatinization temperature type (N=71) obtained 80.3% (Table 6).

- Gel consistency by the C/T SNP marker showed an average overall prediction accuracy of 76.9% with the validation set. Prediction accuracy for medium-hard gel consistency samples (N=11) was 54.5%; 87.8% for soft gel consistency samples (N=41). Repeatability between two separate analyses of the same validation samples was 92.3%. For the test set, overall prediction accuracy was 81.7%. Soft gel types samples (N= 167) obtained 91.0% prediction accuracy, while medium-hard gel types samples (N= 46) obtained 47.8% prediction accuracy (Table 6).

- Fragrance or aroma detection by the 8 bp del and 3 SNP marker showed an average overall prediction accuracy of 82.7% with the validation set. Prediction accuracy for non-aromatic samples (N=44) was 95.5%, while 12.5% for aromatic samples (N=8). Repeatability between two separate analyses of the same validation samples was 100%. On the other hand, test samples (N= 213) showed 88.3% overall aroma prediction accuracy. Prediction accuracy obtained for non-aromatic (N=159) and aromatic (N=42) of test samples were 98.7% and 57.4%, respectively (Table 6).

- Regression and correlation analyses found that molecular marker for gelatinization temperature was moderately associated (r= 0.60) with the alkali-spreading method. Other markers for rice eating quality were weakly associated (r= 0.12-0.33) with the conventional methods. These indicate that among the molecular markers validated, only the GC/TT SNPs marker for gelatinization temperature type can complement the conventional alkali-spreading method.

Table 6. Accuracy and repeatability of the markers for rice eating quality using validation (N=52) and test (N=213) samples

Eating Quality Parameter/ Classification	Validation Samples (N=52)			Test Samples (N=213)	
	No. of Sample	Accuracy (%) Analyst 1	Accuracy (%) Analyst 2	No. of Sample	Accuracy (%)
Amylose Content					
Waxy-Low-Intermediate	38	78.9	78.9	167	79.0
High	14	42.9	42.9	46	40.0
Overall accuracy		76.9	76.9		70.0
Repeatability between 2 analysts using validation samples=100%					
Gelatinization Temperature					
High-Intermediate	30	93.3	93.3	142	93.7
Low	22	90.9	86.4	71	80.3
Overall accuracy		92.3	90.4		89.2
Repeatability between 2 analysts using validation samples=98.1%					
Gel Consistency					
Medium-Hard	11	63.6	45.5	46	47.8
Soft	41	85.4	90.2	167	91.0
Overall accuracy		78.8	75.0		81.7
Repeatability between 2 analysts using validation samples=92.3%					
Aroma Detection					
Non-aromatic	44	95.5	95.5	159	98.7
Aromatic	8	12.5	12.5	54	57.4
Overall accuracy		82.7	82.7		88.3
Repeatability between 2 analysts using validation samples=100%					

Abbreviations and acronymns

ABA – Abscicic acid
Ac – anther culture
AC – amylose content
AESA – Agro-ecosystems Analysis
AEW – agricultural extension workers
AG – anaerobic germination
AIS – Agricultural Information System
ANOVA – analysis of variance
AON – advance observation nursery
AT – agricultural technologist
AYT – advanced yield trial
BCA – biological control agent
BLB – bacterial leaf blight
BLS – bacterial leaf streak
BPH – brown planthopper
Bo - boron
BR – brown rice
BSWM – Bureau of Soils and Water Management
Ca - Calcium
CARP – Comprehensive Agrarian Reform Program
cav – cavan, usually 50 kg
CBFM – community-based forestry management
CLSU – Central Luzon State University
cm – centimeter
CMS – cystoplasmic male sterile
CP – protein content
CRH – carbonized rice hull
CTRHC – continuous-type rice hull carbonizer
CT – conventional tillage
Cu – copper
DA – Department of Agriculture
DA-RFU – Department of Agriculture-Regional Field Units
DAE – days after emergence
DAS – days after seeding
DAT – days after transplanting
DBMS – database management system
DDTK – disease diagnostic tool kit
DENR – Department of Environment and Natural Resources
DH L– double haploid lines
DRR – drought recovery rate
DS – dry season
DSA - diversity and stress adaptation
DSR – direct seeded rice
DUST – distinctness, uniformity and stability trial
DWSR – direct wet-seeded rice
EGS – early generation screening
EH – early heading
EMBI – effective microorganism-based inoculant
EPI – early panicle initiation
ET – early tillering
FAO – Food and Agriculture Organization
Fe – Iron
FFA – free fatty acid
FFP – farmer's fertilizer practice
FFS – farmers' field school
FGD – focus group discussion
FI – farmer innovator
FSSP – Food Staples Self-sufficiency Plan
g – gram
GAS – golden apple snail
GC – gel consistency
GIS – geographic information system
GHG – greenhouse gas
GLH – green leafhopper
GPS – global positioning system
GQ – grain quality
GUI – graphical user interface
GWS – genomwide selection
GYT – general yield trial
h – hour
ha – hectare
HIP - high inorganic phosphate
HPL – hybrid parental line
I - intermediate
ICIS – International Crop Information System
ICT – information and communication technology
IMO – indigenous microorganism
IF – inorganic fertilizer
INGER - International Network for Genetic Evaluation of Rice
IP – insect pest
IPDTK – insect pest diagnostic tool kit
IPM – Integrated Pest Management
IRRI – International Rice Research Institute
IVC – in vitro culture
IVM – in vitro mutagenesis
IWM – integrated weed management
JICA – Japan International Cooperation Agency
K – potassium
kg – kilogram
KP – knowledge product
KSL – knowledge sharing and learning
LCC – leaf color chart
LDIS – low-cost drip irrigation system
LeD – leaf drying
LeR – leaf rolling
lpa – low phytic acid
LGU – local government unit

LSTD – location specific technology development
m – meter
MAS – marker-assisted selection
MAT – Multi-Adaption Trial
MC – moisture content
MDDST – modified dry direct seeding technique
MET – multi-environment trial
MFE – male fertile environment
MLM – mixed-effects linear model
Mg – magnesium
Mn – Manganese
MDDST – Modified Dry Direct Seeding Technique
MOET – minus one element technique
MR – moderately resistant
MRT – Mobile Rice TeknoKlinik
MSE – male-sterile environment
MT – minimum tillage
$mtha^{-1}$ - metric ton per hectare
MYT – multi-location yield trials
N – nitrogen
NAFC – National Agricultural and Fishery Council
NBS – narrow brown spot
NCT – National Cooperative Testing
NFA – National Food Authority
NGO – non-government organization
NE – natural enemies
NIL – near isogenic line
NM – Nutrient Manager
NOPT – Nutrient Omission Plot Technique
NR – new reagent
NSIC – National Seed Industry Council
NSQCS – National Seed Quality Control Services
OF – organic fertilizer
OFT – on-farm trial
OM – organic matter
ON – observational nursery
OPAg – Office of Provincial Agriculturist
OpAPA – Open Academy for Philippine Agriculture
P – phosphorus
PA – phytic acid
PCR – Polymerase chain reaction
PDW – plant dry weight
PF – participating farmer
PFS – PalayCheck field school
PhilRice – Philippine Rice Research Institute
PhilSCAT – Philippine-Sino Center for Agricultural Technology
PHilMech – Philippine Center for Postharvest Development and Mechanization
PCA – principal component analysis
PI – panicle initiation
PN – pedigree nursery
PRKB – Pinoy Rice Knowledge Bank
PTD – participatory technology development
PYT – preliminary yield trial
QTL – quantitative trait loci
R - resistant
RBB – rice black bug
RCBD – randomized complete block design
RDI – regulated deficit irrigation
RF – rainfed
RP – resource person
RPM – revolution per minute
RQCS – Rice Quality Classification Software
RS4D – Rice Science for Development
RSO – rice sufficiency officer
RFL – Rainfed lowland
RTV – rice tungro virus
RTWG – Rice Technical Working Group
S – sulfur
SACLOB – Sealed Storage Enclosure for Rice Seeds
SALT – Sloping Agricultural Land Technology
SB – sheath blight
SFR – small farm reservoir
SME – small-medium enterprise
SMS – short message service
SN – source nursery
SSNM – site-specific nutrient management
SSR – simple sequence repeat
STK – soil test kit
STR – sequence tandem repeat
SV – seedling vigor
t – ton
TCN – testcross nursery
TCP – technical cooperation project
TGMS – thermo-sensitive genetic male sterile
TN – testcross nursery
TOT – training of trainers
TPR – transplanted rice
TRV – traditional variety
TSS – total soluble solid
UEM – ultra-early maturing
UPLB – University of the Philippines Los Baños
VSU – Visayas State University
WBPH – white-backed planthopper
WEPP – water erosion prediction project
WHC – water holding capacity
WHO – World Health Organization
WS – wet season
WT – weed tolerance
YA – yield advantage
Zn – zinc
ZT – zero tillage

List of Tables

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Department of Agriculture

PHILRICE

PHILIPPINE RICE RESEARCH INSTITUTE

We are a chartered government corporate entity under the Department of Agriculture. We were created through Executive Order 1061 on 5 November 1985 (as amended) to help develop high-yielding, cost-reducing, and environment-friendly technologies so farmers can produce enough rice for all Filipinos.

We accomplish this mission through research and development work in our central and seven branch stations, coordinating with a network that comprises 58 agencies and 70 seed centers strategically located nationwide. To help farmers achieve holistic development, we will pursue the following goals in 2010-2020: attaining and sustaining rice self-sufficiency; reducing poverty and malnutrition; and achieving competitiveness through agricultural science and technology.

We have the following certifications: ISO 9001:2008 (Quality Management), ISO 14001:2004 (Environmental Management), and OHSAS 18001:2007 (Occupational Health and Safety Assessment Series).

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OHSAS 18001:2007 CIP/4360/HS/09/10/668

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