PHILIPPINE RICE R&D HIGHLIGHTS 2012

Natural Products and Value-Adding Systems

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Natural Products and Value-Adding Systems

Program Leader: Rolando T. Cruz

The Natural Products and Value-adding Systems Program aimed to increase the income and improve the nutritional status of the rice-based farming households. It aimed to achieve an additional 10% income and to satisfy 5% of the daily recommended energy and nutrient intake (RENI) of the rice-based farming households. To achieve these goals, the program implemented five projects: (1) Development of rice varieties with value-added traits, (2) Improvement of quality and utilization of rice variants, (3) Utilization of rice and high-value crops for food and biomedical applications, (4) Maximizing the potential of rice by-products and renewable energy, and (5) Improvement of the nutrition and productivity of rice-based farming communities.

In 2012, a total of 26 studies were conducted under the program. In Project 1, for rice varieties developed with value-added traits, five aromatic and eight glutinous lines were elevated to the National Coordinated Trial (NCT). The majority of the test entries had resistance to blast, bakanae, and rice tungro virus. For the evaluation of fragrance markers in the aromatic breeding materials, the gel extraction and purification kits were assembled for DNA sequencing of MS 6, MS 8, Basmati 370, KDML 105, and Nipponbare to detect the difference of repeats of bases of these aromatic rice cultivars. In the study on unique grain quality properties of farmers' specialty rices, the upland and irrigated lowland rices were similar in terms of apparent amylose content, gelatinization temperature and gel consistency. In golden rice (GR) studies, hybridization of four selected lines to the golden rice donor was conducted to recover a substantial amount of betacarotene from the donor. Plants resistant to tungro and bacterial blight and homozygous to the GR2 locus were prioritized for production of backcross progenies.

In Project 2, for the improvement and utilization of rice variants, 53 mutant lines positive to the optimized high inorganic phosphate (HIP) assay for screening of putative low phytic acid (lpa) mutants were obtained. This can lead towards the identification of rice varieties or lines with low phytic acid that will be suitable for brown rice production. To extend the keeping quality of light polished NSIC Rc160 brown rice, samples were stabilized by autoclave and microwave heating using different exposure times and stored in various containers at room temperature. To determine the effects of packaging and storage conditions on the shelf-life of unpolished pigmented rice samples, black and red rice were evaluated. Based on the results, the best storage conditions to extend the shelf-life of pigmented rice were the use of aluminum foil packaging material, vacuum sealing, and storage at refrigerated temperature. A study on the effect of organic and inorganic fertilizers, with or without pesticides indicated that yield and grain quality of

irrigated rice did not differ among treatments. An initial evaluation of satiety and glycemic indexes of brown rice was conducted.

In Project 3, for the utilization of rice and high-value crops for food and biomedical applications, the use of chili pepper leaves (CPL) as a supplementary ingredient in bread was evaluated. Results demonstrated the market potential of bread with CPL. Instant am was accepted by the respondents and expected to significantly address the current problems encountered in am preparation. Majority of respondents were willing to pay for instant am at P5 to P10 per serving. Exploring the possibility of preparing less sweet PhilRice tapuy revealed that the use of 70% dilution of fermentation mash was possible to produce wine similar to commercial sake in sweetness, color, alcohol content, and smoothness. In utilizing rice wine lees as ingredient for rice-based food products, results showed that 45% substitution of lees can be used in brownies. Results suggested that food products with intense flavor and dark color, such as brownies, can be effectively used as vehicle for supplementation with lees, without significantly affecting the appearance, flavor and overall acceptability of the food product.

In Project 4, for maximizing the potential of rice by-products and renewable energy, the continuous flow rice hull gasifier was modified into a better prototype by (a) putting up control valve for the intake of gas to the burner so as to provide a means for regulating the temperature and (b) relocation of primary blower at the lower portion of the reactor so that the air to be blown to the reactor shall pass through its hot portion, thus, cooling the gas chamber while heating the air entering the reactor. A pre-commercial unit of the batch-type gasifier stove with a short startup time of less than one minute to produce flame was made. A small-scale biogas production system established in the Palayamanan site had a diesel engine running on 70% diesel and 30% scrubbed biogas and a comparable engine RPM when using pure diesel. A new prototype of instant steam generator was fabricated and designed as attachment to the continuous-type rice hull (CTRH) carbonizer to utilize the generated heat during its operation for steam generation. A prototype of the rice hull carbonizer was fabricated using ferrocement material. A heating chamber was added for cooking or boiling water. The modified CTRH carbonizer could process rice straw into biochar at input capacity of 12kg/h. Other farm wastes like leaves, twigs, coco husks, and corn cobs can also be processed into biochar. When the CTRH carbonizer was used to dry crops, results showed that the carbonizer can be used to replace the furnace of the dryer since a clean flame had developed at the exhaust of the carbonizer (the point where the chimney was attached). In the evaluation of rice hull carbonization drip irrigation system, the carbonizer-pump system filled up one tank load (1m3) in one hour with water pumped from water table approximately 2.5m below the ground. One tank load was found to be enough to irrigate the whole 300m2 area planted with tomatoes.

In Project 5, for the improvement of nutrition and productivity of rice-based farming communities, an evaluation of nutritional status of rice-based farming communities was conducted. The nutritional assessment of rice-based farming households in Nueva Ecija showed that children below 10 years old were normal in terms of weight for age. However, children less than six months, 10-18, and 50-64 year olds did not meet the recommended calorie or energy intake per day. In general, a large portion of the typical meal plate of sample respondents in Nueva Ecija consisted of grains and a small amount of protein and vegetables.

I. Development of Rice Varieties with Value-Added Traits
Emily C. Arocena

Development of aromatic, glutinous, pigmented and high iron/zinc rice varieties
EC Arocena, ME Omaña, JA Andal, KB Geneston, JA Orcino, GM Osoteo, and RC Braceros, GC Santiago, JP Rillon, and MS Duca

The challenge in developing rice varieties with value-added traits such as aroma, waxiness, pigmentation, and enhanced micronutrient content is to maintain high yield and resistance to pests. This is not an easy task since adding one trait can affect another trait, e.g. presence of aroma can make a variety more attractive to insect pests. Also, identification of donors of the traits and selection in the progenies are challenging.

Highlights:

Elite lines in the multi-location trials

- In the National Cooperative Tests (NCT) in DS at PhilRice Central Experiment Station (CES), among the 10 aromatic entries, PR37043-B-6-3-2 had a yield 7.5t/ha and 5.2% yield advantage over the aromatic check Burdagol. Among the eight glutinous entries, PR34859-B-4-1-1-2-1 had a yield of 8.0t/ha and 4.4% yield advantage over the glutinous check variety NSIC Rc15. In WS, PR37299-31-69-16-2-1-2 had the highest yield of 6.7t/ha among the aromatic test entries and 6.4% yield advantage over the check variety NSIC Rc128. Among the glutinous entries, none out-yielded the check variety NSIC Rc13 with a yield of 6.2t/ha.

- In Multi-Environment Test (MET) I during the DS, PR36921-B-6-1-3-1-1, an aromatic line ranked 19th among 600 entries, had a yield of 9.4t/ha. Five entries out of the 14 entries entered in MET had yields close to 9.0t/ha and 8.4% yield advantage over the check variety IRRI 154. In WS, PR34641-2B-15-1-1-1 and PJ(G) 6-2-4-5-4 with yields close to 6.0t/ha were in the top 10% yield performers in Group I. The check variety IRRI 154 had a yield of 5.5t/ha. The top performers PR37343-B-6-3-2-2-2 and

PR33282-B-8-1-1-1-1-1 had an average yield of 6.0t/ha.

Line development

- Line development started with the selection of parental to the generation of crosses and subsequently selection of desirable plants from the segregating generations. Rigorous selection of desirable agronomic traits such as plant type, maturity, panicle type, and other yield enhancing traits was done in the field. Kernel quality evaluation in the laboratory was done in the laboratory to discriminate the non-glutinous, glutinous, and pigmented kernel in F3 up to F8 generation to ensure that the selected lines possessed the desired special traits. Most of the selected plants were non-glutinous (NG) as shown in Figure 1. Each kernel or endosperm type was further segregated into excellent, good, and fair kernel qualities. Excellent kernel quality was prevalent in WS. Only those plants with excellent to fair kernel qualities were advanced for further selection. Plants with poor kernel quality were discarded.

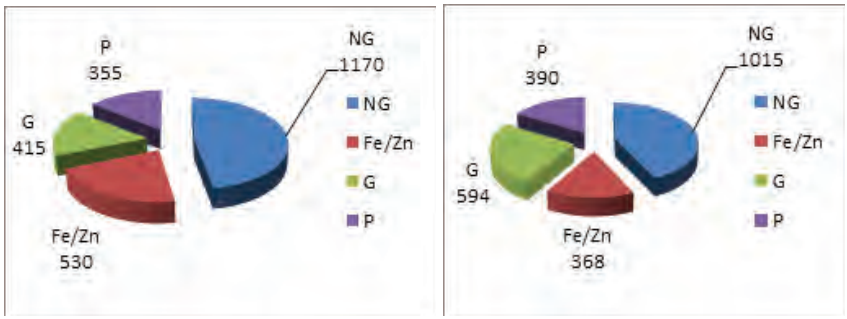


Figure 1. Selected desirable plants in the hybrid population and pedigree nursery segregated based on kernel or endosperm types.

Screening for resistance to disease

- Under induced method of evaluation, none of the entries were resistant to major rice diseases. LUYIN 46, PR4-2-24, PR37043-B-6-3-2 and check varieties MS 11 and Burdagol had intermediate resistance to blast. Forty seven entries had intermediate resistance to bacterial leaf blight. The aromatic lines PR38171-B-2-1-3, PR37348-B-22-1-4-1-1-1, PR36908-B-11-2-6-1-2-3-3-1, and PR37045-B-6-1-1-1-2 had intermediate resistance to sheath blight. Seventeen and 57 entries had intermediate resistance to blast and bacterial leaf blight, respectively. All entries were susceptible to tungro.

- Under natural field condition, the most of the test entries were not susceptible to blast, bakanae, and rice tungro virus.

Screening for resistance to insect pests

A. Field Condition (Stem borer)

- In DS 2012, 267 Preliminary Yield Trial (PYT) entries were evaluated. Results showed that the susceptible check TN1 had 30.2% stem borer damage or whiteheads. From the PYT entries, 34 were resistant, 28 were moderately resistant, 45 with intermediate resistance, 85 were moderately susceptible, and 75 were susceptible to stem borer.
- In WS 2012, stem borer pressure was low.

B. Screen house Condition (Brown Plant Hopper or BPH and Green Leaf Hopper or GLH)

- Two hundred sixty seven entries entries were screened in 2012 DS and 334 entries were screened in 2012 WS. Results showed that majority of the entries were either moderately resistant or susceptible to BPH and GLH in DS and WS.

Grain quality and nutrient evaluation of aromatic, glutinous, pigmented and high iron/zinc rice selections

HM Corpuz, MV Romero, MB Dacumos, ST Gonzales Jr., ZA Lubos, OC Soco, EC Arocena, HA Makahiya and RT Cruz

Rice grain quality encompasses milling yield, physical appearance, physicochemical, sensory properties, and nutritional value. These grain quality characteristics are important guide for breeders in the selection of germplasm with desirable eating quality and high nutrient level.
Although yield is still considered the most important criterion in the breeding program, grain quality also plays a major role because this is extremely important to consumers. Thus, breeders also need to develop rice varieties with excellent grain qualities that suit the particular needs of the consumers.

Highlights:

- A total of 120 and 165 rice selections from 2011 WS and 2012 DS, respectively, were received for grain quality and nutrient evaluation. Results of milling potential determination showed that majority of the specialty rice entries had good milling recoveries. In WS and DS, most of the samples had fair brown rice yield (75.0 to 79.9%), Grade 1 to Premium total milled rice (65.1 to 70.0%), and head rice yield (48.0 to 57.0%). Generally, the milling recoveries of the samples were higher in 2012 DS than 2011 WS.

- No significant change was observed on the grain size and shape of the samples. Majority of the 2011 WS samples had Grade 1 to 3 chalky grains or 2.1 to 15.0% chalkiness.

- The amylose content was very low to low in all high iron/zinc rice selections, low to high in most aromatic rice entries, waxy to intermediate in pigmented rices, and waxy to very low in glutinous rices. Amylose content was higher in 2012 DS than in 2012 WS. Intermediate and low gelatinization temperature grains predominated in all rice types. Crude protein contents were 5.4 to 7.7% in 2011 WS samples.

- Results of phytochemical analysis of pigmented rice entries in WS and DS showed that black rices had higher anthocyanin content compared to red rices (Figure 2). Although the anthocyanin content was low, red colored rices had strong antioxidant activity comparable to that of black rices (Figure 3). Anthocyanin and antioxidant activities of pigmented rice extracts were higher in 2012 DS than in 2011 WS. Antioxidant activity correlated positively with the amount of phenolic compounds in pigmented rices.

- The effect of yield improvement by modern rice technologies on rice grain quality was evaluated. Specialty rices (aromatic, glutinous, pigmented rice types) including inbred and hybrid rice varieties were grown in 2012 WS under optimum nutrient, water, and pest management conditions. Yield potentials of the test varieties were obtained. Seeds of the test varieties were stored for two months prior to grain quality evaluation.

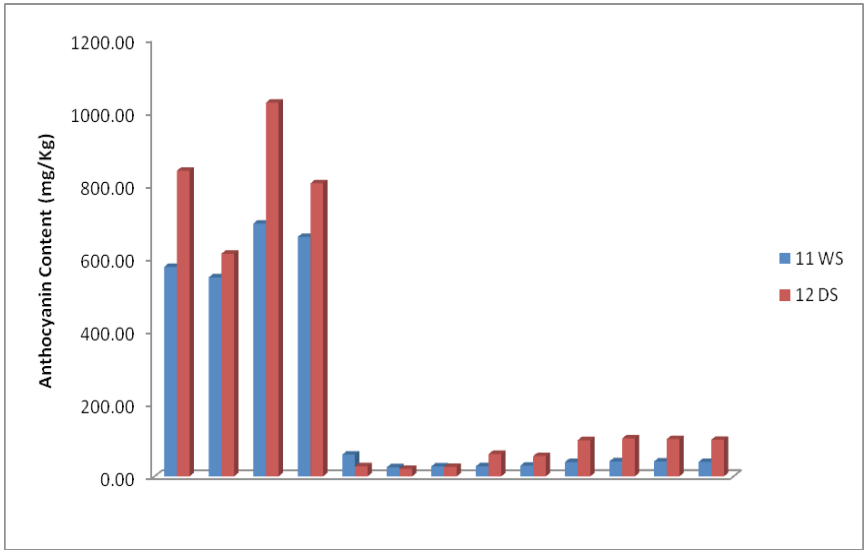


Figure 2. Anthocyanin content (mg/kg) of selected pigmented rices. There were 11 entries in 2011 WS and 12 entries in 2012 DS.

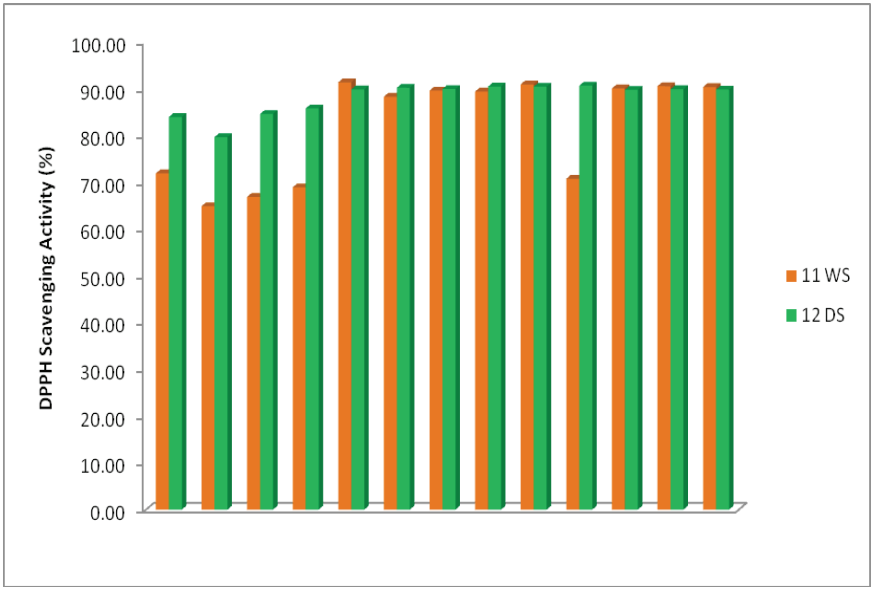


Figure 3. Antioxidant activity of selected pigmented rices. There were 11 entries in 2011 WS and12 entries in 2012 DS.

Identification of unique grain quality properties in farmers' specialty rices

BO Juliano, APP Tuaño, AD Peñaloza, AR Agarin, MM Pontañez, TF Padolina, LM Perez, and NCT Cooperators

There were more than 120 modern varieties that Filipino farmers released for cultivation. These varieties possess a package of desirable agronomic and grain quality traits. However, no variety has so far been bred mainly for export that can compete in the local and international markets with popular excellent quality rices (EQR) such as Thailand' Jasmine and India and Pakistan's Basmati.

In this study, collection and assessment of existing excellent quality rices (mostly traditional cultivars) from various regions of the country were undertaken to aid in the identification of some unique properties in these varieties. Possible parents or sources of identified quality traits will be recommended for inclusion into the national rice breeding program. Packaging all these properties in our elite lines may help improve the end-use quality of locally released rice varieties.

Highlights:

- Analysis of the freshly cooked rice Instron hardness of the 2012 farmers' specialty varieties collection was completed. Rapid

visco analysis (RVA) pasting viscosities of selected samples were also completed. A summary table of ranges and means of some physicochemical parameters of irrigated and upland specialty rices are shown in Table 1. Generally, the grain quality properties of existing upland and irrigated lowland specialty rices are similar including apparent amylose content, gelatinization temperature (GT) and gel consistency, the main determinants of rice cooking and eating quality.

- Gel permeation chromatography analysis of native starch of selected waxy rices differing in GT gave broad curves that seems to have little to no significant differences. Verification trials using refractive index detector on a high performance liquid chromatography (HPLC) system also gave similar curves that may imply similar molecular sizes of starch.

- Amylopectin chain ratios of low-amylose content (AC) and waxy rice samples varying in GT were assessed based on their alkali spreading scores. Only the L-type and S-type amylopectin structures were found. Actual GT values via differential scanning calorimetry revealed true intermediate GT rices among the low-AC class but none in the set of non-waxy rices.

- True amylose and apparent amylose contents (on starch basis) of selected low-AC and waxy rices using high pressure size exclusion chromatography (HPSEC) were lower than the measured apparent amylose content using the colorimetric method on alkaline pH.

- A modification of the current amylose assay at alkali pH was done to reduce amylopectin-iodine complex formation in the analysis of waxy rice samples. Previous data ranging from 0-5% AC were reduced to 0-1% AC that was expected of glutinous rices.

- NSIC Rc222 contained 7.5% long-chain amylopectin via the HPSEC analysis of debranched starch. This was relatively higher than the content measured in other popular intermediate-AC released varieties and such difference could be a factor affecting the harder cooked rice texture of NSIC Rc222 despite its intermediate apparent amylose content.

Table 1. Range and mean physicochemical properties of 169 irrigated lowland and 60 upland farmers' specialty rices collected in 2009-2012

Property	Irrigated Lowland			Upland		
	Samples (no.)	Range	Mean	Samples (no.)	Range	Mean
Brown rice (% of rough rice)	164	64-83	77	59	74-82	77
Total milled rice (% of rough rice)	164	54-73	68	59	58-73	66
Head rice (% of rough rice)	164	14-70	55	59	35-66	47
Head rice of stressed grain (% of rough rice)	113	6-59	32	59	7-54	28
Chalky grains (% of milled rice) nonwaxy	148	1-49	21	56	3-78	23
Chalky grains (% of milled rice) waxy	12	58-100	86	3	92-98	96
Grain length (mm)	169	3.4-7.3	6.1 M	60	4.6-7.5	6.1 M
Grain shape (L/W)	169	1.4-3.7	2.6 B	60	1.8-3.2	2.4 B
Apparent amylose content (%) nonwaxy	157	11-28	18 I	57	14-29	19 I
Apparent amylose content (%) waxy	12	1-8	3 Wx	3	0-2	1 Wx
Alkali spreading value, nonwaxy	157	3.2-7.0	5.1 I	57	3.2-6.6	5.0 I
Alkali spreading value, waxy	12	3.3-6.0	4.7 I	3	3.0,7.0	5.7 I
Gel consistency (mm) nonwaxy	126	30-100	55 M	25	30-79	46 M
Gel consistency (mm) waxy	9	30-90	73 S	2	74,76	75 S
Instron cooked hardness (kg cm^{-2}) nonwaxy	152	1.4-3.1	2.0	57	1.9-4.0	2.6
Instron cooked hardness (kg cm^{-2}) waxy	12	0.8-1.4	1.1	3	1.0-1.2	1.1
RVA peak viscosity (RVU) nonwaxy	84	142-426	159	24	161-278	238
RVA breakdown (RVU) nonwaxy	84	26-223	88	24	47-122	88
RVA setback (RVU) nonwaxy	84	–19~129	44	24	–34~166	37
RVA consistency (RVU) nonwaxy	84	75-262	132	24	78-288	125
RVA peak viscosity (RVU) waxy	8	122-208	159	1		161
RVA breakdown (RVU) waxy	8	17-74	54	1		84
RVA setback (RVU) waxy	8	–45~79	–9	1		–64
RVA consistency (RVU) waxy	8	24-137	45	1		20
Amylograph peak (BU) nonwaxy	48	440-800	637	14	570-840	666
Amylograph breakdown (BU) nonwaxy	48	95-290	172	14	123-290	221
Amylograph setback (BU) nonwaxy	48	–125~780	218	14	80-865	293
Amylograph consistency (BU) nonwaxy	48	40-875	390	14	300-990	514
Amylograph peak viscosity (BU) waxy	6	400-780	536	1		125
Amylograph breakdown (BU) waxy	6	85-240	151	1		5
Amylograph setback (BU) waxy	6	–180~285	6	1		40
Amylograph consistency (BU) waxy	6	60-390	157	1		45

Evaluation and utilization of fragrance markers for high-yielding aromatic breeding materials

LM Perez, TE Mananghaya, MA Camus, RD Baybado and EC Arocena

Aromatic rice cultivars command premium price in the market. However, the trait is recessive, hence, breeding for aromatic trait requires a large number of breeding materials and extensive labor. Molecular markers associated with fragrance or aroma will be useful to breeders in the development of rice varieties with aroma and high yielding traits. This study aimed to evaluate marker-assisted selection for the aroma trait as an aid to breeding.

Highlights:

- The 198 F2 progenies of the PR34641-2B-15-1-1/MS 6 were established in the field for co-segregation analysis. The 198 F2 plants were individually tagged and deoxyribonucleic nucleic acid (DNA) was isolated and genotyped using multiplex fragrance gene markers. The DNA analysis showed a segregation of 65 plants with 580bp and 257bp, diagnostic alleles for homozygous fragrance gene, 81 plants with 580bp, 355bp, and 257bp alleles (heterozygous), and 52 plants with 580bp and 355 bp (homozygous for non-fragrance gene). Results indicated that fragrance trait in the population analyzed was controlled by recessive inheritance in agreement with the previous report of Bradbury et al. (2005 Plant Biotech. J.).

- Potassium hydroxide (KOH) at a concentration of 0.5% was used to phenotypically characterize 198 F2:F3 derived seeds of PR34641-2B-15-1-1/MS 6. Of 198 entries evaluated, 118 F2 plants exhibited aromatic trait.

- To validate the efficiency of fragrance markers to PhilRice aromatic breeding lines, F2 segregating populations of PR34641-2B-15-1-1/MS 6 were established. Of 146 F2 plants identified with fragrance allele using the fragrance markers of Bradbury et al. (2005), 118 of these plants showed aromatic trait based on phenotyping conducted using KOH method. Thus, the efficiency of detecting fragrance trait using DNA markers was 81.5% of the samples analyzed and had matched phenotypes, while 18.5% had mismatched fragrance and non-fragrance trait using DNA fingerprinting and KOH method. Results indicated that there was a chance of detecting approximately 18% false positives using the fragrance markers of Bradbury et al. (2005).

- Introgression of fragrance trait using two advanced breeding lines of direct-seeded materials and MS6 as the aromatic donor parent were established. The two crosses generated 272 F1 naked seeds

and established to produce F2 segregating population. The F2 plants were established to reevaluate co-segregation analysis between fragrance marker allele and fragrance trait.

- Breeding materials of PR34641-2B-15-1-1/MS6 that exhibited aroma using fragrance markers and KOH method were established for advanced generation. Of 118 F2:3 derived plants, only 15 plants were selected and grown in the field. F4 seeds produced were given to the breeding group.

- To detect the genetic similarity of known aromatic rice cultivars, polymorphism surveys of MS 6, KDML 105, and Basmati 370 were done using 14 identified polymorphic simple sequence repeat (SSR) markers (Figure 4). Another set of selected polymorphic markers were assembled for DNA analysis of these three known aromatic cultivars. Gel extraction and purification kits were assembled for DNA sequencing of MS 6, MS 8 Basmati 370, KDML 105, and Nipponbare to detect the difference of repeats of bases of these aromatic rice cultivars.

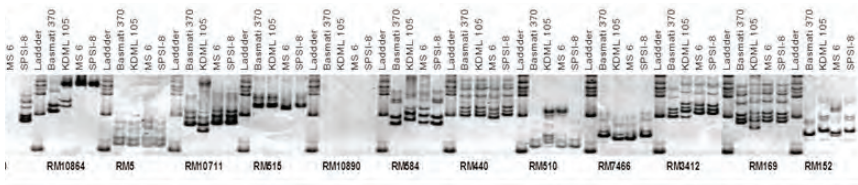


Figure 4. Polymorphism survey of genotypes Basmati 370, KDML 105, MS 6, and SPSI-8 using simple sequence repeat (SSR) markers (RMs). A Ladder was used as a reference DNA to estimate the polymerase chain reaction (PCR) product size. Of the 14 SSR markers, RM 152 (rightmost) showed good polymorphism for the four genotypes. Eight markers were found polymorphic for KDML 105 and Basmati 370 and three markers polymorphic for MS 6 and SPSI-8.

Production of Golden Rice introgression lines in the background of PSB Rc82 and other popular local varieties

AA Alfonso, EO Espejo, DA Tabanao, RT Miranda, ES Avellanoza and ES Nazareno

Golden Rice (GR) is a type of rice that expresses functional Phytoene synthase (psy) and Phytoene desaturase (crt1) genes in the endosperm, resulting in the accumulation of betacarotene (provitamin A) in the grain and giving it a yellow-orange color. This is being eyed as an additional strategy to combat vitamin-A deficiency (VAD) that is a prevalent form of micronutrient malnutrition in the Philippines. This study aimed to introgress the betacarotene biosynthetic genes from GR2R (genetic background of PSB Rc82, with up to 37 ug betacarotene per gram of rice) into popular Philippine rice varieties such as PSB Rc82, NSIC Rc160, NSIC Rc216, and NSIC Rc222. The acceptable morpho-agronomic traits of these varieties increase the likelihood of acceptance by the farmers. The use of molecular markers will help ensure recovery of the genetic constitution of the recurrent parents.

Highlights:

- Eighty-one lines that were established and evaluated in DS resulted in the selection of 30 sublines based on morpho-agronomic data. Molecular analysis enabled us to select 25 sublines for WS planting. Selected sublines were further evaluated at a rate of 200 plants per line. Four lines (A62-10-3-12, A62-10-3-14, A62-10-3-33, and A66-26-1-19) were initially selected based on morpho-agronomic characteristics. All plants from these four lines were subjected to foreground analysis to identify plants possessing the gene of interest. Plants that were homozygous to the golden rice gene were further evaluated based on their phenotypic acceptability.

- Nine plants were finally selected based on homozygosity to the gene of interest and with panicle exertion that was better than the golden rice donor wildtype (Table 2). Figure 5 shows the polished seeds of the nine selected plants expressing the presence of the golden rice gene.

- Hybridization of the four selected lines to the golden rice donor was conducted to recover as much as possible the betacarotene from the donor. BC4F1 seeds were produced from the crosses.

Table 2. Morpho-agronomic and postharvest characteristics of the nine Rc82-GR2R selected plants.

Plant code	Plant #	Plant ht (cm)	Heading days	Maturity days	Panicle exertion	Productive tillers	Panicle length (cm)	Filled spikelets	Unfilled spikelets	100-grain wt (g)	Plant yield (g)	Grain length (mm)	G
A62-10-3-14	46	107	76	106	7	7	25.08	176.40	40.40	2.65	17.91	9.30	
	66	100	77	107	9	7	22.10	93.20	37.00	2.63	8.84	9.00	
	161	96	76	106	7	7	25.80	139.80	23.60	2.57	12.57	8.81	
A62-10-3-33	12	102	74	104	5	8	22.40	70.20	45.00	2.75	8.97	8.85	
A66-26-1-19	156	117	77	107	5	10	28.00	118.00	30.60	2.10	16.83	10.37	
	162	126	77	107	5	6	22.80	84.80	27.00	2.04	7.10	10.50	
	164	119	77	107	7	9	27.80	125.20	26.80	2.80	15.30	10.41	
	171	121	74	104	5	5	20.80	79.60	23.40	2.80	4.59	10.17	
	174	122	74	104	5	9	28.10	131.00	25.40	2.90	18.3	10.10	

Figure 5. Polished seeds of the nine selected plants of Rc82-GR2R.

Production of betacarotene-dense lines with resistance to tungro and bacterial blight

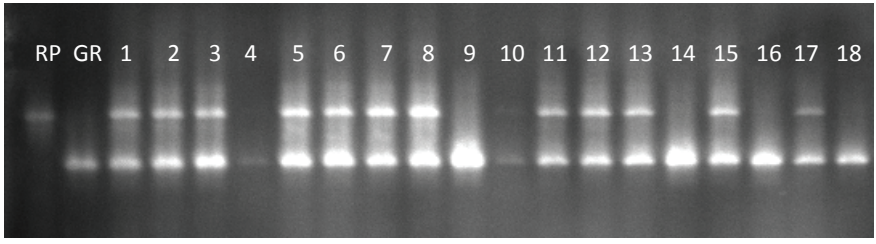
AA Alfonso, EO Espejo, RT Miranda, ES Avellanoza, and ES Nazareno

The presence of new and more devastating strains or biotypes of pathogens and pests exacerbates the problem of pest infestation. Thus, the availability of durable and broad-spectrum resistance remains a great challenge. Pest resistance, excellent grain quality, and high yield continue to be the primary objectives in rice breeding. Moreover, the increasing awareness on the widespread occurrence of health maladies and reduced productivity caused by insufficient micronutrients in the diet make it imperative for breeding programs to give emphasis on the nutritional aspect of rice. This study aimed to address current problems on rice diseases particularly tungro and bacterial blight, and micronutrient malnutrition particularly Vitamin A deficiency by combining the ability to produce beta-carotene and agronomically important genes into locally adapted rice germplasm.

Highlights:

- In DS 2012, another batch of screening for elite breeding lines was conducted to identify new donors for disease resistance. Eventually, a new line, IR78581-12-3-2-2, was identified to be resistant to tungro and bacterial blight diseases. Hybridization of this line with the golden rice donor was immediately conducted wherein 75 F1 seeds were produced. Continuous hybridization of PR37171-1-1-1-2-2-1-1 with the golden rice donor was conducted wherein 57 BC2F1 seeds were produced. A three-way cross was also conducted involving the F1 seeds of IRBB62/ Matatag 1 and crossed with the golden rice donor where 52 F1 seeds were produced.

- In WS 2012, screening of the progenies for disease resistance was conducted, wherein 42 F2 plants from PR37171-1-1-1-2-2-1-1 x GR2R were evaluated. Nineteen plants were found to be resistant to tungro while 12 plants had intermediate resistance. With the use of an event-specific marker for the detection of the golden rice gene, three plants were homozygous to the golden rice locus while 12 plants were heterozygous. Figure 6 shows a gel picture in identifying progenies that were heterozygous, i.e., possessing both the banding patterns of the parents or homozygous if it only possessed either one of the parent's allele. Progenies having an allele homozygous to the golden rice donor were primarily selected for further hybridization activities. Reevaluation of these progenies for bacterial blight reaction will be conducted to confirm initial results obtained. Plants conferring resistance to tungro and bacterial blight and homozygous to the GR2 locus are priority for production of backcross progenies. Boots from selected plants were collected for anther culture activities.



RP= recurrent parent allele GR= GR2R allele 1-18= progenies

Figure 6. Foreground selection of progenies using event-specific marker. Progenies were heterozygous when possessing the banding patterns of the parents or homozygous when possessing one of the parent's alleles.

II. Assessment and improvement of quality and utilization of rice variants
Marissa V. Romero

Low phytic acid mutants as sources of good quality brown rice with improved mineral bioavailability
BO Juliano, APP Tuaño, AD Peñaloza, AR Agarin, MM Pontañez, LM Perez, TF Padolina, NV Desamero, and QY Shu

Most non-starch health-related beneficial compounds (e.g. antioxidants, B-vitamins, dietary fiber, fat) are concentrated in the bran layer of brown rice and are removed during milling to produce polished/white rice. Absorption in the body of some minerals such as Ca, Zn, Fe, and Mg is affected by an anti-nutrition factor – phytic acid that is also present in the bran. Phytic acid has been shown to be beneficial due to its antioxidant and anticancer properties. However, its ability to combine with minerals prevents the efficient absorption of micronutrients in the body.

Recent animal feeding studies using brown rice showed that low phytic acid (lpa) mutants had higher mineral absorption as compared to their wild type counterparts. However, the corresponding negative effect on seedling vigor needs further attention since phytic acid is the essential storage form of phosphorus needed in the metabolism of the germinating rice seed. This collaborative study aimed to: 1) characterize two lpa indica rice mutants from China; and 2) screen local elite mutant lines from PhilRice CES.

Highlights:

- Two screening methods were optimized, validated, and adopted for use in screening local mutant lines for high-inorganic phosphate (HIP) as indicator of lpa phenotype. Pooled seeds were used for preliminary screening and half-seeds were used for further screening and seedling vigor analysis. Panicle seed screening will be optimized and validated using the 2012 WS harvested panicles of previously selected lines.

- In 2012 DS, 274 PhilRice mutant lines from various wild type rice cultivars like Azucena, NSIC Rc9, and Balatinao were tested and 53 mutants were positive to the optimized HIP assay. Six lines from the traditional variety Azucena were selected giving consistent HIP scores of 2.5-3.0 in more than 50% of the seeds analyzed. This range of HIP score corresponded to ~50% reduction in seed phytic acid level.

- In 2012 DS, grain yield of the selected Azucena-based mutant lines ranged from 3.5 to 6.2t/ha. They generally had uniform and short plant types with height ranging from 81to 91cm, medium-sized grains and tiller count ranging from 12 to 18 tillers. Grain quality and

phytic acid levels of these selections will be determined after panicle screening of 2012 WS seeds.

- BC2F1 seeds from the cross between NSIC Rc160 and Os-lpa-MingHui 86 (ex China) gave different HIP scores ranging from 2.5 to 5.5 while BC1F1 seeds from the cross between NSIC Rc160 and Os-lpa XQZ-1 (ex China) gave a narrow range of HIP scores of 2.5 to 3.5. Half-seeds with embryo of the seeds analyzed were returned to LM Perez's team for germination and seedling vigor testing.

Improvement of cooking, eating, nutritional and keeping quality of brown rice

HM Corpuz, MB Dacumos, MJC Ablaza, LM Manlapig, ME Chico, BV Ylarde, and MV Romero

Brown rice is relatively superior to milled white rice in terms of nutritional quality because its bran layers contain higher amounts of vitamins, minerals, and phytochemicals. Despite its nutritional advantages, brown rice remains unappealing to some because of its longer cooking time, harder cooked grains and shorter shelf life. These undesirable characteristics of brown rice grains are greatly attributed to the waxy and oily bran layers. Our previous study showed that physical treatment such as light polishing and fissuring treatment improved the cooking and eating quality of brown rice. However, light polishing speeds up the conversion of freed oil into free fatty acids through lipase enzyme-catalyzed lipolytic hydrolysis reaction. Free fatty acids are then oxidized and degraded into secondary products (hydroperoxides) that are responsible for the rancid off-odor and flavor of brown rice grains. However, lipase enzyme is heat-sensitive and its activity can be stabilized through suitable heat treatments. Thus, this study was conducted to (a) determine the effects of heat treatments and storage containers on the shelf life of brown rice with improved cooking and eating quality; and (b) optimize and improve a rapid, efficient, and reliable colorimetric method for the determination of phytic acid in brown rice and its products.

Highlights:

- Light-polished NSIC Rc160 brown rice grains were stabilized by autoclave and microwave heating at different exposure times, packed in nylon-coated plastic, wooden and plastic box, and stored at room temperature. The changes in the cooking, eating, and nutritional qualities and physicochemical properties of stabilized brown rice were monitored monthly for a period of one year. Results of initial tests showed that the free fatty acid (FFA) content of light polished brown rice was higher than that of unpolished brown rice. Unlike microwave heating, a slight decrease was observed in

FFA, moisture content, antioxidant activity, Instron hardness, and cooking time of brown rice after autoclave heating.

- Analysis of variance revealed that stabilization time, type of storage containers, and storage period had significant effect on the physicochemical properties, cooking, sensory, and antioxidant activity of light-polished brown rice aged for eight months. Autoclave heat treatment increased the FFA values during the first three months and gradually decreased in the succeeding months. However, the FFA content of light-polished brown rice stabilized by microwave heating continually increased up to the sixth month of storage and slightly decreased from seventh to eighth month (Figure 7). Lipase activity and formation of FFA in light-polished brown rice stabilized by both heating methods decreased with increasing stabilization time. FFA contents of the treated samples stored in plastic box and nylon-coated plastic were significantly lower than that of the samples kept in wooden box.

- Antioxidant activity, Instron hardness, cooking time, and moisture content of autoclave-heated brown rice significantly decreased with increasing stabilization time. For microwave heating, stabilization time did not affect the antioxidant activity, cooking time, and cooked grains Instron hardness. However, moisture content decreased.

- Different heat stabilization methods were tested to prolong the storage quality of regular or unpolished brown rice. Heat treatments effectively reduced the free fatty acid formation after a three-month storage period: (a) oven heating at 80 to 1000C for 20 to 30 min and 125 to 1750C for 5 min, (b) microwave heating for 3 to 5 min at 1000 W, (c) steaming for 10 to 20 min and oven-drying at 400C, and (d) autoclave heating at 1250C for 3 to 5 min.

- Preliminary results of protocol optimization showed that the computed phytic acid content of brown rice using hydrochloric, nitric, and sulfuric acids at < 2.5% concentration was close to the reference value of 1.27% for NSIC Rc160. A ratio of 0.4-0.6:10 (flour weight in g and extractant volume in ml) gave phytic acid values comparable to that of the check variety.

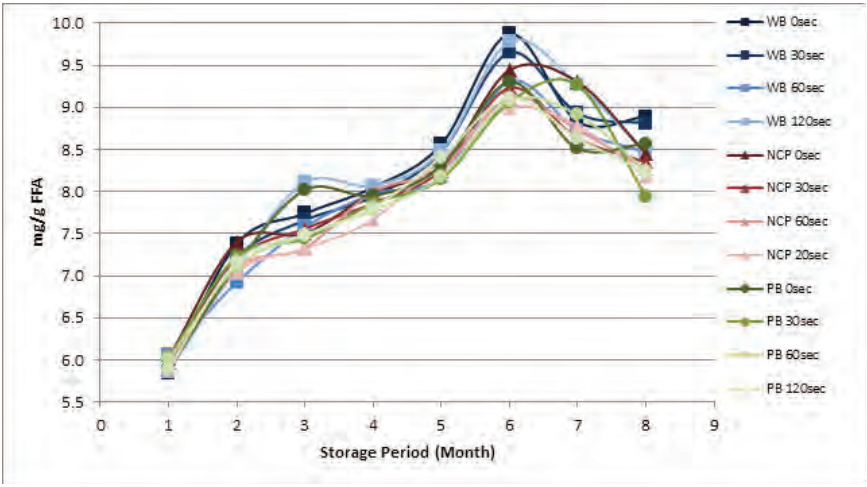


Figure 7. Effect of storage time on the free fatty acid formation in microwave-stabilized brown rice stored in wooden box (WB), nylon-coated plastic (NCP), and plastic box (PB).

Design fabrication and performance test of pedal-operated household-type brown rice mill

HV Valdez and AS Juliano

Filipinos are becoming health conscious nowadays. Some consumes healthy food such as brown rice while others maintain their physical health through exercise. Traditionally, brown rice was produced using mortar and pestle. PhilRice developed two prototypes of brown rice milling machine with promising output. These prototypes required 5hp single phase electric motor and 10hp three-phase electric motor. The present study focused on designing a pedal-operated household type brown rice mill. This pedal-operated machine does not use electric power and can be used for exercise.

Highlights:

- The original design of feeder roll was modified to reduce the feeding rate (Figure 8). Results showed that the feeding rate was reduced from 235kg/h to 69kg/h in the first passing. The speed of rotation of the feeder roll during the test was 622rpm and was directly connected to the slower rubber roll.

- An attempt to further reduce the feeding rate was conducted. A 1.5Hp single-phase electric motor with about 1,785rpm was coupled to the unit. Drive pulley of the slower and faster rubber roller was interchanged. Drive pulley of the feeder roll which was directly connected to the faster rubber roll with average speed of

1,489rpm was changed with three pulley diameters of 4", 3", and 2". The resulting speeds of the feeder roll during first passing were 1,161rpm, 1,508rpm, and 2,136rpm, respectively. The resulting feeding rates for the first passing were 62.56kg/h, 40.62kg/h, and 40.63kg/h for the three feeder roll speeds, respectively.

- Centrifugal type blower was also incorporated into the unit to separate the hull from the middling. A collector was connected to collect output from the rubber roll and passes to stream of air blown by the blower, thus, hull separation was accomplish. After two recirculations of the middling, the best output product was at the average feeder roll speed of 1,510 rpm (3" dia. drive pulley) with 99.46% BR, 0.20% unhulled paddy, and 3.46% hull.

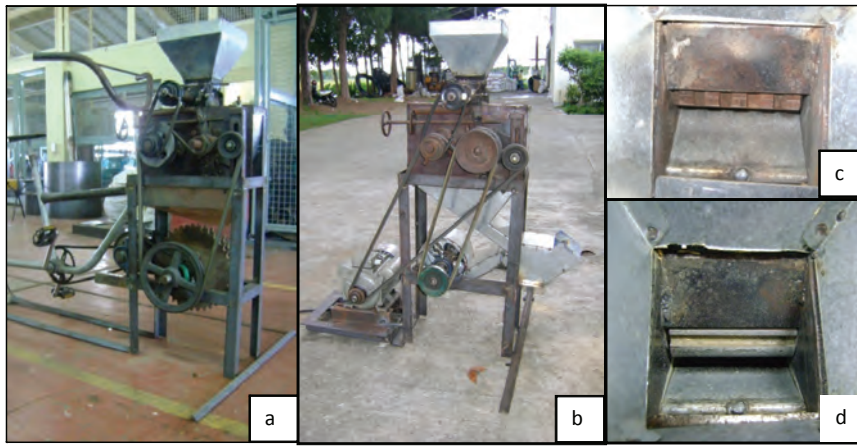


Figure 8. Modified pedal operated BRM prototype showing the (a) feeder roll attach to slower rubber roll, (b) FR attach to faster RR and blower attach to slower RR, (c) original or first design of FR, and (d) modified FR.

Characterizing the nutraceutical content and enhancing the utilization of pigmented rice in the Philippines

MV Romero, NC Ramos, OC Soco, and HF Mamucod

White rice is the form commonly consumed in many parts of the world. However, there are also various kinds of pigmented rice such as black, purple, and red rices. Anthocyanins are responsible for the pigmentation of these rices. Other polyphenol compounds in pigmented rice were reported to have some form of antioxidant, anti-inflammatory, or anticancer activities.

Evaluation of beneficial components in pigmented rice has been conducted in local varieties in neighboring Asian countries. In the Philippines, this activity is limited despite the presence of numerous pigmented rice varieties.

In our previous research, about 100 pigmented rices from the PhilRice Genebank were characterized for grain quality and functional properties such as anthocyanin content, total phenolic content, and antioxidant activity. The brown rice or unpolished form of rice is nutritionally better than milled rice due to higher amounts of fiber, vitamins, minerals, antioxidants, and other phytonutrients. However, it has shorter shelf-life due to greater susceptibility to hydrolytic and oxidative rancidity of the lipids in the bran caused by enzymes such as lipase and lipoxygenase. The shelf-life of a product can be extended through the use of appropriate packaging materials and proper storage conditions. This study aimed to evaluate the effect of packaging and storage conditions on the shelf-life of unpolished pigmented rice samples and to characterize them periodically in terms of grain quality, functional properties, free fatty acid content, and other parameters.

Highlights:

- Ballatinao (black rice) and Chorchoros (red rice) were obtained from Benguet while NSIC Rc160 (non-pigmented rice) was obtained from PhilRice-CES. The rice samples (Figure 9) were packed in nylon-coated plastic, polyethylene plastic, and aluminum foil pouch (Figure 10), sealed with or without vacuum, and kept at room and refrigerated temperatures. They were also subjected to evaluation of grain quality, proximate composition, functional properties, and free fatty acid (FFA) content.

- Chorchoros consistently had the highest brown rice, total milled rice, and head rice recovery. Ballatinao had the lowest brown rice and total milled rice recovery but NSIC Rc160 had the lowest head rice recovery. Ballatinao and Chorchoros had medium grain length but the former had intermediate grain shape while the latter was bold. Meanwhile, NSIC Rc160 had long and slender grains. Chorchoros had higher amount of chalky grains (11.45%) compared to NSIC Rc160 (1.65%). Ballatinao had opaque grains. In terms of amylose content, Ballatinao was waxy or glutinous while Chorchoros and NSIC Rc160 were of low amylose-types. Based on alkali spreading value, all samples were classified to have low gelatinization temperature.

- Ballatinao had the highest crude protein, crude fat, and ash content while Chorchoros had the lowest values for all the parameters except carbohydrates. NSIC Rc160 had the highest crude fiber content.

- Vitamin content of the samples was measured using high performance liquid chromatography (Figure 11). Ballatinao exhibited the highest amount for all the vitamins except for pyridoxine where it had the same value as that of Chorchoros. On

the contrary, NSIC Rc160 had the lowest thiamin, riboflavin, and pyridoxine content.

- Ballatinao had the highest anthocyanin content (5,674 mg/mL) and total phenolics (9.30mg GAE/g) but only second in terms of antioxidant activity (83.7%). Chorchoros had the highest antioxidant activity (89.%) and second in anthocyanin content (60.9 mg/mL) and total phenolics (6.18 mg GAE/g) contents. NSIC Rc160 was consistently lowest in anthocyanin content (42.7mg/mL), antioxidant activity (52.4%), and total phenolics (1.03mg GAE/g).

- The amount of free fatty acid (FFA) is an indicator of oxidative degradation. The initial FFA content of the samples ranged from 0.021 to 0.026% and the changes during storage. A significant increase in FFA content was observed during the first month of storage for all samples but it was more dramatic for unpacked samples. Based on the results, the best storage conditions to extend the shelf-life of pigmented rice were the use of aluminum foil packaging material, vacuum sealing, and storage at refrigerated temperature.

Figure 9. Rice samples used for shelf-life evaluation.

Figure 10. Ballatinao (top), Chorchoros (middle), and NSIC Rc160 in different packaging materials sealed with or without vacuum.

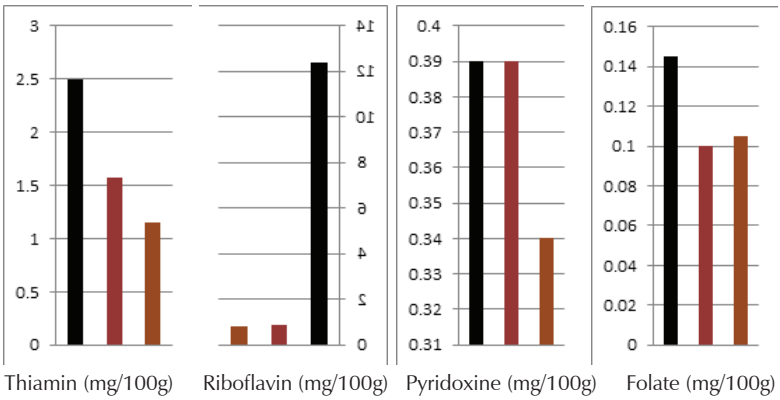


Figure 11. Vitamin content of the rice samples.

Assessment of soil fertility, yield, grain quality, and nutrient content of irrigated rice as affected by organic and inorganic fertilizer and pesticide application

KLS Tafere, CP Mamaril, MV Romero, NC Ramos, and MB Castillo

Organic agriculture has been extensively promoted all over the world and many farmers and entrepreneurs are slowly shifting to organic farming and related businesses. Likewise, organic food has become popular among consumers believing that it gives more nutritional benefits. In contrast, conventional farming that uses high-yielding varieties and huge amounts of inorganic fertilizers and pesticides are said to be eroding the inherent productivity of the soils and produces crops that are of lower nutritional quality. This study aimed to evaluate the effect of organic and inorganic fertilizers, with or without pesticides on the yield and grain quality of irrigated rice.

Highlights:

UPLB Experimental Site DS 2012 (January - May 2012)
Agronomic Parameters

- No significant differences in grain yield of PSB Rc18 were obtained in DS 2012 with or without the application of pesticide as well as from the fertilizer management treatments (Figure 12). Treatment with inorganic fertilizer obtained the highest yield (5.7t/ha) followed by treatments in descending order half organic + half inorganic fertilizer (5.6t/ha), organic fertilizer only (5.6 t/ha), and control being the lowest (5.3t/ha).

- As shown in the site soil analysis (Table 3), the soil was relatively fertile that even the control yielded 5.3t/ha.Thus, it could be the reason why there was no significant difference in yield with the application of different fertilizer materials.

UPLB Experimental Site WS 2012 (August-December 2012)
Agronomic Parameter

- There was a significant difference among treatments in the grain yield of Rc18 during the WS 2012 (Figure 12). Treatment with inorganic fertilizer obtained the highest yield of 5.2t/ha, followed by treatments in descending order, half organic + half inorganic fertilizer (4.9t/ha), organic fertilizer only (4.46t/ha), and control (4.33t/ha) being the lowest yielding.

- Due to higher irradiance, yields were higher in DS than in WS for all treatments.

Grain Quality

- Milling recovery data showed no significant difference among treatments with different pesticide application. The brown rice (BR) recovery of the samples ranged from 74.31 to 75.25% for 2011 WS and 73.30 to 76.00% for 2012 DS. The samples were classified to have poor to fair BR recovery. Almost all of the samples had Grade 2 to 1 total milled rice that ranged from 65.14 to 66.57 % for 2011 WS and 62.40 to 67.80% for 2012 DS. Head rice ranged from 56.14 to 57.91% for 2011 WS, and 49.70 to 60.10% for 2012 DS. The chalkiness ranged from 0.30 to 3.93% for 2011 WS and 2.53 to 6.60% for 2012 DS.

- All samples had intermediate amylose content. In terms of percent crude protein of the rice samples, no significant difference was observed among treatments with pesticide application. Without pesticide application, control obtained the lowest crude protein content. No significant difference was observed in terms of antioxidant content among treatments with different pesticide applications. The antioxidant content of the samples ranged from 34.43 to 37.94% for 2011 WS and 31.70 to 43.40% for 2012 DS.

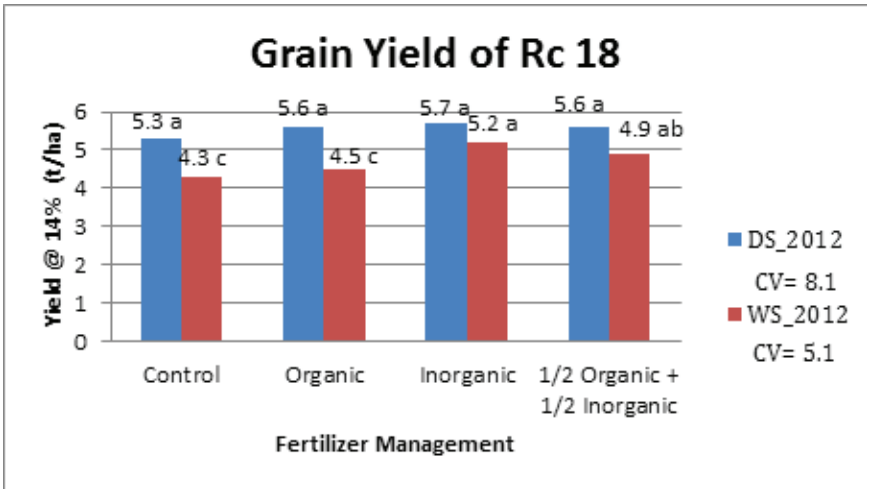


Figure 12. Effect of fertilizer management on the grain yield of PSB Rc18 in C8- Area 3, UPLB in 2012 DS and WS.

Table 3. Analysis of soil samples from C8- Area 3, UPLB.

	C8-Area 3, UPLB	Optimum Values
pH	5.9	5.5 - 6.5
OM (%)	4.0	3.4– 5.2
P (ppm)	10	10 – 15
K (me/100g soil)	0.80	> 0.20

Brown rice satiety and glycemic indexes
BO Juliano, AdR Felix, TP Trinidad, and APP Tuaño

Brown rice (BR) can be an important functional food for the rice-consuming Filipinos considering the low glycemic index (GI) values of whole-grain cereals and their associated health benefits. In 2010, a "raider" to our study on GIs of milled rice was implemented to measure the GI and satiety index of BR. The study used two varieties, one with low apparent amylose content (AC) and one with intermediate AC (the most popular grain quality types preferred by many Filipinos). The GI of BR was found lower than its milled form, but only in the low-AC (Sinandomeng) rice variety, and not in the intermediate-AC (IR64). Results indicated the need for a follow-up research to establish the effects of starch properties and dietary fiber on GI and satiety of BR, particularly since we noted significant differences in GI among seven milled rice of waxy, low, intermediate, and high AC.
This study aimed to complete the satiety and glycemic indexes of brown rice of varying amylose types, with focus on a waxy variety (Improved Malagkit Sungsong 2 [IMS2]), a high-AC rice variety (PSB Rc10) and a local modern low-AC variety (NSIC Rc160). At the end of the study, the proposed association of GI and satiety quotient with AC and dietary fiber will be validated. Also, the effect of bulk density and cooked rice texture on post-meal food intake and satiety potential of BR will be determined.

Highlights

- Results of proximate and physicochemical analyses of the 2012 DS samples to be used for the feeding trials are shown in Table 4. PSB Rc10 had a lower AC value using the ammonium-buffered assay than the acetate-buffered assay (27.0%, PhilRice LB 2010 data). IMS2 had normal protein content compared to previous data (9.9%, PhilRice LB 2010 data). With these results, GI and satiety index of waxy rice with normal protein content may be compared with a

high protein, waxy rice previously tested. NSIC Rc160 was included in the study in order to compare previous results from Sinandomeng (ex Laguna) with a locally-released popular modern variety of similar AC.

- Instron hardness values of cooked rice with fixed water uptake ratio (~1.1 to 1.2) varied relative to amylose type of the samples. Rice-water ratios giving cooked brown rice of similar Instron hardness were determined (Table 4).
- Preliminary screening of human subjects for the GI and short-term satiety index measurement was completed.

Table 4. Proximate analysis and physicochemical properties of 2012 DS samples to be used for GI and satiety index study

Grain Quality Parameter	IMS2[a]	NSIC Rc160	PSB Rc10
Proximate analysis (freeze-dried cooked brown rice)			
Moisture content (%)	16.0	15.8	12.6
Crude protein (%)	7.5	8.2	7.5
Crude fat (%)	4.5	3.1	2.0
Ash (%)	1.7	1.5	1.3
Total Carbohydrate (%)	70.3	71.4	75.6
Energy (kcal)	352	346	359
Rice-water ratio yielding similar Instron hardness	(1.3)	(1.8)	(2.2)
Physicochemical analysis (milled rice)			
Apparent amylose content (%)	2.4	12.3	21.7
Alkali spreading value	6.0	6.0	4.7
RVA pasting viscosity (RVU)			
Peak	178	287	193
Breakdown	73	121	77
Setback	–41	–31	161
Consistency	32	90	238
Amylograph pasting viscosity (BU)			
Peak	460	760	740
Breakdown	150	280	60
Setback	–155	–60	440
Consistency	–5	220	500

[a]IMS2 - Improved Malagkit Sungsong 2

III. Utilization of Rice and High-Value Crops for Food and Biomedical Applications

RA Ramos

Development of vegetable supplements and their utilization in rice-based snacks

RV Manaois, AV Morales, HF Mamucod, and RA Ramos

Addition of nutrients or fortification is a common approach to improve the nutrient profiles of foods. The health promoting properties of vegetables, along with their rich nutrient profile, make them an important component of the food-based approach to reduce public health problems in the Philippines. Developing a technology on processing highly nutritious vegetables, such as the leaves of chili pepper or sili, for incorporation in foods and diets will ensure availability of the vegetables all year round, and consequently, an increased intake of micronutrients among all segments of the population. This is a sustainable way of combating and preventing micronutrient malnutrition. This study explored the development of shelf-stable fortificant from sili leaves and its utilization in different food products. The storage quality of the powder and the nutritional properties of the food products were evaluated.

Highlights:

- The use of chili pepper leaves (CPL) as a supplementary ingredient in bread was evaluated. Fourteen laboratory sensory panelists were utilized to determine the product attributes and acceptability of lees-substituted samples. Eight sensory attributes were identified during lexicon development of bread with and without chili leaves and commercially available reference samples to develop a scorecard and characterize the sensory properties of the samples based on unstructured 15cm scale.

- Sensory evaluation by 14 semi-trained laboratory panelists of bread with different levels of crushed (CCPL) and powdered (PCPL) chili pepper leaves showed that samples with up to 1% supplementation of CCPL and 0.5% PCPL were comparable with the control at $p=0.05$. Increasing the amount of CPL negatively affected the appearance, aroma, taste, mouth-feel, and overall acceptability of bread.

- Supplementation of bread with CPL at 0.5% significantly improved the beta-carotene and folic acid levels of the product by more than 200 ug/100g and 120 ug/100g, respectively (Table 5). The iron and total dietary fiber levels of the breads with CCPL and PCPL were higher than the control at $p=0.05$.

- Water activity values of bread samples ranged from 0.81 to 0.83. The total plate and mold counts were within the acceptable limits (<10 x 104 CFU/g and <1,000 CFU/g for TPC and molds, respectively), based on the standards of the United Nations World Food Program (2009).
- Bread with 0.05% CCPL and the control were similarly acceptable (97%) to 60 consumer panelists aged >18 years with 29 males and 31 females (Table 6). Purchase intents for the samples were high, with 90% for bread with CCPL and 87% for PCPL, but they were scored higher if test samples were known to have additional nutrients. This indicates that nutritional information of a product had a significant effect on the willingness of consumers to buy and use the product. Results demonstrated the market potential of bread supplemented with chili pepper leaves.

Table 5. Nutritional composition of bread supplemented with chili pepper leaves.

Parameters	Level of supplementation (g/100g)		
	0	0.5 CCPL	0.5 PCPL
Vitamin C (mg/100g)	1.0±0.0[a]	1.0±0.0[a]	1.0±0.1[a]
Calcium (mg/100g)	10.8±0.4[b]	11.6±0.1[b]	12.8±0.1[a]
Iron (mg/100g)	3.6±0.0[c]	4.3±0.1[a]	4.0±0.0[b]
Beta-carotene (ug/100g)	<1.0±0.0[c]	214.5±6.4[b]	237.5±0.7[a]
Folic acid (ug/100g)	273.5±17.7[b]	401.0±25.5[a]	418.5±4.9[a]
Total Dietary Fiber (g/100g)	1.7±0.0[b]	2.4±0.2[a]	1.9±0.2[ab]
Total sugars as Invert (g/100g)	18.5±0.0[a]	17.3±0.4[b]	17.4±0.3[ab]
Total fat (g/100g)	5.8±0.0[a]	5.7±0.0[a]	5.6±0.0[a]

Mean values in the same row with the same letter are not significantly different at $p=0.05$.

Table 6. Consumer preference scores and acceptability of bread with chili pepper leaves.

Properties	Level of chili pepper leaves (g/100g)		
	0	0.5 CCPL	0.5 PCPL
1. Acceptability[a]	97	97	93
2. Rating[b]	4	3	3
3. Willingness to buy if[a]			
a. available in the market	93	90	87
b. with additional nutrients (iron, beta-carotene, dietary fiber)	92	93	95
4. Cost of product subject is willing to pay[a]			
P 1.50	39	45	48
P 2.00	40	35	38
P 2.50	13	10	7
Other price (Php)	8	10	7
5. Ranking[c]	1	2	3

Sensory evaluation conducted at PhilRice CES, employing 60 staff as subjects.
[a]Based percent of positive responses
[b]1= poor, 2= fair, 3= good, 4= very good, 5= excellent
[c]1=highest, 3=lowest

Development of condiments and natural fortificants from rice-based crops: chili pepper leaves

HF Mamucod and RG Abilgos-Ramos

Shelf-life evaluation of crushed and powdered chili pepper leaves

Vitamin and mineral deficiencies affect a third of the world's people debilitating minds, bodies, energies, and the economic prospects of nations. It is estimated that more than two billion people in the world are deficient in vitamin A, iodine, iron, zinc, and other micronutrients. In the latest Vitamin and Mineral Deficiency Assessment Report issued by UNICEF and Micronutrient Initiative of USA, 23% of children under six in the Philippines had sub-clinical vitamin A deficiency. The estimated annual number of child death caused by vitamin A deficiency was about 4,500. Fortifying foods with basic vitamins and minerals is considered both essential and affordable. Fortification is a process of enriching food products that are regularly consumed by a significant proportion of the population with essential vitamins (e.g. A, B, C) and minerals (e.g. Most of the commonly and locally grown vegetables are known to be rich sources of essential nutrients like vitamin A, C, and iron. Chili pepper (Capsicum sp.) leaf, locally called as dahon ng sili, is a native American plant which has become a popular ingredient in Asian cuisine. Based on the Philippine Food Composition Table (FNRI-DOST, 1997), the nutritional composition of chili pepper leaves was comparable with the more popular moringa leaves. It was proven to have a good antioxidant activity due to the presence of □-tocopherol. Substantial amount of lutein and chlorophyll is also found in the leaf (Kim et al., 2011). This study aimed to (a) process chili pepper leaves into crushed and powdered supplement using previously optimized oven-drying method, (b) identify the most suitable material for product packaging and storage, and (c) establish a baseline nutritional profile of the powdered supplement.

Highlights:

- Processing of chili pepper leaves into powder yielded 15.4% based on fresh weight.

- Baseline nutritional analysis showed that powdered chili pepper leaves contained 13.88 mg/100g iron, 157.75 mg/100g calcium, 57.50 mg/100g B- carotene, 6.08 mg/100g folic acid, and 10.68 mg/100g vitamin C (Figure 13). The effect of storage and packaging material on the nutritional composition of the powdered supplement will be assessed.

- Initial moisture content (MC) of crushed supplement was significantly higher than that of powdered form. However, on the eighth until tenth month of storage, the MCs of the samples were comparable regardless of form and packaging material. Samples generally remained stable throughout the storage time with only

slight changes on the second until sixth month of storage. This indicates good product storability.

- Powdered samples had significantly lower initial total plate and mold counts compared with crushed samples. As the storage time progressed, no significant change was observed between the treatments. Interestingly, the microbial counts of all samples significantly dropped after two months of storage. This indicated that the chili pepper leaves possessed certain inhibitory component that could prevent further growth of microorganisms. Because of the smaller particle size of powdered samples, the inhibitory component was probably more readily released and came easily in contact with the microorganisms. This assumption requires further investigation, particularly an antimicrobial assay of chili pepper leaves against several species of bacteria and fungi.

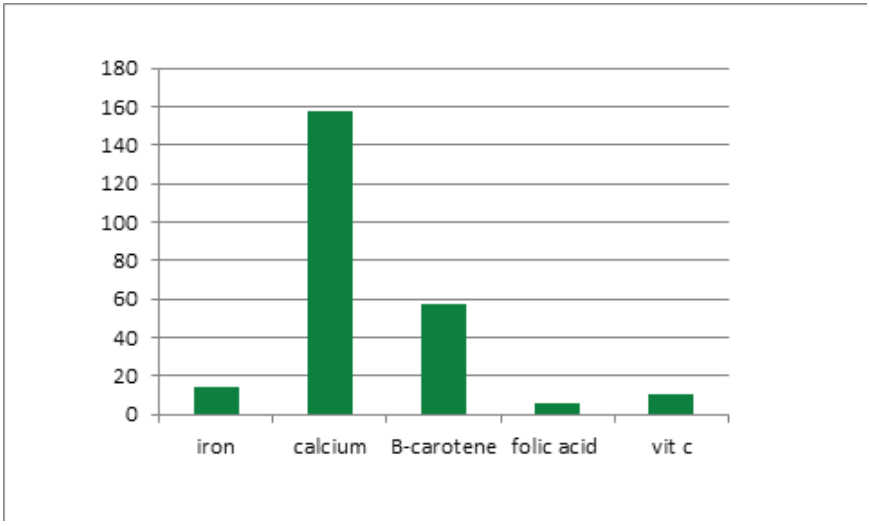


Figure 13. Nutritional composition of powdered chili pepper leaves

Development and evaluation of rice beverage

EH Bandonill, GG Corpuz, HF Mamucod, and MV Romero

Rice water, locally known as am, is traditionally given by mothers to their babies as supplement to breast or formula milk. In rural areas, homemakers from low income families rely heavily on am for the satiety of their babies. Boiled rice water (am) is also used as a remedy to diarrhea among young children especially where oral rehydration solution (ORS) is not readily available. Several clinical trials conducted between 1981 and 1996 demonstrated the effectiveness of rice-based ORS over glucose-based ORS. Am is conventionally prepared by scooping out viscous liquid

from boiling rice or by boiling rice powder in excess water. This method, however, requires time and fuel for cooking. Short shelf life of rice water and high cost of rice-based ORS are additional limitations to these products. This study aimed to document the conventional way of preparing am and established that its use in many households is still being practiced. Furthermore, it explored different methods of preparing instant am that is safe to consume, convenient to use, affordable, and has longer shelf life, in the form of cold water soluble starch (CWS). Instant am produced was further characterized.

Findings:

- The survey among 49 mothers from Maligaya, Muñoz, Nueva Ecija revealed that majority of the respondents prepared am using rice flour cooked in boiled water instead of scooping the liquid from boiled rice. Instant am was accepted by the respondents and expected to significantly address the current problems encountered in am preparation. Respondents (78%) were willing to pay for instant am at P5 to P10/serving.

- Spray drying method was tested in preparing CWS using a Niro Atomizer. IR64 starch had the highest water solubility compared to other forms (grains and flour) (Table 7).

- The effect of alcoholic-alkaline treatment on the water solubility of isolated starches was tested. IMS2 had the highest initial water solubility, followed by NSIC Rc160 and NSIC Rc222. The granular structure of CWS starches remained intact but became larger than the original native granules.

- The modified Shimizu method (Figure 14) was used in testing rice with varying amylose content. IMS2 (waxy) and NSIC Rc160 (low) cooked well within 30-min steaming while IR64 (intermediate) and PSB Rc10 (high) cooked longer (45 minutes) with additional water sprayed. Succeeding experiments then utilized IMS2 and NSIC Rc160 since both produced rice flours that easily dissolved and gelatinized upon addition of tap water.

- To determine the saturation point of soaking milled rice by Shimizu method, the water absorption capacity of milled rice samples were evaluated within three hours to 10 days. Saturation point was at 24-hr soaking.

- Steaming time at 97+2oC of one-day-soaked IMS2 was more than 20 minutes while seven-day-soaked IMS2 gelatinized completely in 20 minutes. NSIC Rc160 had longer cooking time (25 minutes).
- In addition to the optimized Shimizu and gun-puffing methods, pre-

gelatinization by boiling and autoclaving were done and cold-water solubility (CWS) of rice flours was tested. Commercial waxy rice flour had higher CWS than non-waxy rice flour while the untreated IMS2 had higher solubility (3.30%) than NSIC Rc160 (1.82%). Gun-puffing which expands rice grains 10 times its original size produced rice flour with higher CWS (50%) for IMS2 and 15% for NSIC Rc160.

- The functional properties of rice flour prepared from the different methods were tested. Pre-gelatinized IMS2 rice flours showed higher water absorption index (WAI) compared to native glutinous flours, CGF, and IRF. Highest value was observed in IS7 (7.23g/g) followed by IPR (6.92g/g). The lowest WAI was noted in IRF (1.33g/g) and CGF (1.66g/g). Similarly, water solubility index (WSI) of native glutinous flours was lowest, followed by IS1 and IS7 while the highest WSI was noted in IPR (0.27g/g). All rice flour samples had comparable swelling power. On the other hand, highest oil absorption index (OAI) was observed in NPR (3.47g/g) while the other samples had similar reading.

Table 7. Water solubility of spray-dried samples*

SAMPLE	WATER SOLUBILITY (%)
NSIC Rc160, polished rice grains	14.22[b]
NSIC Rc160, polished rice flour	13.17[b]
NSIC Rc160, germinated brown rice	12.90[b]
IR64 starch	20.12[a]

**Mean values in the same column with the same letter are not significantly different at 5% level DMRT.*

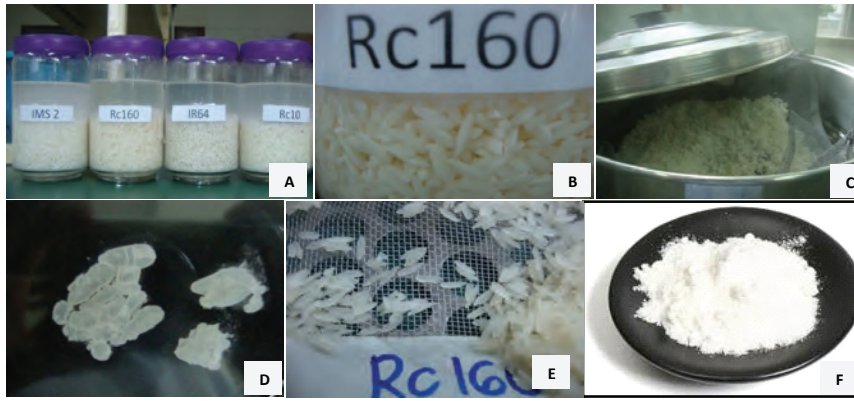


Figure 14. (A) Soaking of rice samples for 7 days at ref temperature. (B) NSIC Rc160 grains soaked in water after seven days. (C) Steaming of rice grains for 30-45 minutes. (D) Testing for doneness by pressing cooked grains in between two petri plates. (E) Dried NSIC Rc160 (12 hour at 40oC). (F) Powdered rice sieved through 140.

Improvement of PhilRice tapuy and development of rice wine variants
EH Bandonill, AV Morales, MJC Ablaza, MV Romero

The process of wine production using glutinous rice has long been established in PhilRice and the product is now commercialized. However, the quality of wine deteriorates through time. Off- flavor develops and color intensifies during storage especially at room temperature. There is a need to study the critical stages where the product can be improved. Important compounds which may have caused these problems should be identified and properly documented. Equipment that can be used to remove these compounds may also be tested to possibly address these problems.

Moreover, to offer consumers another way of enjoying rice wine, preparation of a new variant by blending fruit wine to PhilRice tapuy is a possible option. Most fruit wines especially the deep- colored ones are rich in phytochemicals, flavonoids, and anthocyanins which are said to increase appetite, reduce the incidence of coronary heart disease, and even decrease cancer cells (Manila Bulletin, 2010; AGRIS, 2011). Thus, the study explored blending commercial bignay wine and PhilRice Tapuy and its distilled form to possibly increase the anthocyanin content and establish the shelf life of the resulting blends.

Highlights:

- For rice wine variant development, commercial bignay wine and PhilRice Tapuy and its distilled form were blended at 50:50 and 80:20 ratios and stored for 12 months at ambient (AT) and

refrigerated temperatures (RT). Anthocyanin content of the deep-colored samples decreased as storage time progressed with greater reduction in the AT-stored samples (Figure 15). Other physicochemical properties did not significantly change during storage. Microbial load of the samples remained in the tolerable levels.

- Color sensory score of 50:50 blend and tapuy dramatically increased at 10 and eight months, respectively while clarity of 80:20 blend and tapuy decreased at 10 months. Overall acceptability of the wine samples gradually decreased, however bignay wine, 50:50, and 80:20 blends kept at AT and RT remained highly acceptable even after 12 months. The nutritional properties of the wine blends were determined. Calories, total carbohydrates, sugars, calcium, and butylated hydroxyanisole (BHA) in 50:50 blend were higher than in 80:20 blend.

- The shelf life of rice wine from pure starter (PC) and commercial starter cultures (bubod) (CB) were evaluated (Figure 16). Absorbance at 520 nm of wine samples stored at ambient temperature (AT) intensified on the fourth until 14 months. Refrigerated samples remained colorless during storage. This was evident in the sensory scores for color and off-odor of wine which significantly rose on the second and fourth month, respectively with greater increase in wine using CB. Thus, AT-stored wine was less preferred at seven (CB) and nine (PC) months with CB having the larger decline. On the other hand, no dramatic change was observed in the properties of wine stored at refrigerated temperature.

- The effect on wine quality of water obtained from the wine production area and main laboratory building was assessed. Microbial load of water was determined. During sampling periods, water from the production area had brown particles and tolerable bacterial count while water from the main laboratory building was clear and without bacteria. However, physicochemical (yield, pH, total soluble solids, alcohol content) and sensory properties of wine from the two sources did not differ significantly regardless of fermentation container and rice varieties used (Figure 17).

- In addition, exploring the possibility of preparing less sweet PhilRice tapuy revealed the use of 70% dilution of fermentation mash to produce wine with similar sweetness, color, alcohol content, and smoothness with commercial sake.

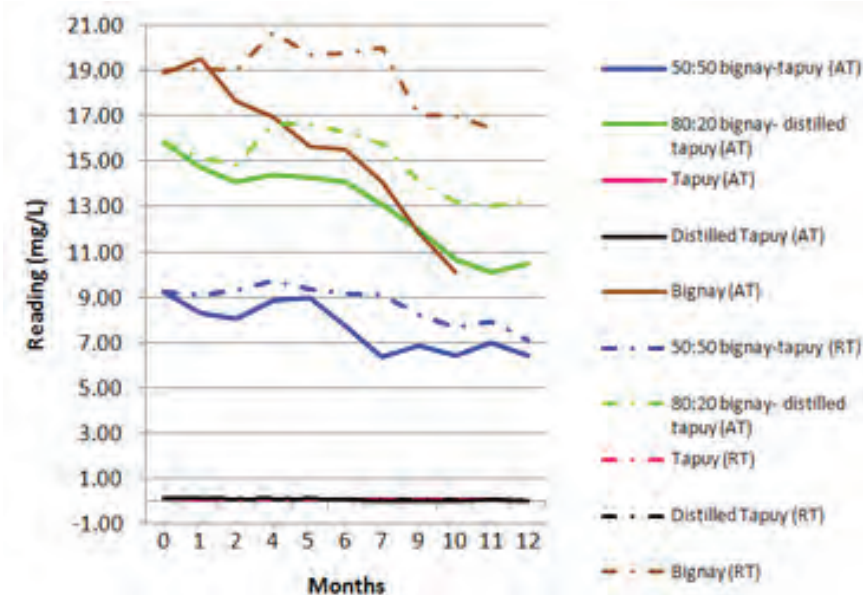


Figure 15. Anthocyanin content of wine blends stored at ambient and refrigerated temperatures.

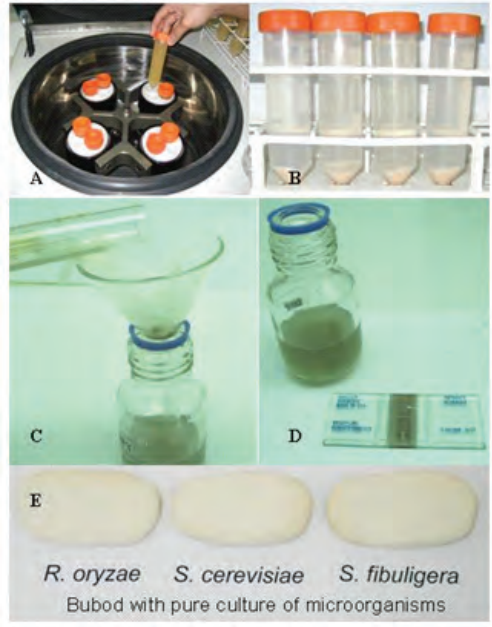


Figure 16. A. Collection of yeast cells by centrifugation. B. Collected yeast cells. C. Collection of mold spores. D. Counting of mold spores E. Bubod from pure starter culture

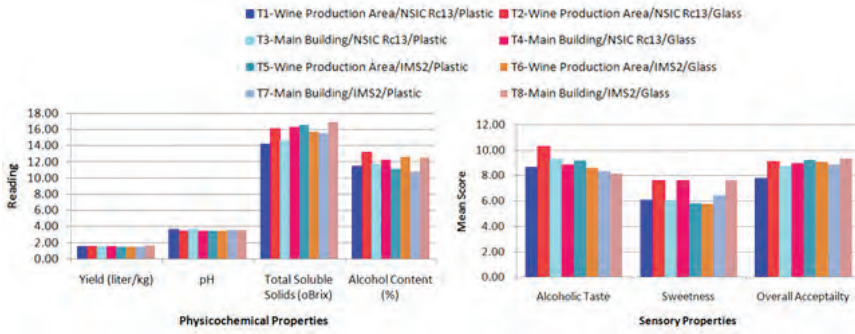


Figure 17. Physicochemical and sensory properties of rice wine from different sources of water.

Utilization of rice wine lees in the production of nutritious rice-based food products

RV Manaois and AV Morales

Tapuy or rice wine is a value-added food product produced from rice. In the tapuy production process, polished glutinous rice is fermented with yeast and the fermentate or the wine is collected, leaving behind residues called rice wine lees. Lees is currently discarded as its properties and potential applications have not yet been fully investigated. Initial analysis of the properties of tapuy lees showed that it has high levels of protein and fiber. In this study, tapuy lees was prepared into shelf-stable flour and tested as supplementing ingredient in food products.

Highlights:

- Storage stability of flour made from rice wine lees was studied. Samples were packed in 0.03- and 0.07-mm polyethylene (PE) bags and stored at ambient temperatures of 25 to 28oC and refrigerated at 4 to 5oC. Water activity (a¬w) of tapuy lees flour stored at room temperature had higher values than those at refrigerated temperature. However, a¬w values remained below 0.6, the level wherein spoilage microorganisms start to grow. Samples stored at room temperature had higher moisture content, but all the values were below 10%, above which the sample would be prone to quality deterioration due to microbial growth and textural changes. Total plate and bacterial counts ranged from 1.30 to 6.82 and 1.00 to 6.82 x 104 cfu/g, respectively. All values, however, were still within the safe levels (<10 x 104 cfu/g and <1,000 cfu/g for TPC and molds, respectively), according to the United Nations World Food Program (2009).

- Sensory evaluation of stored tapuy lees powder showed that overall acceptability decreased significantly and rancid off-odor in sample

stored in 0.07-mm PE bag at ambient temperature became apparent after three and five months, respectively. Alcoholic off-flavor also became apparent in samples stored at ambient temperature after three months. In refrigerated samples, no evident changes in sensory attributes were observed, except for color and overall acceptability of sample stored in 0.03-mm PE bag. Low temperature storage is therefore recommended for flour prepared from tapuy lees.

- Based on previous tests on lees utilization, the presence of off-flavors and darker color would have low acceptability for lees-substituted food products. Hence, food products employing processing steps or with ingredients that would reduce or mask off-flavors were tested. Butterscotch, a baked product with strong caramel flavor, was selected as a vehicle for supplementation with lees. Fifteen laboratory sensory panelists were trained to determine product attributes and acceptability of lees-substituted butterscotch samples. The panelists identified 12 sensory attributes during lexicon development of butterscotch with and without 60% lees, commercially available butterscotch (Bongbong's®), and different reference food products. A scorecard was developed to characterize the sensory properties of the samples based on an unstructured 15-cm scale.

- Using the developed scorecard, the 15 trained laboratory panelists found the laboratory-prepared butterscotch samples with different levels of tapuy lees flour (Figure 18) comparable with the control at $p=0.05$ based on caramel and buttery aroma, sweetness, caramel taste, stickiness, denseness, and moistness. Beyond 30% lees substitution resulted in samples with remarkably higher lees-like off-odor and lower overall acceptability than the unsubstituted control (Table 8).

- Moisture content and water activity increased with increasing level of lees flour. Microbial analysis showed that the samples had very low total plate, bacterial, and mold counts, which signify that they were safe for consumption.

- Nutritional analysis of butterscotch with 30% lees showed that it contained significantly higher crude protein and total dietary fiber than the control sample. Higher vitamin A and iron levels were recorded for the control because all-purpose flours are enriched with the said nutrients.

- Shelf life evaluation of the lees-supplemented butterscotch packed in aluminum and PE bags showed that the total plate, bacterial, and mold counts were still within safe levels (<10 x 104 CFU/g

and <1,000 CFU/g for TPC and molds, respectively). Regardless of packaging, overall sensory acceptability of butterscotch with lees decreased significantly on the third week of storage, mainly due to reduced moistness and stickiness of the products. Storage for three weeks also negatively affected the aroma of the lees-substituted sample. Starting on the first month of storage, however, the overall sensory qualities of lees-substituted samples were rated lower than those of the unsupplemented samples because of marked off-flavors and undesirable texture.

- The use of brownies, a product characterized for its dark color and strong chocolate flavor, was tested as another potential product for lees supplementation. Formulation of brownies was optimized and established. Lees was substituted at 15, 30, 45, and 60% (wt/wt all-purpose flour).

- Sensory evaluation by 13 semi-trained laboratory panelists of brownies with different levels of lees revealed that samples with up to 45% lees were comparable with the control at $p=0.05$. Increasing the amount of lees to 60% resulted in samples with noticeable lees-like off-odor, reduced chocolate flavor, and decreased chewiness, but overall acceptability of the sample was still comparable with the control. Color of the samples was not affected by lees substitution.

- The physicochemical and microbial qualities of brownies were assessed. The moisture content of sample with lees increased with corresponding increase in amount of lees, but the water activity value increased starting on the 45% substitution only. Higher aw could signify higher susceptibility of food product to microbial growth, and consequently, spoilage. Total plate counts of the samples were significantly higher starting at 45% substitution, but all values indicated that the samples were within safe levels. Hence, up to 45% substitution of lees can be used in brownies. These results suggest that food products with intense flavor and dark color, such as brownies, can be effectively used as vehicle for supplementation with lees, without significantly affecting appearance, flavor, and overall acceptability of the food product.

Figure 18. Butterscotch samples with different substitution levels (per cent weight of all purpose flour) of tapuy lees flour.

Table 8. Sensory properties of butterscotch with different levels of tapuy lees flour.

Sensory properties	Tapuy lees flour substitution (%wt/wt flour)				
	0	15	30	45	60
Appearance					
Color[3]	7.27[b]	5.51[c]	7.04[b]	7.97[ab]	9.11[a]
Texture[4]	6.25[ab]	6.21[ab]	7.43[a]	7.39[a]	5.25[b]
Aroma					
Caramel[1]	7.39[a]	6.66[a]	6.42[a]	5.67[a]	5.61[a]
Buttery[1]	6.51[a]	6.32[a]	6.34[a]	5.09[a]	4.73[a]
Off-odor (lees-like)[2]	2.07[b]	3.10[b]	3.64[b]	6.83[a]	7.40[a]
Taste					
Sweetness[1]	10.07[a]	9.95[a]	9.23[a]	9.51[a]	9.25[a]
Caramel[1]	6.33[a]	6.01[a]	5.69[a]	5.30[a]	5.44[a]
Off-taste (lees-like)[2]	1.86[b]	1.83[b]	2.85[b]	5.54[a]	6.59[a]
Mouthfeel[5]	6.81[ab]	6.30[b]	7.87[ab]	8.84[a]	8.67[a]
Stickiness[6]	6.05[a]	6.53[a]	6.13[a]	5.78[a]	5.23[a]
Denseness[7]	11.49[a]	10.81[a]	10.66[a]	11.31[a]	10.71[a]
Moistness[8]	4.86[a]	4.39[a]	4.19[a]	4.27[a]	4.19[a]
Overall acceptability[9]	9.71[a]	8.71[ab]	7.92[abc]	6.54[bc]	5.89[c]
Ranking[10]	1	2	3	4	5

Mean values in the same row with the same letter are not significantly different at $p=0.05$.

[1]0= none; 15= very intense
[2]0= none; 15= very perceptible
[3]0= light brown; 15= dark brown
[4]0= smooth; 15= very rough
[5]0= smooth; 15= very grainy
[6]0= separated; 15= very
[7]0= airy; 15= compact
[8]0= dry; 15= very moist
[9]0= dislike; 15= like very much
[10]1= highest; 5= lowest

IV. Maximizing the Potential of Rice By-Products and Renewable Energy

Ricardo F. Orge

Adaptation of a continuous flow rice hull gasifier as heat source for mechanical drying of palay

MJC Regalado, JA Ramos, and AT Belonio

A prototype of the continuous flow rice hull gasifier is being improved and tested for paddy drying operation. Earlier, refinements had been incorporated in its design and changes were based on results of previous testing and evaluation. Recently, significant improvements were made on the prototype performance to further enhance its operation.

Highlights:

- Several changes were made on the design of the gasifier's ash discharging component since the old design with a screw-type discharger failed to function properly during actual tests. A six-bladed paddle configuration, oriented from a common shaft, was more appropriate for discharging carbonized rice hull (CRH) (Figure 19).

Figure 19. The 6-bladed paddle as ash discharging device.

- Another improvement was the installation of a secondary suction fan along the gas pipe line near the jet burner. This aided the main blower in directing the gas flow towards the burner for firing since the source of gas was far from the dryer's plenum.

- The performance of the gasifier was evaluated three times under actual drying operation using a 6-ton capacity batch recirculating dryer. The recorded gas and flame temperatures were 215oC and 510oC, respectively. The gasifier took about an hour to start-up for firing. Gasifier operation was interrupted two to three times during the test run as the flame was extinguished when too much CRH was removed from the combustion zone. Refiring however did not take much time.

- Complete set of data gathered from the three test trials are shown in Table 9. The temperature reading at the plenum reached as high as 106oC at the start of gas firing. The lowest drying temperature maintained was 70oC, with the blower at its lowest setting and the gas valve adjusted at ¾ of its opening. The gas valve could not be adjusted further beyond its ¾ opening as the flame would already be put out.

- The latest modifications on the gasifier were: (a) putting up of control valve for the intake of gas to the burner so as to provide a means for regulating the temperature, and (b) relocation of primary blower at the lower portion of the reactor so that the air to be blown to the reactor shall pass through its hot portion, cooling the gas chamber while heating the air entering the reactor.

Table 9. Data gathered during actual drying operation using the gasifier as heat source.

Trial 1	Trial 2	Trial 3
Weight of paddy: 5,856 kgs ~ 117 sacks	Weight of paddy: 5,760 kgs ~ 115 sacks	Weight of paddy: 6,000 kgs ~ 120 sacks
Initial MC: 19%	Initial MC: 19%	Initial MC: 22%
Final MC: 13%	Final MC: 12%	Final MC: 12%
Firing time: 0.6H	Firing time: 0.75H	Firing time: 0.7H
Drying time: 3.5H	Drying time: 3.75H	Drying time: 6.5H
Drying temperature: 70°C	Drying temperature: 70°C	Drying temperature: 70°C
Maximum temperature:106°C	Maximum temperature:102°C	Maximum temperature: 95°C
Rice hull consume: 176 kgs ~ 20 sacks	Rice hull consume: 184 kgs ~ 21 sacks	Rice hull consume: 290 kgs ~ 32 sacks

Improvement and commercialization of the rice husk gasifier stove (NVP-005-003)

MJC Regalado, JA Ramos, and AT Belonio

A gasifier stove creates a clean flame like that of a liquefied petroleum gas (LPG) stove but some irritants that emanates from its biomass fuel and char produced during gasification. If this problem can be minimized, a gasifier stove can be a good alternative for LPG stove. PhilRice has been developing a continuous flow gasifier stove. A prototype has been fabricated and tested but it needs improvement. The starting gas production should take place within a short time and there is a need to sustain a stable flame after firing.

Highlights:

- During the testing of the CHRET prototype, it was observed that it took time to stabilize the gas generation prior to firing. Heavy smoke was visible for a considerable period of time before combustible gas was produced. Hence, the improvement of the prototype was carried out for easier stove ignition and operation with a low-cost design.

- The new prototype features a 12-cm diameter reactor, a regulated feeding hopper, and a rotating ash discharger (Figure 20). The burner was placed at the same level with the hopper. Initially, it was held near the gas chamber to shorten gas conveying which is an ideal location. But during feeding, the rice husks tend to spill over to the burner.

Figure 20. Prototype of rice husk gasifier stove

- With this new prototype, firing took six minutes while gas production took another five minutes before the gasifier produced the flame. Noticeably, shortly after igniting the rice hull, heavy smoke was visible then went off gradually before firing the generated gas. Results of test showed that 2.5kg of rice husk was consumed in an hour of continuous operation. The fuel consumption was high relative to the size of the reactor that had a 220 kg/hr-m2 specific gasification rate. The amount of char recovered was only 27.5% of the fuel used.

- A pre-commercial unit of the batch-type gasifier stove was fabricated (Figure 21). The model had a reactor that measured 140cm and 60cm in diameter and height, respectively. During the latest testing, one batch of operation lasted for about 45 minutes. The significant result attained for this model (14D-60) was the short startup time that was achieved in less than a minute.

Figure 21. Batch-type rice hull gasifier stove, 14D-60 model.

Evaluation of small-scale biogas plant for the rice-based farming system
HV Valdez, RG Corales, and AS Juliano

The increasing oil prices and decreasing oil reserves prompted researchers to study alternative fuels for vehicles. Viable substitutes for oil are gaseous hydrocarbons, hydrogen gas, alcohol, producer gas, and biogas. Biogas consists of approximately 55 to 60% methane. Research studies conducted showed the potential of biogas as fuel for engines. The use of separated methane from biogas as fuel can substantially reduce harmful engine emission.

Highlights:

- A small scale biogas production system was established at the Palayamanan site at PhilRice Nueva Ecija. It was composed of a onem3 capacity plastic tank serving as the biogas digester and two plastic drums connected in series serving as gas holder (Figure 22). The set-up was tested using carabao manure collected from the CLSU Dairy Farm, Science City of Muñoz. The slurry was a mixture of 1kg manure and 1L of water.

- Carabao manures (275kg and 470kg) were loaded into the digester for gas generation. During a 30-day retention time, gas productions

were 7.390m3 for 275kg manure and 12.428m3 for 470kg manure. Specific gas production was 0.264 to 269m3/kg. An increase in gas generation was observed during the first 15 days followed by a decline on the 16th to 19th day until the 30th day (Figure 23). On the 30th day, there was still considerable amount of biogas generated. Gas generated was measured using the installed biogas meter. The gas generated was successfully ignited on the fifth to seventh day.

- Minor modifications were made on the 3.5hp gasoline and a 7.0hp diesel engines, i.e., to run on scrubbed and unscrubbed biogas. A gas pipe was installed before the carburetor of the gasoline engine and on the air intake manifold of the diesel engine. The amount of biogas fed into the engine was controlled using a cut-off valve installed along the intake line. At the start, the engines were first operated using their respective fuels and then gradually shifted to biogas. The gasoline engine was set at 2950 to 2960 rpm and fed with biogas as fuel after it consumed the gasoline in the fuel line. The gasoline engine consumed 1.243m3/h and 0.771m3/h of unscrubbed and scrubbed biogas, respectively. Engine RPM decreased when engine was run on unscrubbed biogas. When using scrubbed biogas, the engine maintained its speed and slightly increased as the engine heated up.

- The diesel engine was operated using part diesel and scrubbed biogas. It was set initially at 1350 to 1360 rpm and fed with 70% diesel and 30% scrubbed biogas. It consumed 0.552m3/h of scrubbed biogas and 0.261L/h of diesel. Engine RPMs were comparable when run on 70% diesel and 30% scrubbed biogas versus pure diesel.

Figure 22. The biogas digester set-up.

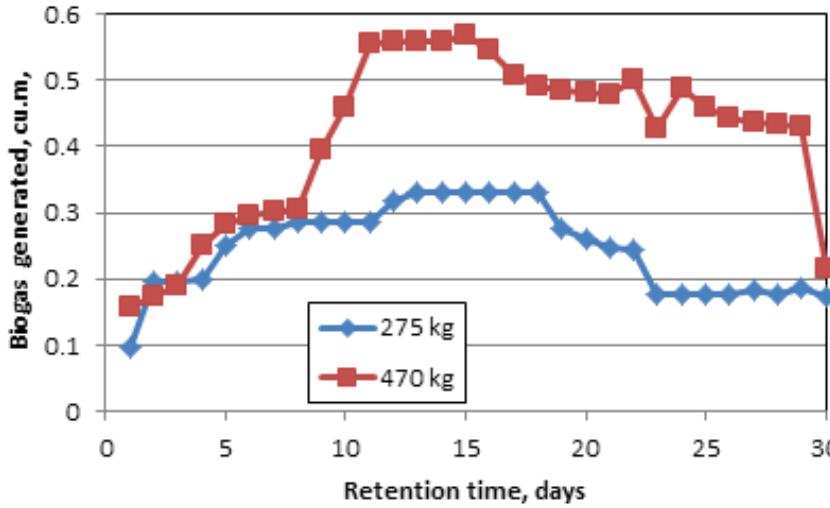


Figure 23. Daily biogas generation in 30-day retention time.

Evaluation of an instant steam generation concept
RF Orge and JEO Abon

PhilRice is currently developing the rice hull carbonizer-pump system that uses steam as motive fluid for its jet pump component. Results of tests showed that the system could successfully pump water by just using the heat generated during the process of rice hull carbonization. The system is equipped with a boiler, the component that converts the water into steam which is pressurized and has the potential to explode if safety measures in its manufacturing and operation are not properly observed. Hence, there is a need to conduct parallel study to explore other ways of steam generation technology that could be installed in the system, and other biomass energy conversion systems for future development to eliminate operation risks.

Highlights:

- A prototype of the instant steam generator was designed and fabricated (Figure 24), mostly from BI pipes and copper tubings. The surface area exposed to heat was 848cm2 while the volume of its empty space (where water passes through) was128 cm3 or a ratio of 6.6.

- When tested at water pumping rates ranging from 58 to 250 mL/min using a manually operated piston pump, steam was instantly produced as manifested by a cloud of vapor emanating from the nozzle discharge end of the prototype. Pressure ranged from 6.2 to 6.4kg/cm (88.6 – 91.4 psi) or an average of 6.3kg/cm (89.6 psi).

Higher steam pressure was observed at lower pumping rates (Table 10). Results indicate that there is potential for the instant steam generation concept for power generation. It is much safer and cheaper than the conventional boiler since steam is only generated at the time when it is needed.

- A new prototype is currently being fabricated and designed to be attached to the CTRH carbonizer to utilize the generated heat during its operation for steam generation.

Figure 24. The instant steam generator prototype mounted on a charcoal stove.

Table 10. Results of performance tests of the instant steam generator prototype.

Test Parameters	Test Run		
	1	2	3
Water pumping rate (input), mL min^{-1}	58.3	183.3	250.0
Steam pressure reading (output), kg cm^{-2} (psi)	6.4 (91.36)	6.3 (90.20)	6.2 (88.6)
Temperature at vicinity of the ISG, °C	919.18	903.83	902.23
Ambient temperature, °C	30.66	30.71	30.47
Total amount of charcoal consumed, g	200	200	200
Total pumping time, min	6	6	6

Improvement of the rice hull carbonizer-water pump system for the rice-based farming system

RF Orge and JEO Abon

PhilRice is currently developing the rice hull carbonizer-pump system that uses the heat generated during the carbonization of rice hull to produce steam used as motive fluid of the jet pump. Results of tests showed that the system could successfully pump water. However, it still needs some design improvement and optimization to increase its efficiency, reduce its cost, and make it much safer to operate.

Highlights:

- Refinements were made on the design of the continuous-type rice hull (CTRH) carbonizer to enhance its performance and lower its cost of fabrication. The bottom portion of the front side was tapered inward so as to minimize the amount of unburned rice hull that got mixed with the CRH during collection. A prototype of the rice hull carbonizer was fabricated using ferrocement material and tested for durability (Figure 25). With ferrocement, the cost of fabrication was drastically reduced by about 50%.

- Aside from the current jet pump design, another design for the pumping component was tried to come up with a pumping component that can operate with low steam pressures for safer operate. A steam-operated reciprocating mechanism was designed and fabricated. It consisted of two cylinders rigidly installed in frame along a common vertical axis, each housing a plunger that was attached to both ends of a connecting rod. Through a specially designed and fabricated valve, the steam was introduced alternately into each cylinder so as to create a reciprocating motion of the connecting rod along a vertical plane. This movement will be used to drive a commercially available jetmatic pump. Results of preliminary tests showed some leak problems at the cylinder and plunger that resulted in low net force transmitted at the connecting rod. The fabrication of these parts required relatively high degree of precision to minimize leaks. Existing standard parts for internal combustion engines will be tested.

- A heating chamber (Figure 26) was developed as an accessory for the carbonizer. In this chamber, the boiler can be mounted and detached for generating steam needed in operating the pump. The heating chamber system had the option to utilize the generated heat for steam generation and other applications. Thus, when pumping was not needed, the generated heat could be utilized for other purposes such as cooking or boiling water.

Figure 25. The continuous-type rice hull (CTRH) carbonizer made of ferrocement.

Figure 26. The heating chamber (attached to the CTRH carbonizer) undergoing water boiling test.

Development of an on-site rice straw carbonizer
RF Orge and JEO Abon

PhilRice is recommending the incorporation of rice straw into the soil during land preparation. However, most farmers do not follow this because it hampers the plowing and harrowing operations. Thus in most cases, rice straws are burned right there in the field. If appropriate technology could be developed for onsite carbonization, rice straw, in its carbonized form, could be easily incorporated into the soil. Moreover, utilizing the heat generated during the carbonization process could be a potential source of power for some applications in the farm.

Highlights:

- To save on fabrication costs (material and labor), as well as on the time needed in the development of the machine, the continuous-type rice hull (CTRH) carbonizer was used as the benchmark design. The operating mechanism was further studied and modifications were done on some components to satisfy some requirements specific to rice straw. In particular, the hopper cover originally with louvers, was replaced by two hinged sheet metal panels to allow wide opening for straw feeding.

- Results of tests showed that the prototype processed rice straw into biochar at input capacity of 12kg/h. Biochar yield was 23.89%. Thick smoke was observed at the chimney during operation indicating the need to consider modifying the air intake to ensure complete combustion of the pylolytic gases before coming out of the chimney.

- Aside from rice straw, the machine was able to process other farm wastes like leaves, twigs, coco husks, and corn cobs (Figure 27) based on actual tests conducted.

Figure 27. Processed biochar from (L-R) rice straw, dried leaves, and corn cobs.

Performance evaluation of the CTRH Carbonizer as heat source for drying crops

RF Orge and JEO Abon

PhilRice recently developed a continuous-type rice hull (CTRH) carbonizer. This carbonizer was designed to recover the heat generated during the carbonization process for some specific applications in the farm, particularly within the Palayamanan area. To maximize the benefits of investing on this carbonizer, there is a need to evaluate its multi-function capability. The potential of the CTRH carbonizer as heat source for drying crops was evaluated by (a) providing the carbonizer with a heat recovery component (HRC) for trapping the heat needed in the drying process and (b) providing the carbonizer with added components to function like a gasifier where the generated producer gas was combusted to provide the heat for the dryer.

Highlights:

a. Heat recovery component

- Two prototypes of the carbonizer's HRC were designed, fabricated, and tested. Both prototypes used two concentric cylinders, with the inner one as the chimney. The space between the chimney and the outer cylinder served as the pathway of the ambient air to recover the heat from the flue gas travelling along the full length of the chimney. In the first design (Figure 28), the ambient air entered through the upper end of the chimney and traveled along a spiral path down to the outlet located at the bottom of the chimney where the heated air was ready to be introduced into the dryer. In the second design, the space between the two concentric cylinders was longitudinally divided into four sections with the air inlet and outlet both located at the bottom portion of the chimney. With this configuration, the ambient air was made to travel along the whole length of the chimney four times. For each travel, 1/4 of the circumference of the circular cross section of the chimney was covered.

- Results of tests showed that the CTRH carbonizer provided sufficient heat for drying and for other agricultural applications. Of the two designs tested, the highest temperature of the heated air came from the first design wherein the ambient air temperature (28.6 to 36.6 oC) could be raised to 140.3 oC for an air flow rate of 883m3/h. However, for applications that required clean hot air (e.g., drying of leaves of medicinal plants or heating of poultry houses), the second design is recommended. With the second design, there is less contamination with harmful flue gases like carbon monoxide, especially if the chimney was punctured due to continued use.

b. Gasifier

- Provisions were made so that ambient air can be introduced into the combustion zone to increase the air equivalence ratio to a level required for a gasifier. This was done by putting a frustum-shaped detachable frame fitted inside the wall of the hopper at a horizontal plane around 15cm below the top edge. Once installed and the hopper was filled, the frame created an empty space that served as passage way for the ambient air that entered through a hole on one side of the hopper (Figure 29). During testing, the chimney was removed and the introduced air was provided by a motorized blower. During actual operation, however, this air can be tapped from the dryer's blower.

- Results of preliminary test showed that a clean flame was developed at the exhaust of the carbonizer (the point where the chimney was attached) indicating that it was technically feasible for the carbonizer to replace the furnace of the dryer. The carbonizer will be coupled to the mechanical dryer to determine the appropriate size of the dryer that would match the size of the carbonizer.

Figure 28. The carbonizer equipped with (heat recovery component) HRC during testing.

Figure 29. The continuous-type rice hull (CTRH) carbonizer equipped with line for supplying supplemental air.

Evaluation of CRH as desiccant for drying and storage of palay seeds
JEO Abon and RF Orge

High humidity or rainy conditions create storage problem and viability maintenance of seeds. Cold storage rooms can provide long-term seed viability. However, cold storage facility is expensive and impractical for ordinary farmers. As reported in earlier studies, storing seeds with desiccants under a hermetic condition can preserve seed viability for a long period of time. But desiccants can be costly. There is a need to find a local and inexpensive desiccant substitute that an ordinary farmer can afford. This study aimed to evaluate the use of carbonized rice hull (CRH) as a desiccant for drying and storing palay seeds.

Highlights:

- A significant reduction in seed moisture content (MC), down to 20 to 32%, was observed during the first four hours of desiccant drying with CRH (Figure 30).

- For treatments T1, T2, and T3, paddy seeds of PSB Rc82 were contained in a hermetic container after mixing with specified amounts of CRH (25%, 50% and 75% CRH by volume for T1, T2, and T3, respectively). The control was placed in an open space to

simulate the air drying process. Seed MC decreased with increased percentage of CRH (by volume). MC of control seeds also decreased due to low ambient humidity during the day. Results indicate that seed storage with CRH desiccant can decrease MC up to a certain extent. The CRH desiccant in relation to MC fluctuations, preserving seed viability, and controlling storage pests should be assessed.

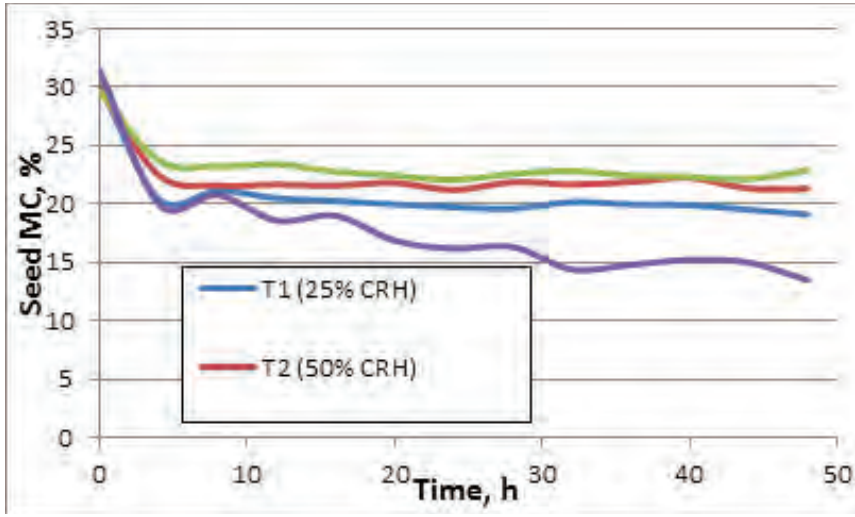


Figure 30. Moisture content profile of the paddy seeds with different carbonized rice hull (CRH) treatments.

Evaluation of rice hull-carbonization drip irrigation system for vegetable production

JEO Abon, RF Orge, and RG Corales

The use of a continuous-type rice hull (CTRH) carbonizer in generating steam for pumping water for irrigation was proven successful. The study coupled the carbonizer-pump set-up to a complete crop production system to assess its practicality. The system's productivity and income will be evaluated later on.

Highlights:

- The carbonizer-pump set-up was established in a 300m2 Palayamanan area planted with tomatoes (Figure 31). It was composed of (a) 1m3 plastic tank for storing the pumped water, (b) the rice hull carbonizer equipped with a boiler that generated steam to drive the jet pump, and (c) the drip irrigation component that made use of ½in diameter plastic pipe laid out along each row of the plants (Figure 32). Drip holes were manually made on the pipe using 1mm diameter heated metal.

- Water discharge of 2.38-3.35L/h from the drip holes did not vary significantly in full and half-filled tanks. It was observed that some drip holes often got clogged, but clogging was easily solved by repuncturing the holes to flush out the materials that blocked the holes.

- The carbonizer-pump system was capable of filling up one tank load (1m3) in one hour with water pumped from water table approximately 2.5m below the ground. One tank load was enough to irrigate the whole 300m2 area planted with tomatoes. However, the system's operation was not sustained throughout the duration of the crop growth because of some operational problems encountered in pumping. There were times when the jet pumping system failed. Improvements are currently undertaken to solve this problem.

Figure 31. The carbonizer-pump set installed in a drip-irrigated tomato plot.

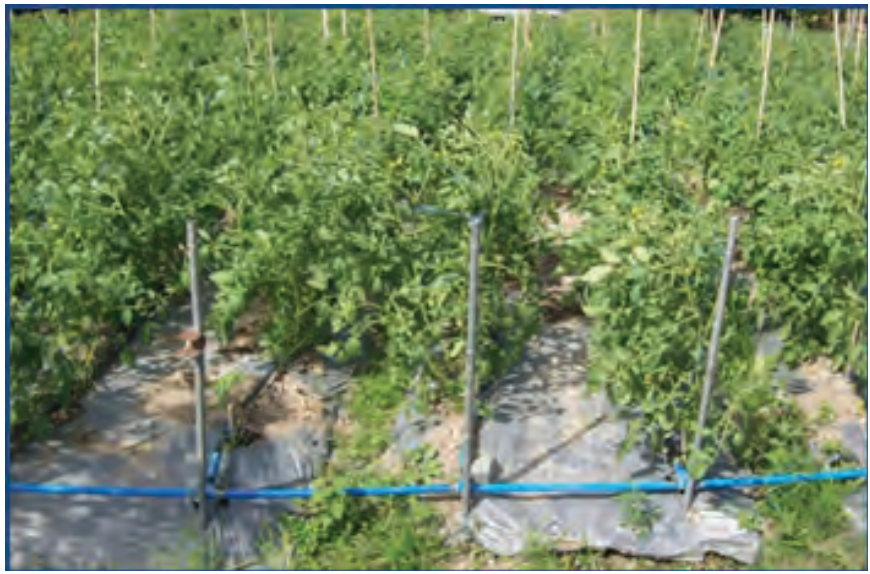


Figure 32. The drip irrigation system made from locally available plastic pipes.

V. Improvement of the Nutrition and Productivity of Rice-Based Farming Communities

RG Corales

Nutritional assessment of rice-based farming households

RG Abilgos-Ramos, KB Avila, and CC Launio

According to the World Bank (2010), the Philippines has a high prevalence of malnutrition (26.2%) that is believed to be a product of interrelated factors – health, physical, social economics and others. Food supply and its distribution and consumption pattern have consequent impact on the nutritional status. Reports showed that there was enough food to feed the population, but hunger and malnutrition still exist among Filipinos due to inadequate intake of food and nutrients. Except for protein, typical Filipino diet was found to be grossly inadequate for energy and other nutrients. Understanding nutrition and dietary patterns in the household may significantly influence agricultural productivity. Good health through proper nutrition and agricultural productivity are essential to counter poverty. Hence, there is a need to understand the factors influencing the nutritional status of rice-based farm households.

Highlights:

- Average household head age was 54 and the household size was five. For the sample household, head of the family reached approximately first year high school with two of their family members with a major occupation.

- About 56% of the total respondents obtained their income from agricultural sources, either on-farm or off-farm, 76.3% of which came from rice farming. Generally, households sampled in Nueva Ecija were above the poverty threshold of 87% based on 2009 National Statistics and Coordination Board (NSCB) data.

- Fifty percent (50%) of the sampled families had land holdings of one to three hectares, i.e., 40% with less than one hectare and only 10% with more than three hectares. Average farm area was 1.56ha, 92% of which was devoted to rice production.

- About 33 years of the household life were devoted to farming. Forty per cent owned the land they tilled and 60% was an amortizing owner, a lessee, or tenant.

- Fifty percent (50%) practiced rice-rice as cropping pattern for the last five years and 13.5% for rice-onion. Other cropping patterns were rice-fallow, rice-vegetable, and vegetable-vegetable.

- Based on the self-rated health status of the respondents, 79.5% considered themselves healthy while 4% and 16.5% had abnormality and major illness, respectively.

- For the on-farm interviews by enumerators, a 3-day-24-hour food recall was employed to all individual members of the sample households (Figure 33).

- Anthropometric measurements (Table 11) for children below 10 years showed that most of them were normal in terms of weight for age, 18% underweight and 6% overweight. Height for age measurement showed that 64% had normal linear growth. In terms of weight for height, 76% of the children was at normal range of growth while 10% was overweight and 14% was wasted.

- Weight of adults was classified as normal, obese, overweight, and underweight. The results showed that 13% was overnourished and 35% was undernourished in terms of weight for height.

- The recommended calorie (energy) intake per day is shown in Table 12. Data showed that children less than six months, 10 to 18 and

50 to 64 year olds did not meet the recommended amount. This may be due to less diversified diet composition and inadequate macronutrient intake of the household members based on the three-day-24-hour food recall data (Table 13).

- Table 14 presents the top 10 foods consumed by the respondents in Nueva Ecija. Slightly more than half (52%) of the total food intake was rice. Coffee, creamer, and sugar accounted for 15%. Pork, fish paste, egg, soft drinks, and fish (tilapia) were at 5% each. Vegetables comprised only 4% of the total diet composition. String beans and eggplant were popularly consumed. Other carbohydrate source was bread at 3%.

- In general, a large portion of the typical meal plate of sample respondents in Nueva Ecija consisted of grains and a small amount of protein and vegetables. Instead of dairy milk, coffee was their common drink. Coffee drinking was popular even among children. Most commonly eaten vegetables were string beans, squash, jute, sweet potato tops, bitter gourd, eggplant and sponge gourd. Common fishes consumed were catfish, milkfish, and mudfish. Breastfeeding was a common practice among the lactating mothers interviewed.

- On occasions such as birthdays, fiestas, planting and harvesting seasons, dog meat is eaten as a viand and finger food while drinking liquor. Frogs were also consumed in place of regular meat during lean months.

Figure 33. Actual interviews by enumerators. A three-day-24-hour food recall was employed to all individual members of the sample households.

Table 11. Anthropometric data of 256 respondents from 52 households in Nueva Ecija.

Age group	Anthropometric measurements	N	%
0-10 years old	Weight for Age		
	Normal	25	75.8
	Overweight	2	6.1
	Underweight	3	9.1
	Severely Underweight	3	9.1
	Height for Age		
	Normal	21	63.6
	Stunted	10	30.3
	Tall	2	6.1
	Weight for Height		
	Normal	16	76.2
	Overweight	2	9.5
	Wasted	3	14.3
Above 10 years old	BMI		
	Normal weight	115	52.5
	Obese	3	1.4
	Overweight	24	11.0
	Underweight	77	35.2

Table 12. Adequacy of total calorie intake per day based on a three-day 24-hour food recall.

Age-Sex Cat	Gender	Age group	Calorie Requirement per Day	Actual Calorie Intake per Day	% Adequacy
1	MF	0-<0.5	560	187.0	33.4
2	MF	0.5-<1	720	698.2	97.0
3	MF	1-3	1070	1542.3	144.1
4	MF	4-6	1410	1641.5	116.4
5	MF	7-9	1600	1656.3	103.5
6	M	10-12	2140	1193.2	55.7
7	F	10-12	1920	1599.6	83.3
8	M	13-15	2800	1693.9	60.5
9	F	13-15	2250	2124.7	94.4
10	M	16-18	2840	1694.0	59.6
11	F	16-18	1860	1710.5	91.9
12	M	19-29	2490	2187.5	87.8
13	F	19-29	1860	1892.1	101.7
14	M	30-49	2420	1927.2	79.6
15	F	30-49	1810	1692.4	93.5
16	M	50-64	2170	1927.9	88.8
17	F	50-64	1620	1396.7	86.2
18	M	65+	1890	1441.4	76.3
19	F	65+	1410	1414.7	100.3

Table 13. Macronutient intake of rice-based farm household members in Nueva Ecija (g/day).

Age group	Protein	Fat	Carbohydrates
0-<0.5	108.5	33.2	208.6
0.5-<1	79.7	27.9	230.6
1-3	105.1	35.6	384.6
4-6	88.5	39.2	312.9
7-9	97.8	38.2	276.1
10-12	54.5	15.8	183.6
10-12	123.4	49.1	250.1
13-15	86.3	39.3	281.3
13-15	84.5	48.3	269.1
16-18	142.2	33.6	263.1
16-18	83.2	35.9	272.3
19-29	89.1	46.3	263.1
19-29	97.8	34.9	286.1
30-49	95.4	39.0	245.7
30-49	78.0	30.4	223.8
50-64	90.2	32.1	262.7
50-64	115.9	45.5	302.6
65+	59.4	27.7	244.4
65+	62.4	28.6	243.0

Table 14. Top 10 foods consumed by the rice-based farm households in Nueva Ecija.

	freq	%
Rice, well-milled, boiled	1741	45.8
Sugar, white, refined	450	11.8
Coffee, inst, 100% pure	397	10.4
Pork belly, less fat, broiled	179	4.7
Softdrink, cola	179	4.7
Egg, chicken, whole, boiled	164	4.3
Fish paste, anchovy	160	4.2
Tilapia (*Tilapia mossambica*)	121	3.2
Eggplant , boiled	114	3.0
Coffee, creamer & sugar (3 in 1)	101	2.6
Bread, pan de sal	101	2.6
String/Yard long bean pod, green, boiled	97	2.5

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

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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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CERTIFICATION INTERNATIONAL
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OHSAS 18001:2007 CIP/4360H/09/1068