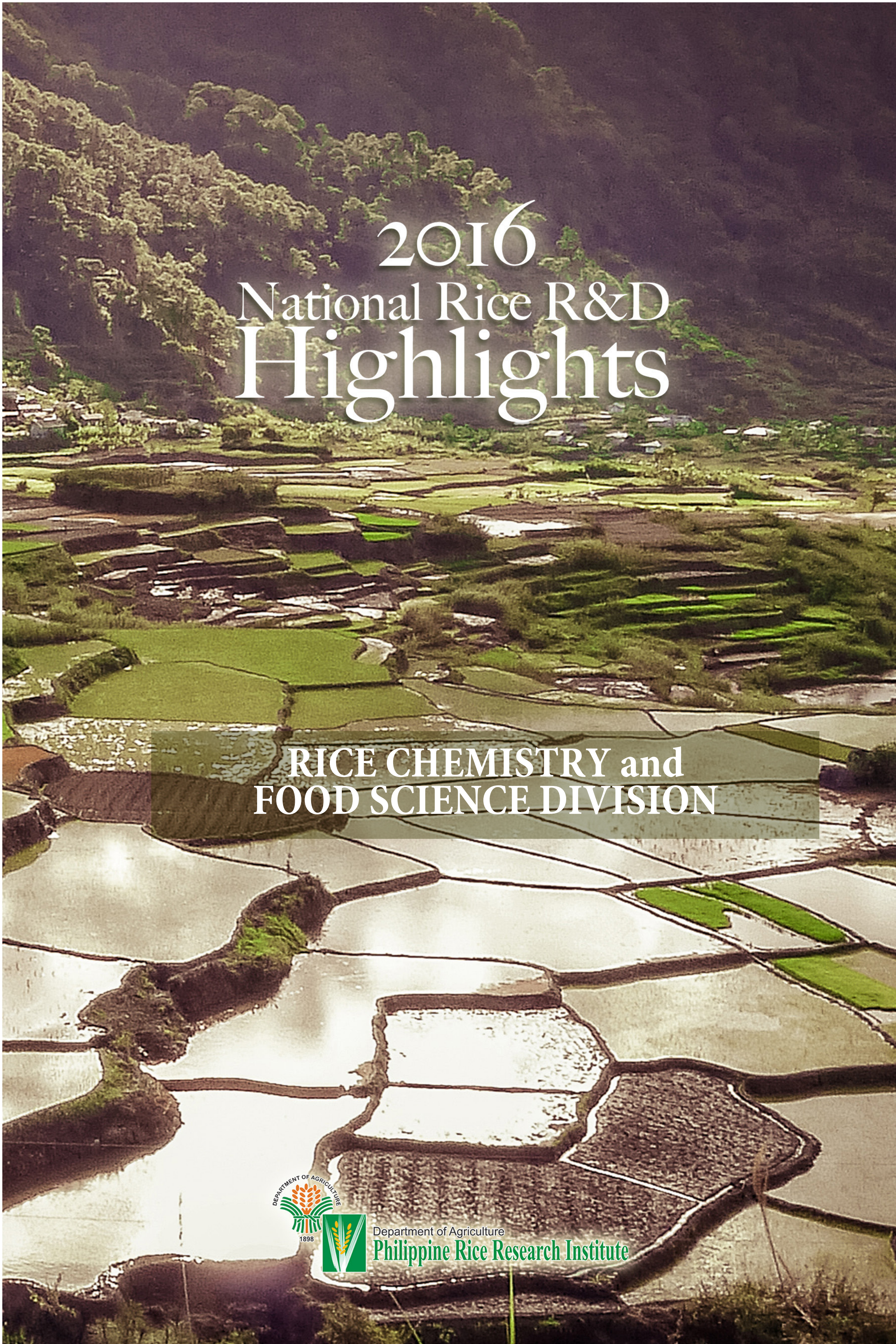

2016 National Rice R&D Highlights

RICE CHEMISTRY and FOOD SCIENCE DIVISION

Department of Agriculture
Philippine Rice Research Institute

TABLE OF CONTENTS

Rice Chemistry and Food Science Division

Division Head: Rosaly V. Manaois

Executive Summary

Grain quality (GQ) evaluation of rice lines is being conducted to assist breeders in identifying promising rice lines for entry into the National Cooperative Test (NCT). Enhancing the efficiency of the varietal screening process, specifically GQ evaluation, is endeavored through adopting advanced techniques. To further support the breeding process, specifically in the release of location specific varieties based on GQ, survey of the grain quality preferences of consumers, millers and traders is being conducted.

For Study 1, 1,396 entries from 2015 wet season (WS), 2015 dry season (DS), and 2016 DS were screened for grain quality. A total of six lines from the Rainfed-Multi-Environment Trial, 52 Rainfed-Traditional Varieties, seven Rainfed-IVC, four Rainfed-Submergence (SUB); and three SUB samples were identified with good grain qualities for the 2015 DS. Under the 2015 WS, six lines from Irrigated Lowland-Direct Seeded Rice passed the GQ standards, while three Preliminary Yield Trial (PYT), 25 PYT-Special Purpose, 17 IL-DSR, and five Fe/Zn Seed Increase lines were identified to have good grain characteristics.

Results of the Study 2 indicated that crude protein was more accurately predicted among the three physicochemical constituents. Among all sample forms, the best prediction models were developed for floured samples. Models using rough rice and brown rice showed good performance in predicting amylose content and gelatinization temperature, respectively.

Study 3 revealed that 100 respondents from rainfed and saline areas of seven municipalities of Pangasinan and rainfed areas in three municipalities of Nueva Ecija favored long and white raw milled rice, with whole grains. They preferred cooked rice which has high volume expansion, and is tender, aromatic, cohesive, and white. When presented with actual samples, the respondents chose very white, long and slender, and translucent raw milled rice and aromatic, tender, white, and tasty cooked rice.

Project 2 evaluates the nutritional and health promoting properties of rice and rice-based crops. Antioxidant capacity and composition of local rice-based crops grown in rice-based farms was evaluated to aid in the production of high quality foodstuffs from rice growing areas and in consumer selection of products for health maintenance and disease prevention. Study 2 aims to generate information on the market demand for rice-based products to guide researchers on their high-value product development initiatives. Lastly, Study 3 assesses the potential therapeutic effects of pigmented rice germplasms deposited at PhilRice genebank for use

as medicinal rice, for functional food or nutraceutical development, or as breeding materials for high antioxidant rice.

Study 1 evaluated the phytochemical content and antioxidant capacities of 41 raw and 40 cooked rice-based vegetables. Raw turmeric, camote tops, jute, lowland water spinach, and eggplant displayed the highest total phenolic content (TPC) and antioxidant capacities measured using three methods, while turmeric, lowland water spinach, eggplant, and two green pepper varieties exhibited the highest TPC and antioxidant values after boiling. Reduction in TPC and antioxidant capacities was generally observed after boiling, and the level of phenolics is correlated to the displayed antioxidant power of the vegetables.

Results of Study 2 showed that the top five rice-based product concepts generated from the three focus group discussions of experts from the food industry were flour-based food products, personal care or hygiene products, drinks or beverages, special purpose products (e.g. fortified rice products), and convenience products.

Lastly, 88 pigmented rice germplasms from PhilRice genebank were characterized in Study 3. The amylose content ranged from 0.3 to 24.4% or were classified waxy to high amylose, respectively. In polished form, the highest total TPC, anthocyanin content, total flavonoid content (TFC), and FRAP antioxidant capacity was recorded for Tapol. It also displayed the highest TFC, DPPH, ABTS, and FRAP antioxidant activities in unpolished form.

I. Grain Quality Assessment of Rice Lines and Varieties

Project Leader: EH Bandonill

Grain quality (GQ) evaluation is the final trial that rice lines undergo after meeting standards for yield, disease and insect resistance, agronomic and other traits. The ultimate objective of the three studies of the project is to enhance breeding efficiency for grain quality, ensure availability of appropriate rice variety in a specific location, and develop prediction models of milled rice for rapid grain quality analysis. Study 1 of this project covers GQ evaluation of rice lines before they are elevated in the advance stages of the National Cooperative Test (NCT). Its purpose is to select promising entries to expedite the screening, thereby reducing cost and maximizing resources. Thus, Study 2 intends to gather information on rice grain quality characteristics preferred by various stakeholders in Luzon as well as determine the grain qualities of rice varieties that they usually buy, while Study 3 wants to know the form of rice samples (grain, brown, milled or flour) that can efficiently predict crude protein, gelatinization temperature, and apparent amylose content of milled rice, as well as identify the spectral pre-treatments and wavelength ranges that should be used for maximum effectiveness of the predictions.

Centralized grain quality screening

AV Morales, GG Corpuz, RP Tubera, JD Adriano, JMC Avila, and MJC Ablaza

Grain quality evaluation (GQE) plays an important role in the rice breeding program of PhilRice. Aside from yield, resistance to pests and diseases, and agro-morphologic characteristics, grain quality is also influenced by genotype. The physical appearance of milled rice is important to the consumer, which in turn makes it important to marketer and the miller. Grain length and shape are among the first rice quality criteria that breeders consider when developing new varieties for release. On the other hand, the presence of chalk in the rice grain has been described as a defect that affects milling, marketing and storage properties. Early generation and pre-NCT lines must therefore be evaluated and screened for grain quality to trim down the number of lines advanced for further trials, thus reducing cost and maximizing resources. Furthermore, early generation screening may also allow the identification of entries with properties suited for special purposes.

Activities:

- This year, 1,396 rice lines were received for grain quality. Samples were from 2015 dry season (DS), 2015 wet season (WS), and 2016 DS distributed under Rainfed-MET, Rainfed-TRV, Rainfed-IVC, Rainfed-SUB, IL-DSR, PYT-R, PYT-SP, ION-BEAM, Fe/Zinc Seed Increase, MYT-CES which were submitted by the different breeding groups of the Plant Breeding and Biotechnology Division (PBBD). Seven hundred fifty seven (757) out of the 1,396 rice lines were screened for grain quality while analysis of the other entries is on-going.

Results:

2015 Dry Season

- The grain quality of 43 rice samples from Rainfed-Multi Environment Trial (MET) was assessed. All samples had fair brown rice recovery. Most of the samples had premium total milled rice (32 samples) wherein 12 samples had premium head rice. Moreover, 24 samples had intermediate and 16 had slender grain shape. Most of the samples had intermediate to high gelatinization temperature. Six samples with line designations PR39269-B-3-B-1-3, PR41392-SHZ-2-IVC2009DS 1-2-1, PR41398-ICRL2008WS-PSB Rc68 34-1-1, PR41398-ICRL2008WS-PSB Rc68 34-2-1, PR45713-Salumpikit-IVM2011WS 1-9-8, and PR45713-Salumpikit-IVM2011WS 1-5-14 had intermediate amylose content that also had fair brown rice recovery, premium milled rice recovery, grade 1 to premium head rice recovery, intermediate shape, and intermediate (I) to high intermediate (HI) gelatinization temperature.

- Fifty two (52) samples from Rainfed-Traditional Varieties (TRV) study were evaluated. Most of the samples had fair to good brown rice recovery, grade 1 to premium milled rice, medium grain length, bold to intermediate grain shape, and intermediate amylose content. The protein content ranged from 3.6 to 8.6% wherein the lowest was obtained in line designation Baddang and highest in purple rice.

- The grain quality of 96 samples from Rainfed-IVC study was assessed. Most of the samples had excellent milling recovery having fair brown rice recovery (95), premium milling recovery (96), and premium head rice recovery (87). For physical attributes, eight samples had grade 1 chalky grains and two were premium, 77 had short grain length, and 90 had intermediate grain shape. Eighty samples had intermediate gelatinization temperature (GT). In addition, eighty one (81) samples had intermediate amylose content that also showed excellent grain quality for having fair brown rice, premium milled and head rice, and intermediate grain shape. Six out of 81 samples with intermediate amylose had grade 1 chalky grains (PR45713-Salumpikit-IVM2011WS 1-4-7, …1-3-5, …1-4-5, …1-3-32, …1-4-9, and …1-3-32). Only one sample (PR45713-Salumpikit-IVM2011WS 1-8-4) had low amylose content that also had fair brown rice, premium milled rice and head rice, intermediate grain shape and GT.

- A total of 92 samples from Rainfed-Submergence (SUB) study were evaluated. Additional parameters (determination of % hull, % bran and % brokens; grain dimension of rough and brown rice) were also evaluated. For the forty six (46) FAV-SUB samples, all had fair brown rice recovery while most of the samples had grade 1 to premium milled and head rice. The percent hull ranged from 19.4 to 23%, bran from 5.3 to 9.3%, and brokens from 4.5 to 23.2%. Most of the samples had slender rough, brown and milled rice grain shape; and had intermediate to high amylose content. While four samples had low amylose content (PR42300-4-2, PR42300-12-2, IR64-AC97WP-128 and PR42300-8-29) that also had grade 1 to premium milled and head rice.

- For the forty six (46) SUB samples, most had fair brown rice, grade 1 milled rice, and grade 2 head rice. The percent hull ranged from 21.4 to 26.0%, bran from 4.6 to 8.8%, and brokens from 8.2 to 39.6%. Most of the sample had slender rough, brown and milled grain shape; and had low to intermediate amylose content. Among the samples that had intermediate amylose content, three (3) with line designation PR42271-1-1-6-40, PR39924-B-4-B-2, and IR64-Sub1 had grade 1 milled rice, grade 1 to premium head rice, and slender grain shape.

2015 Wet Season

- Grain quality of fifty four (54) samples from Irrigated Lowland-Direct Seeded Rice (IL-DSR) was assessed. Most of the samples had fair brown rice, grade 1 to premium milled rice, grade 3 to grade 2 head rice, long grain length, slender grain shape, and low to intermediate amylose content. Among the samples that had intermediate amylose content, six samples with line designations PR 44701-19-3-2-B, PR 43377-2-3-1-3-B, PR 43433-5-3-1-2-B, PR 43435-7-2-3-1-B, PR45297-57-1-1-B, and PR43425-12-3-1-1-1-B had fair to good brown rice, grade 1 to premium milled rice, grade 1 head rice, long to extra long grain length, and intermediate to slender grain shape.

2016 Dry Season

- Twenty one (21) entries from the Preliminary Yield Trial (PYT-R) group were evaluated. Most of the samples had fair brown rice, grade 1 to premium milled and head rice, medium to long grain length, and intermediate to slender grain shape. Meanwhile, one sample had very low amylose, eight had low, nine had intermediate, and three had high amylose content. Among samples that had intermediate amylose, three with line designations PR41818-3B-118-3, PR43776-B-5-1-1, and PR43776-B-25-1-1-3 had fair brown rice, premium milled rice, grade 1 to premium head rice, medium to extra long grain length, and intermediate to slender grain shape.

- From the second batch of 24 PYT-R rice lines evaluated for grain quality, 21 had grade 1 milled and head rice recovery. Eight (8) samples had grade2 chalky grains, 14 had long and 10 had medium grain length, 9 had slender and 14 had intermediate grain shape.

- Twenty three (23) entries from the Preliminary Yield Trial for Special Purpose Rice (PYT-SP) composed of 14 aromatic, 1 glutinous, 1 pigmented, and 7 from the Pedigree Nursery Research Consortium (PNRC-A). All aromatic entries had fair brown rice. Most of the samples had grade 1 to premium milled rice and intermediate amylose content. The glutinous entry has excellent grain quality with high milling recovery and waxy amylose content. All PNRC-A entries also had fair brown rice recovery. Samples had grade 1 to premium milled rice, medium to long grain length, intermediate to slender grain shape, and low to intermediate amylose content.

- A third batch of 12 PYT-R lines were evaluated. Out of the 12, majority had excellent grain quality with fair brown rice recovery, grade 1 and grade 2 milled rice recovery, and slender shape. Ten samples were long grain while the remaining two samples were extra long.

- From the 94 Rainfed-MET rice lines evaluated for milling recovery, 44 lines had premium brown rice recovery, while most of the samples had grade 1 milled and grade 2 head rice recovery. Sixty-six (66) lines had long grain length, 44 had slender shape and 68 had intermediate amylose content. The crude protein of the samples ranged from 6.6 to 9.6%.

- Ten lines out of the 12 PYT-SP had high amylose content while 2 lines (PR43172-2B-19-1-2 and PR41622-JR-B-B-23-1-2-1-1-2) had intermediate amylose. Meanwhile, 17 out of 19 IL-DSR lines had very good grain quality having grade 1 milled rice, medium to extra long grain length, intermediate to slender grain shape, and low to intermediate amylose content.

- The grain quality of 31 Fe/Zinc Seed Increase rice lines were evaluated. Majority of the samples had very good grain quality having fair brown rice and grade 1 milled rice recoveries, long and slender grain, intermediate amylose content and low gelatinization temperature. Five lines had low amylose content which also had long to extra long grain length and intermediate to slender grain shape.

Visible-near-infrared spectroscopy for rapid assessment of grain quality of Philippine rice
JG Tallada, LH Lopez, NRL Sevilla, and EH Bandonill

Evaluating grain quality for breeding work and NCT requires measurement for several physicochemical parameters that includes moisture, crude protein, apparent amylose content, gel consistency, gelatinization temperature, and grain dimensions, amongst others. Conventional laboratory testing requires chemical preparations that are not only quite hazardous to health and safety, but are long, tedious and very prone to errors. In addition, cost of consumables, such as chemicals and laboratory supplies contribute mainly to the expense for analysis. Regularly having a large number of samples for analysis makes it cost effective to use advance technologies such as a near infrared (NIR) instrument. The estimation of constituents using NIR spectroscopy was being adopted by many laboratories for analytical purposes. This technology features minimal sample preparation, faster analysis, reduced risks to hazardous chemicals and acceptable accuracy of results. However, it must first be shown feasible for the intended set of analysis through calibration procedures. This study aims to develop prediction NIR models for the grain quality of Philippine rice of different sample forms namely: rough rice (RR), brown rice (BR), milled rice (MR) and floured rice (FR) to assess the efficacy of the NIR method.

Activities:

- A total of 135 samples were collected on a 2014 wet season experiment. They were then subjected to laboratory analysis for collection of physicochemical properties such as Colorimetric Iodine Assay Index for quantifying amylose content, Kjeldahl Method for the determination of protein and gelatinization temperature via the alkali spreading value test.

- The samples were subjected to different milling stages and processed into four different forms namely: rough, brown, milled rice and flour covering a total of 540 samples. Each sample was packed and labeled according to its form and contained sufficient volume to fill a standard petri dish. Alocally developed InGaAs-based (904 nm – 1684 nm) instrument at Cavite State University was used to scan 135 samples.

- A total of 540 samples composed of 135 for each of the four forms were individually analyzed by collecting their absorbance spectra. A software (PircPlus) which displays and collects NIR spectra and data was used and later transferred to an Excel file.

- Samples were scanned twice for averaging. The InGaAs based instrument had a spectrometer that collects absorbance spectra in the wavelength range 904 nm -1684 nm. When the prediction models were developed, the wavelength range was constrained to 950 nm - 1650 nm to remove the low signal-to-noise ratio portion of the spectra. The absorbance data was then merged with the physicochemical data collected (CP, AC, GT) along with its sample label (135 samples) into an Excel file and saved in ASCII format. ParLeS, a chemometric software, was used to analyze the merged data in different spectral treatments namely; No-pretreatment, Standard Normal Variate (SNV), and SNV + 1st Derivative.

- In the analysis for amylose content, the number of samples was reduced to 105 due to the removal of waxy samples (10% and below AC). On the other hand, all samples were considered for CP and GT. A system for sample partitioning was adopted during the calibration-validation sample sets formation. The entire samples (135 for CP and GT, 105 for AC) were divided to 2/3 calibration and 1/3 for validation or prediction. The merged data where sorted in an ascending order and labeled 1, 2, and 3. Labels 1 and 2 samples were used for calibration model development to predict the samples having label 3. The data were then imported to ParLeS for a full cross-validation (leave-one-out) using the calibration samples to identify the optimum number of factors based on the RMSE and number of factors relationship.

Results:

- Results showed that floured rice is the most consistent among the four sample forms with regards to predicting constituents. Crude protein was predicted the easiest amongst the three constituents. Considering all forms, floured rice had the best model (R2=0.951, SEP=0.269, RPD=4.57) (Figure 1).

- A model using rough rice samples, unexpectedly, showed good performance statistics in predicting amylose content (R2=.0.895, SEP=1.397, RPD=3.02) (Figure 2).

- Accurately predicting GT seems not plausible for any form at this time, but seemed to be best estimated by a model for brown rice having no spectral pretreatment (R2=.0.774, SEP=0.640, RPD=2.15) (Figure 3).

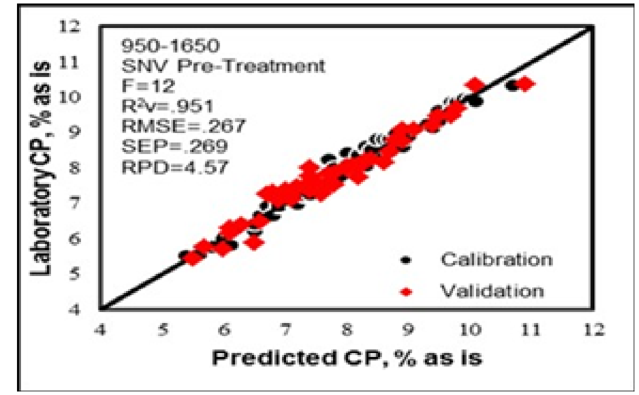

Figure 1. Scatter plot for the best prediction model for crude protein with wavelength range of 950-1650 using an InGaAs-based NIR spectroscopy instrument and floured rice samples.

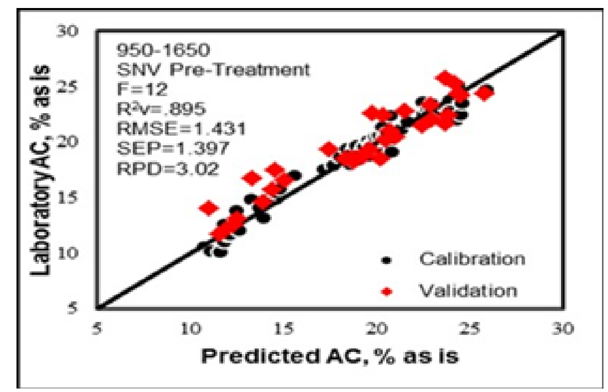

Figure 2. Scatter plot for the best prediction model for amylose content with wavelength range of 950-1650 using an InGaAs-based NIR spectroscopy instrument and rough rice samples.

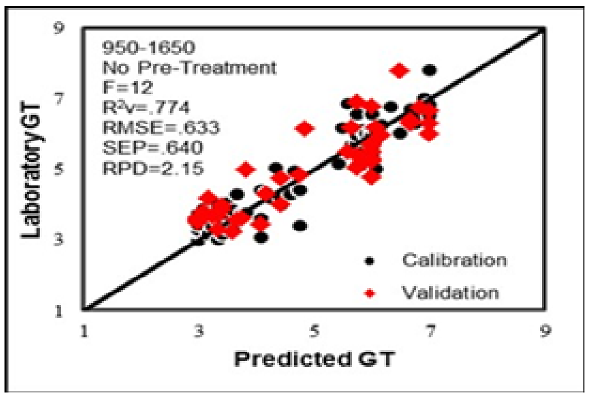

Figure 3. Scatter plot for the best prediction model for gelatinization temperature with wavelength range of 950-1650 using an InGaAs-based NIR spectroscopy instrument and brown rice samples.

Bringing the appropriate variety in Luzon as determined by rice grain qualities preferred by consumers, millers, and traders

EH Bandonill, GG Corpuz, MJC Ablaza, MB Castillo, LC Castillo, and OC Soco

The study on grain quality preferences in various regions of the Philippines has been conducted for more than two decades already and has to be verified and updated. Promising rice lines with consistent high yield in specific sites of the NCT Project are recommended for release as location specific varieties. To further support the location specific release emphasizing grain quality as one of the major basis for recommendation and bring the appropriate rice varieties in a specific location, this study was conceptualized. It aims todetermine the raw and cooked milled rice grain quality preference of consumers in north, central, and southern Luzon particularly in the upland, cool elevated, saline, and rainfed lowland ecosystems, determine the differences or similarity in raw and cooked milled rice characteristics between perceived and preferred qualities, and assess the quality of rice samples consumed by respondents through laboratory analysis.

Activities:

- Questionnaire for the survey was drafted and pre-tested in Aurora, Cagayan, Isabela, and Benguet and rice samples were collected and analyzed in the laboratory as to their Instron cooked rice hardness, physicochemical and sensory properties.

- Final questionnaire was reproduced based on modifications from the pre-testing and sensory score cards were devised. The consumer survey and sensory evaluation were conducted among 100 respondents in the randomly selected barangays in the large rainfed and saline areas of Pangasinan (Bani, Mabini, Agno, Alaminos) and (Lingayen, Mangaladan, Bayambang), respectively and rainfed areas in Nueva Ecija (Cuyapo, Talugtog, and Lupao. Data gathered and samples collected from Nueva Ecija are being processed.

- The survey was conducted in addition to the sensory evaluation to verify the difference in the perceived and preferred cooked and milled rice characteristics by the respondents. Initially, they were asked for the characteristics that they want in cooked and milled rice and then presented with the actual samples during verification.

- Two sets of consumer sensory evaluation for cooked rice were also conducted, first using samples representing the three amylose classifications (high, intermediate, low) and aromatic type and another set using rainfed lowland and saline tolerant released varieties representing hard, intermediate and soft texture.

Results:

- The demographic profile of the respondents from the rainfed and saline areas of Pangasinan is shown in Table 1. Majority of the respondents are female (57 and 63%), married (80 and 70%), with household size of 1 to 12.

- The characteristics that the respondents looked for in raw milled rice were white, with long and whole grains, aromatic, and has high volume expansion when cooked while in the cooked form, they wanted the rice to be tender, aromatic, cohesive, and white.

- During the verification survey where actual samples were presented, respondents chose the samples with the following raw rice qualities: very white, long and slender, and translucent. In the sensory evaluation of cooked rice, the most preferred sample was NSIC Rc238 with aromatic, tender, white, and tasty characteristics, while the least preferred was the rice sample with hard and separated properties represented by NSIC Rc222.

- In the sensory evaluation of rainfed lowland and saline tolerant released varieties, the hard-textured samples had lower cooked rice acceptability and preference score than the soft-textured while higher scores were obtained by samples with long and slender grains than those with medium and intermediate length and shape (Table 2). It is important to note that out of the 34 rainfed lowland and 27 saline tolerant released varieties since 1992-2015, 11 and 3 and were classified as having high; intermediate (20 and 17); and low (2 and 7) amylose content, respectively. Twenty-seven (27) rainfed lowland varieties had long and slender grains while saline tolerant varieties had 14 long and slender and 13 medium to short and intermediate classification.

- From the 18 collected rice samples from Isabela, Benguet, Aurora, and Pangasinan, the amylose content of the 13 samples were high while low to intermediate for the five (5) samples. Crude protein ranged from 5.8-9.1% and cooked rice description were tender to slightly tender having an Instron cooked rice hardness of 1.5-1.9 kg/cm2 (Table 3).

- From respondents surveyed in the saline areas in Pangasinan, the source of rice usually cooked at home was from the market (61%) labelled as Sinandomeng, while the commonly planted varieties in the area were Rc18, Sinandomeng, Rc160 which were perceived to be tasty when cooked.

Table 1. Demographic profile of respondents surveyed in the the rainfed and saline areas of Pangasinan.

rofile	Values	
	Rainfed	Saline
ge (y/o)	23-80	25-81
ender (%)		
emale	57	63
Male	43	37
atus (%)		
Married	80	70
ngle	13	20
idow/Widower	3	10
ousehold size	2-10	1-12

Table 2. Acceptability and preference score of rainfed lowland and saline tolerant released rice varieties.

Parameters	Values	
	Rainfed	Saline
Cooked Rice		
Soft-Textured		
Acceptability (%)	86.7	90.0
Preference Score	7.3	12.6
Hard-Textured		
Acceptability (%)	56.7	33.3
Preference Score	-14.5	-19.0
Raw Rice		
Long and Slender		
Acceptability	90.0	90.0
Preference Score	8.8	15.8
Medium and Intermediate		
Acceptability		33.3
Preference Score		-15.0

Table 3a. Grain quality characteristics of collected rice samples in Isabela, Aurora, Benguet, Pangasinan (rainfed lowland areas).

Source	Name	Values/Classification						
		Amylose Content (%)	Class	Crude Protein (%)	Gelatinization Temp.	Class	Instron Hardness (kg/cm²)	Cooked Rice Description
Ilagan, Isabela	Gracia Salvador	22.2	H	7.35	6.0	I/L	1.5	tender
La Trinidad, Benguet	Super Angelica	23.1	H	8.30	5.0	I/L	1.6	tender
Baler, Aurora	C-18	25.4	H	7.20	6.1	I/L	1.8	Slightly tender
Baler, Aurora	Aurora	22.8	H	7.68	5.5	I/L	1.8	Slightly tender
Baler, Aurora	Angelica	22.1	H	7.66	3.7	H/HI/L	1.9	tender
Baler, Aurora	Thailand Broken	24.5	H	8.28	5.4	I/L	1.7	Slightly tender
Alaminos, Pangasinan	Baak	21.6	I	6.88	5.2	I/L	1.9	Slightly tender
Bani, Pangasinan	Bigante	20.1	I	9.09	4.9	I	1.7	Slightly tender
Agno, Pangasinan	NSIC Rc160	17.9	I	7.65	5.6	HI/I/L	1.7	Slightly tender
Alaminos, Pangasinan	Rumble	16.4	L	7.75	7.0	L	1.6	tender

Amylose Content, Gelatinization Temperature: L – low; I – intermediate; H - high

Table 3b. Grain quality characteristics of collected rice samples in Pangasinan (saline tolerant areas).

Source	Values/Classification											
	Head Rice (%)	Chalky Grains (%)	Class	Grain Length (mm)	Class	Grain Shape (mm)	Class	Amylose Content	Class	Gel Temp	Class	Crude Protein (%)
Matalava, Lingayen	2.9	24.7	gg	7.0	L	3.2	S	24.0	H	4.3	HI/I	5.8
Domalandan, Lingayen	55.3	11.0	G3	7.3	L	3.4	S	24.7	H	5.9	HI/L	7.1
Naguelguel , Lingayen	31.2	6.3	G2	7.0	L	3.3	S	26.5	H	5.0	I	7.8
Pogo, Mangaldan	51.4	12.3	G3	6.8	L	3.1	S	24.5	H	6.6	L	7.9
Salay, Mangaldan	55.2	14.7	G3	6.8	L	3.1	S	23.2	H	5.4	HI/I/L	7.8
Dusoc, Bayambang	67.1	16.4	gg	6.8	L	3.0	I	24.6	H	5.8	L	7.4
Telbang, Bayambang	21.6	14.1	G3	6.7	L	3.1	S	20.9	I	6.1	I/L	8.3
Amancosiling Sur, Bayambang	58.9	12.9	G3	6.7	L	3.0	I	23.3	H	6.7	L	7.8

Grain Length: L – long; Grain Shape: S – slender; I - intermediate
Amylose Content, Gelatinization Temperature: L – low; I – intermediate; H - high % Head Rice is based on Total Milled Rice

II. Nutrition, Health and Wellness Potential of Philippine Rice and Rice-Based Crops

Project Leader: RG Abilgos-Ramos

Nutrition, health and wellness potential of rice and other crops grown in rice environment are important considerations in value-adding. There is an increasing interest in using rice and other crops found in rice-based farms for health and other industrial purposes. Study 1 looks into the antioxidant capacities of crops commonly grown in rice-based farms and their phytochemical levels significant for consumers' health enhancement. Study 2 aims to determine the market needs and wants for health and nutrition products from rice and rice-based crops. Lastly, Study 3 intends to examine the bioefficacy of pigmented rice in the prevention of common chronic diseases such as cancer, hypertension, and diabetes.

Antioxidant capacity and antioxidant components of rice-based crops in the Philippines

RV Manaois, JEI Zapater, and AV Morales

Plants are known rich sources of biologically active compounds, mainly antioxidants, known to lower risks of life-threatening diseases, which include diabetes, cardiovascular diseases, and various forms of cancer. The Philippines has a wide array of plant foods, which could be tapped for health promotion and disease prevention and for the production of functional foods and nutraceuticals. Some of these foodstuffs are commonly cultivated in rice farming areas. Such practice of planting of various crops in between rice cropping seasons is a key feature of agricultural integration and diversification currently being advocated by PhilRice. This study aims to evaluate the total antioxidant capacities and composition of different crops and foodstuffs cultivated in rice-based farming areas in the Philippines. Data generated from this study will aid in the production of high quality foodstuffs from rice growing areas and in consumer selection of products for health maintenance and disease prevention. Additionally, it would provide information on several factors that favor the maximum production of antioxidants in local foodstuffs.

Activities:

- A total of 52 vegetables cultivated in rice farming areas during June 2015 to October 2016 were procured as samples. These consist of 24 botanical fruits, 11 plant leaves, six tubers and root crops, three flowers, three bulbs, two rhizomes, one pulse, one shoot, and one stalk. The edible portions of the samples were collected, washed, and when applicable, boiled for 3 min for leafy vegetables; 4 min for botanical fruits; 5 min for tubers and squash samples; and 30 min for corn and mungbean. The raw and boiled samples were oven-dried or lyophilized and powdered for antioxidant extraction.

- Of the processed samples, 41 were subjected to hydrophilic extraction and the total phenolic content (TPC) using the Folin-Ciocalteau method and antioxidant capacities using 2,2′-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity, 2,2′-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) radical cation scavenging activity, and the ferric reducing antioxidant power (FRAP) were determined using the extracts.

Results:

- Table 4 summarizes the results of the TPC assay. The TPC of the raw samples ranged from 0.78 to 79.62 mg GAE/g, while those of the cooked samples ranged 0.11-76.27 mg GAE/g. The samples which had the highest TPC in their raw forms were turmeric (79.62mg GAE/g), camote tops (38.33), jute (31.78), lowland water spinach (28.35), and eggplant (22.52).

- Boiling generally reduced the TPC of the crops by as much as 77%, although green pepper, sweet potato, and tomato had significantly higher TPC after boiling (Table 4). The vegetables which displayed the highest level of phenolics after cooking were turmeric (76.27mg GAE/g), lowland water spinach (30.67), eggplant (21.08), and green peppers Django (16.04) and Korean (19.92).

- The antioxidant capacities of samples were measured by DPPH radical scavenging activity, ABTS scavenging activity, and ferric reducing antioxidant power (FRAP). The raw samples which consistently exhibited high antioxidant capacities using the three assays were turmeric, camote tops, jute, lowland water spinach, and eggplant (Tables 5-7).

- The DPPH values of raw vegetables ranged from 0.58 to 303.24 μmol TE/g, while cooked samples had 0.42-295.71 μmol TE/g (Table 5). Reduction by as much as 84% in the DPPH values was likewise observed after boiling. However, green peppers, sweet potato, tomato, squash fruits, and bitter gourd showed increased DPPH scavenging activities, with up to 268.4% improvement after boiling.

- Similar to the TPC results, antioxidant capacities of turmeric, lowland water spinach, eggplant, and the two green pepper varieties were the highest among the boiled samples as determined by the three assays (Tables 5-7).

- FRAP values of raw and cooked vegetables ranged 1.96-334.71 μmol TE/g and 1.19-311.50 μmol TE/g, respectively (Table 7). Camote tops had the highest FRAP value (334.71 μmol TE/g) among the raw vegetables, while turmeric topped the list of boiled vegetables in terms of FRAP value (311.50 μmol TE/g).
- Turmeric notably displayed high TPC values and antioxidant capacities measured using the three techniques, whether raw or boiled. Retention of antioxidants was also observed in this sample as indicated by the non-significant differences between the values of its raw and boiled forms.

- Correlation analyses showed that TPC values were highly correlated with all the antioxidant capacity measurements (DPPH, ABTS, FRAP), both in raw (r=0.913, 0.976 and 0.909, respectively) (Figure 4a) and boiled forms (r= 0.941, 0.980 and 0.926, respectively) (Figure 4b). This signifies the substantial contribution of phenolic compounds on the antioxidant capacity in the vegetables.

Table 4. Total phenolic content (TPC) of vegetables commonly grown in rice-based farms.

Crop	TPC (mg GAE/g dry weight)		
	Raw sample[1]	Cooked sample [1]	Difference[2]
Bamboo shoot	14.39 ± 0.44^{g}	5.87 ± 0.26^{hi}	-59.2*
Banana blossom	9.14 ± 0.20^{jkl}	8.03 ± 0.21^{fg}	-12.1*
Bitter gourd	2.46 ± 0.14^{tuvw}	2.35 ± 0.04^{klm}	-4.5
Bitter gourd leaves	7.79 ± 0.34^{lmn}	2.34 ± 0.15^{klm}	-70.0
Bottle gourd	2.34 ± 0.10^{tuvwx}	1.58 ± 0.10^{lm}	-32.5*
Camote tops	38.33 ± 1.19^{b}	9.50 ± 0.40^{ef}	-75.2*
Chili	10.34 ± 0.27^{ij}	10.51 ± 0.13^{e}	+1.7
Chinese cabbage	9.54 ± 0.46^{jk}	2.33 ± 0.17^{klm}	-75.6*
Corn	1.28 ± 0.04^{vwx}	0.11 ± 0.01^{m}	-91.4
Cowpea	6.27 ± 0.30^{opq}	5.22 ± 0.30^{hi}	-16.8*
Eggplant	22.52 ± 1.80^{e}	21.08 ± 1.29^{c}	-6.4
Garlic	1.33 ± 0.02^{vwx}	1.23 ± 0.05^{lm}	-7.5*
Ginger	7.25 ± 0.19^{mno}	7.16 ± 0.60^{gh}	-1.2
Green pepper, variety 1	9.14 ± 0.04^{jkl}	16.04 ± 0.32^{d}	+75.5*
Green pepper, variety 2	8.26 ± 0.31^{klm}	19.92 ± 0.39^{c}	+141.2*
Jute	31.78 ± 0.02^{c}	8.53 ± 0.32^{efg}	-73.2*
Lettuce	12.62 ± 0.53^{h}	n/a	n/a
Moringa leaves	17.81 ± 0.26^{f}	9.21 ± 0.27^{ef}	-48.3*
Mongo	1.04 ± 0.04^{wx}	0.81 ± 0.05^{lm}	-22.1*
Mushroom, milky	2.13 ± 0.09^{tuvwx}	0.67 ± 0.00^{lm}	-57.3*
Mushroom, oyster	2.91 ± 0.22^{tuv}	0.91 ± 0.03^{lm}	-77.0*
Mustard	10.29 ± 0.17^{ij}	4.85 ± 0.19^{ij}	-52.9*
Okra	5.83 ± 0.28^{pqr}	4.32 ± 0.13^{ijk}	-25.9
Onion	2.38± 0.05^{tuvwx}	2.22 ± 0.07^{klm}	-6.7*
Peanut	2.99 ± 0.20^{tu}	2.47 ± 0.11^{kl}	-17.4*
Radish	1.37 ± 0.11^{uvwx}	1.38 ± 0.12^{lm}	+0.7
Spinach	6.75 ± 0.06^{opq}	2.26 ± 0.14^{klm}	-66.5*
Sponge gourd	1.96 ± 0.03^{tuvwx}	1.47 ± 0.08^{lm}	-25.0
Squash flower	11.31 ± 0.16^{hi}	8.51 ± 0.24^{efg}	-24.8*
Squash fruit, variety 1	0.78 ± 0.01^{x}	0.72 ± 0.03^{lm}	-7.7*
Squash fruit, variety 2	0.96 ± 0.02^{wx}	1.05 ± 0.03^{lm}	+9.4*
Squash fruit, variety 3	1.13 ± 0.00^{wx}	1.28 ± 0.07^{lm}	+13.3
String beans	5.58 ± 0.15^{qr}	4.21 ± 0.27^{ijk}	-24.6*
Sweet potato	1.59 ± 0.07^{uvwx}	2.88 ± 0.26^{jkl}	+81.1*
Taro stalk	2.81 ± 0.07^{tuv}	2.74 ± 0.08^{kl}	-2.5
Taro tuber	4.62 ± 0.33^{rs}	2.56 ± 0.18^{kl}	-44.6*
Tomato	4.61 ± 0.21^{rs}	5.31 ± 0.04^{hi}	+15.1*
Turmeric	79.62 ± 0.96^{a}	76.27 ± 3.93^{a}	-4.2
Water spinach (Lowland)	28.35 ± 2.22^{d}	30.67 ± 1.66^{b}	+8.2
Water spinach (Upland)	3.53 ± 0.13st	5.87 ± 0.16^{hi}	+66.3*
Winged bean	6.33 ± 0.24^{opq}	5.01 ± 0.32^{i}	-20.9*

Means ± SD (n=3)

1Mean values with the same small letter within the same column are not significantly different ($p<0.05$) using ANOVA.

2Differences with * are significant ($p<0.05$) using t-test.

Table 5. DPPH radical scavenging activity of vegetables commonly grown in rice-based farms.

Crop	DPPH (μmol Teq/g)		
	Raw sample[1]	Cooked sample[1]	Difference[2]
Bamboo shoot	5.39 ± 0.18^{qr}	2.28 ± 0.09^{kl}	-57.7*
Banana blossom	46.02 ± 1.56^{h}	46.42 ± 2.48^{f}	+0.9
Bitter gourd	6.21 ± 0.24^{pqr}	7.95 ± 0.24^{jkl}	+28.0*
Bitter gourd leaves	26.97 ± 1.83^{lmn}	4.28 ± 0.58^{kl}	-84.1*
Bottle gourd	14.20 ± 0.48^{o}	9.45 ± 0.97^{jkl}	-33.5*
Camote tops	254.94 ± 4.46^{b}	48.83 ± 4.12^{f}	-80.8*
Chili	23.27 ± 0.77^{mn}	29.70 ± 0.68^{gh}	+27.6*
Chinese cabbage	30.44 ± 0.75^{l}	10.72 ± 0.81^{jkl}	-64.8*
Corn	2.98 ± 0.06^{r}	2.79 ± 0.14^{kl}	-6.4
Cowpea	24.72 ± 1.87^{lmn}	28.34 ± 0.63^{ghi}	+14.6*
Eggplant	191.77 ± 6.46^{d}	178.49 ± 12.83^{c}	-6.9
Garlic	2.27 ± 0.16^{r}	1.76 ± 0.12^{kl}	-22.5*
Ginger	38.07 ± 1.27^{ij}	20.20 ± 1.24^{ghij}	-46.9*
Green pepper, variety 1	40.85 ± 0.27^{hij}	81.04 ± 0.61^{e}	+98.4*
Green pepper, variety 2	31.10 ± 0.90^{kl}	114.58 ± 1.19^{d}	+268.4*
Jute	239.32 ± 1.29^{c}	52.02 ± 2.47^{f}	78.3*
Lettuce	67.51 ± 4.90^{f}	n/a	n/a
Moringa leaves	60.62 ± 2.16^{g}	31.19 ± 0.78^{g}	-48.5*
Mongo	1.73 ± 0.13^{r}	1.09 ± 0.06^{kl}	-37.0*
Mushroom, milky	3.13 ± 0.29^{r}	1.06 ± 0.08^{kl}	-66.1*
Mushroom, oyster	5.59 ± 0.44^{qr}	0.42 ± 0.05^{l}	-92.5
Mustard	36.57 ± 1.44^{jk}	14.09 ± 0.38^{ijkl}	-61.5*
Okra	37.93 ± 1.43^{ij}	23.27 ± 1.51^{ghij}	-38.7*
Onion	4.30 ± 0.20^{qr}	4.25 ± 0.23^{kl}	-1.2
Peanut	12.22 ± 0.29^{op}	8.64 ± 0.27^{jkl}	-29.3*
Radish	4.47 ± 0.2^{qr}	3.36 ± 0.26^{kl}	-24.8*
Spinach	21.83 ± 1.03^{n}	8.78 ± 0.60^{jkl}	-59.8*
Sponge gourd	5.19 ± 0.03^{qr}	3.02 ± 0.13^{kl}	-41.8*
Squash flower	28.94 ± 1.02^{lm}	11.19 ± 0.18^{jkl}	-61.3*
Squash fruit, variety 1	0.58 ± 0.01^{r}	1.11 ± 0.02^{kl}	+91.4*
Squash fruit, variety 2	0.80 ± 0.03^{r}	0.95 ± 0.01^{kl}	+18.8*
Squash fruit, variety 3	1.24 ± 0.05^{r}	3.29 ± 0.05^{kl}	+165.3*
String beans	24.47 ± 1.94^{lmn}	15.72 ± 1.39^{hijkl}	-35.8*
Sweet potato	6.47 ± 0.36^{pqr}	21.96 ± 2.58^{ghij}	+239.4*
Taro stalk	10.45 ± 0.70^{opq}	10.96 ± 0.59^{jkl}	+4.9
Taro tuber	43.39 ± 0.60^{hi}	16.32 ± 1.24^{hijkl}	-62.4*
Tomato	15.00 ± 0.28^{o}	16.63 ±0.21^{ghijk}	+10.9*
Turmeric	303.24 ± 8.99^{a}	295.71 ± 10.42^{a}	-2.5
Water spinach (Lowland)	170.83 ± 5.04^{e}	193.59 ± 26.02^{b}	+13.3
Water spinach (Upland)	55.76 ± 0.28^{g}	56.63 ± 4.14^{f}	+1.6
Winged bean	27.50 ± 0.27^{lmn}	14.80 ± 0.41^{hijkl}	-46.2*

Means ± SD (n=3)

1Mean values with the same small letter within the same column are not significantly different ($p<0.05$) using ANOVA.

2Differences with * are significant ($p<0.05$) using t-test.

Table 6. ABTS radical-cation scavenging activity of vegetables commonly grown in rice-based farms.

Crop	ABTS (µmol Teq/g)		
	Raw sample[1]	Cooked sample[1]	Difference[2]
Bamboo shoot	2.46 ± 0.15^{q}	1.11 ± 0.09^{op}	-54.9*
Banana blossom	56.54 ± 1.89^{f}	47.41 ± 2.07^{f}	-16.1*
Bitter gourd	2.20 ± 0.28^{q}	3.88 ± 0.11^{mnop}	+76.4*
Bitter gourd leaves	23.97 ± 1.21^{jk}	7.88 ± 0.53^{lmn}	-67.1*
Bottle gourd	4.57 ± 0.14^{q}	3.84 ± 0.47^{mnop}	+16.0
Camote tops	162.77 ± 4.15^{b}	33.15 ± 1.24^{g}	-79.6*
Chili	22.83 ± 0.20^{k}	21.79 ± 0.25^{hi}	-4.6*
Chinese cabbage	32.00 ± 1.00^{i}	7.73 ± 0.50^{lmno}	-75.8*
Corn	2.56 ± 0.19^{q}	2.92 ± 0.18^{mnop}	+14.1
Cowpea	20.50 ± 0.70^{klm}	19.63 ± 0.63^{hij}	4.2
Eggplant	82.22 ± 5.55^{e}	85.01 ± 6.63^{c}	+3.4
Garlic	1.81 ± 0.08^{q}	1.39 ± 0.04^{nop}	-23.2*
Ginger	50.62 ± 3.62^{g}	43.22 ± 2.9^{f}	-14.6
Green pepper, variety 1	30.72 ± 1.78^{i}	53.14 ± 0.74^{e}	+73.0*
Green pepper, variety 2	21.57 ± 0.29^{kl}	77.64 ± 3.02^{d}	+259.9*
Jute	136.84 ± 3.27^{c}	82.68 ± 0.95^{cd}	-39.6*
Lettuce	46.44 ± 2.91^{gh}	n/a	n/a
Moringa leaves	45.44 ± 0.85^{h}	31.59 ± 1.56^{g}	-30.5*
Mongo	1.64 ± 0.11^{q}	1.24 ± 0.36^{op}	-24.4
Mushroom, milky	2.19 ± 0.03^{q}	0.83 ± 0.05^{p}	-62.1*
Mushroom, oyster	5.71 ± 0.43^{pq}	0.45 ± 0.08^{p}	-85.3*
Mustard	28.07 ± 0.94^{ij}	16.22 ± 1.04^{ijk}	-42.2*
Crop	**ABTS (µmol Teq/g)**		
	Raw sample[1]	**Cooked sample[1]**	**Difference[2]**
Okra	22.63 ± 0.68^{k}	17.54 ± 0.35^{hijk}	-22.5*
Onion	4.01 ± 0.39^{q}	3.69 ± 0.28^{mnop}	-8.0
Peanut	12.63 ± 0.79^{no}	8.21 ± 0.25^{lm}	-35.0*
Radish	3.23 ± 0.17^{q}	1.81 ± 0.20^{mnop}	-44.0*
Spinach	16.06 ± 0.89^{mn}	15.88 ± 1.31^{ijk}	-1.1
Sponge gourd	5.14 ± 0.19^{pq}	0.60 ± 0.08^{p}	-88.3*
Squash flower	18.54 ± 0.26^{klm}	11.91 ± 0.31^{kl}	-35.8*
Squash fruit, variety 1	1.38 ± 0.06^{q}	1.37 ± 0.01^{nop}	-0.7
Squash fruit, variety 2	2.38 ± 0.19^{q}	1.36 ± 0.13^{nop}	-42.9*
Squash fruit, variety 3	2.10 ± 0.02^{q}	2.25 ± 0.05^{mnop}	+7.1*
String beans	17.13 ± 0.33^{lmn}	15.11 ± 0.53^{jk}	-11.8*
Sweet potato	3.84 ± 0.09^{q}	6.08 ± 0.55^{lmnop}	+58.3*
Taro stalk	10.08 ± 0.36^{op}	8.19 ± 0.50^{lm}	18.8*
Taro tuber	23.65 ± 0.54^{jk}	11.93 ± 1.45^{kl}	-49.6*
Tomato	12.21 ± 0.43^{no}	15.61 ± 0.68^{ijk}	+27.8*
Turmeric	322.67 ± 8.86^{a}	323.99 ± 9.57^{a}	+0.4
Water spinach (Lowland)	101.10 ± 0.68^{d}	114.73 ± 4.08^{b}	+13.5*
Water spinach (Upland)	30.25 ± 0.43^{i}	22.66 ± 0.94^{h}	-25.1*
Winged bean	20.70 ± 0.41^{klm}	15.47 ± 0.93^{jk}	-25.3*

Means ± SD (n=3)

1Mean values with the same small letter within the same column are not significantly different ($p<0.05$) using ANOVA.

2Differences with * are significant ($p<0.05$) using t-test.

Table 7. Ferric Reducing Antioxidant Power (FRAP) of vegetables commonly grown in rice-based farms.

Crop	FRAP (µmol Teq/g)		
	Raw sample[1]	Cooked sample[1]	Difference[2]
Bamboo shoot	9.47 ± 0.33^{kl}	4.14 ± 0.29^{stu}	-56.3*
Banana blossom	52.71 ± 4.09^{g}	52.85 ± 0.21^{g}	+0.3
Bitter gourd	5.47 ± 0.12^{l}	9.40 ± 0.07^{qrs}	+71.8*
Bitter gourd leaves	56.69 ± 1.77^{fg}	27.02 ± 1.50^{ij}	-52.3*
Bottle gourd	10.25 ± 0.14^{kl}	15.36 ± 0.57^{lmno}	+49.9*
Camote tops	334.71 ± 14.37^{a}	79.86 ± 2.65^{f}	+76.1*
Chili	38.10 ± 1.31^{hi}	42.43 ± 3.88^{h}	+11.4
Chinese cabbage	49.38 ± 0.39^{gh}	15.79 ± 1.59^{lmn}	-68.0*
Corn	4.91 ± 0.19^{l}	5.42 ± 0.34^{rstu}	+10.4
Cowpea	21.54 ± 1.99^{jk}	27.68 ± 0.98^{ij}	+28.5*
Eggplant	160.79 ± 9.38^{d}	170.12 ± 1.89^{c}	+5.8
Garlic	4.75 ± 0.27^{l}	2.81 ± 0.27^{u}	-40.8*
Ginger	48.74 ± 0.77^{gh}	44.61 ± 3.66^{h}	-8.5
Green pepper, variety 1	66.55 ± 1.93^{f}	98.26 ± 0.95^{e}	+47.7*
Green pepper, variety 2	46.25 ± 2.39^{gh}	157.52 ± 5.65^{d}	+240.6*
Jute	208.55 ± 3.00^{c}	50.15 ± 2.13^{g}	-76.0*
Lettuce	92.42 ± 0.68^{e}	n/a	n/a
Moringa leaves	94.19 ± 0.87^{e}	50.32 ± 2.89^{g}	-46.6*
Mongo	2.55 ± 0.16^{l}	1.91 ± 0.20^{u}	-25.1*
Mushroom, milky	3.51 ± 0.07^{l}	2.25 ± 0.37^{u}	-35.9*
Mushroom, oyster	10.02 ± 0.76^{kl}	1.19 ± 0.13^{u}	-77.5*
Mustard	58.71 ± 1.69^{fg}	23.24 ± 0.79^{jk}	-60.4*
Crop	**FRAP (µmol Teq/g)**		
	Raw sample[1]	**Cooked sample[1]**	**Difference[2]**
Okra	38.91 ± 2.46^{hi}	28.69 ± 2.59^{i}	-26.3*
Onion	7.82 ± 0.26^{kl}	9.96 ± 0.34^{pqr}	+27.4*
Peanut	15.71 ± 0.55^{kl}	10.60 ± 0.46^{opqr}	-32.5*
Radish	7.92 ± 0.28^{kl}	8.66 ± 0.45^{rst}	+9.3
Spinach	31.51 ± 0.08^{ij}	20.60 ± 2.14^{kl}	-34.6*
Sponge gourd	12.23 ± 0.18^{kl}	8.36 ± 0.27^{rst}	-31.6*
Squash flower	46.19 ± 0.68^{gh}	14.43 ± 0.19^{mnop}	68.8*
Squash fruit, variety 1	2.16 ± 0.06^{l}	2.88 ± 0.19^{u}	+33.3*
Squash fruit, variety 2	1.96 ± 0.07^{l}	2.51 ± 0.10^{u}	+28.1*
Squash fruit, variety 3	3.09 ± 0.06^{l}	3.72 ± 0.09^{tu}	+20.4*
String beans	20.77 ± 1.71^{jk}	19.85 ± 0.91^{klm}	-4.4
Sweet potato	6.72 ± 0.49^{l}	23.13 ± 1.10^{jk}	+244.2*
Taro stalk	10.86 ± 0.70^{kl}	10.53 ± 0.78^{opqr}	-3.0
Taro tuber	28.82 ± 2.48^{ij}	16.01 ± 1.23^{lmn}	-44.4*
Tomato	28.90 ± 0.99^{ij}	27.97 ± 0.13^{ij}	-3.2
Turmeric	311.36 ± 22.37^{b}	311.50 ± 4.86^{a}	+0.0
Water spinach (Lowland)	204.36 ± 5.80^{c}	253.93 ± 4.49^{b}	+24.3*
Water spinach (Upland)	53.22 ± 3.01^{g}	44.36 ± 1.07^{h}	-16.6*
Winged bean	31.33 ± 0.89^{ij}	21.63 ± 1.66^{k}	-31.0*

Means ± SD (n=3)

1Mean values with the same small letter within the same column are not significantly different ($p<0.05$) using ANOVA.

2Differences with * are significant ($p<0.05$) using t-test

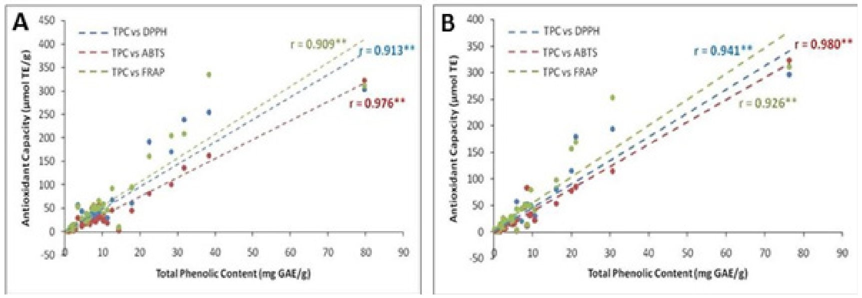

Figure 4. Correlation between TPC and antioxidant capacities of (a) raw (n=41) and (b) boiled (n=40) vegetables.

Exploratory market research and pre-feasibility study for the development of rice-based products with health and nutritional value
JF Ballesteros, RG Abilgos-Ramos, and RV Manaois

Development of rice-based products encourages profitability in rice-producing communities, thereby increasing their income and improving their nutritional status. This study aimed to develop rice-based products concepts with health and nutritional value based on the current market trends on health and wellness. Three (3) focus group discussions were conducted to explore views and perception of 24 experts with an average of 13.18 years of experience in the field of product development, marketing and distribution, nutrition and health from both the public (academia, research organizations, regulatory bodies, health agencies) and private sectors (food manufacturing and service companies, bakeshop company, chamber of health industries, marketing and distribution company, non-government organization). A market survey was also conducted with 350 respondents from the seven (7) provinces in Central Luzon. A more market-driven approach in product development will enable the creation of rice-based products that would suit and satisfy customer needs and wants.

Activities:

- Three (3) focus group discussions were conducted in March, April, and May 2016 with participants who are experts or experienced people in the field of product development and marketing of products. This is to describe participants' perception on health and wellness and develop rice-based food products concepts considering health and nutrition. In addition, rice-based products with health and nutritional value were identified through a customer-driven approach by exploring market needs and wants.

- Rice-based product concepts were identified from the

analyzed data results of the three FGDs in June 2016.

- Market survey was conducted with 350 respondents in Aurora, Bataan, Bulacan, Tarlac, Pampanga, Nueva Ecija, and Zambales from October to November 2016.

- Market survey data were already encoded. Data processing is on-going.

Results:

- There were 24 participants in the three (3) focus group discussions. Participants were selected in terms of their expertise in the field of product development, business and marketing in order to gain valuable insights in developing rice-based products with added value in health and nutrition in accordance with observed trends in the market. There were 18 female and seven male participants. There were six from the academe, six from government agencies, five from food manufacturing companies, two from healthcare/hospital, two from a marketing and distribution company, one from a non-government organization, one from a bakeshop company, one from a chamber of industries, and one from a cooperative.

- Participants mainly perceived health and wellness to be mainly about food, proper diet, and nutrition; health products; lifestyle; views on quality of life; and exercise/physical activity (Figure 5).

- In the meals category, participants said that consumers tend to eat fast food and restaurant meals (57%); home cooked meat/fish (18%); and instant meals (8%) (Figure 6).

- According to the participants, the most commonly consumed snacks and drinks/beverages were crackers and chips (Figure 7) and ready-to-drink coffee drinks (Figure 8).

- In the non-food categories, facial care products (19%) were the most commonly used hygiene and beauty products (Figure 9), while food supplements (46%) were the most commonly bought pharmaceutical/nutraceutical products (Figure 10).

- More than 5 product concept categories were generated. The top 5 based on the participants' perception are flour products (e.g. rice muffin, rice cake), personal care/hygiene products (e.g. soap, facial scrub, and ointment), drinks/beverages (e.g. rice bran tea, rice juice) special purpose products (e.g. fortified rice products), and convenience products (e.g. instant rice meals).

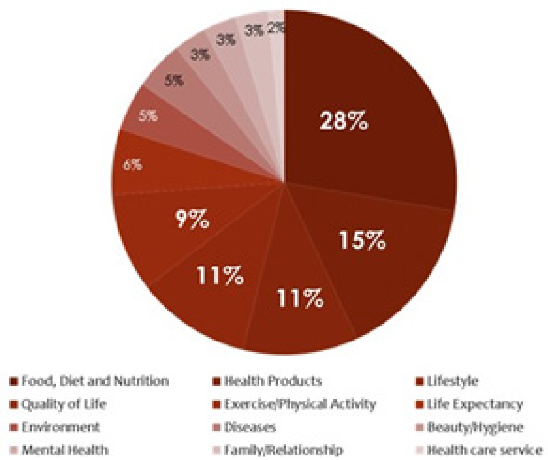

Figure 5. FGD participants' perception about health and wellness.

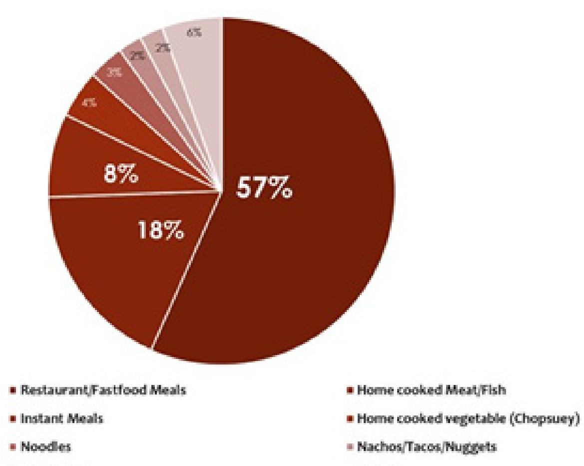

Figure 6. Meals and meal products commonly bought by consumers, according to FGD participants (n=24).

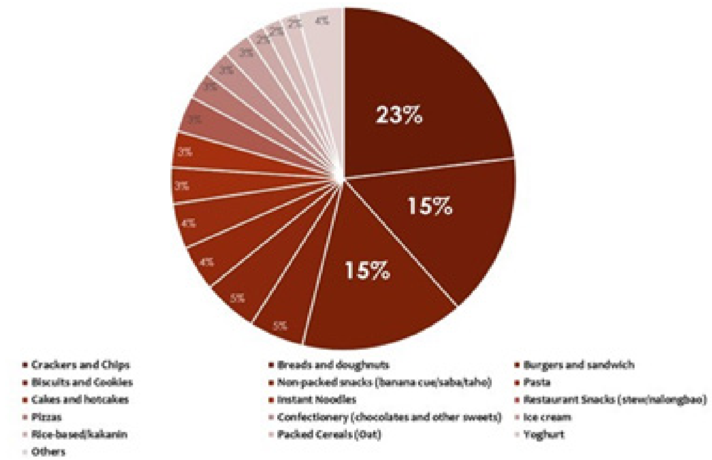

Figure 7. Snack products commonly bought by consumers, according to FGD participants (n=24).

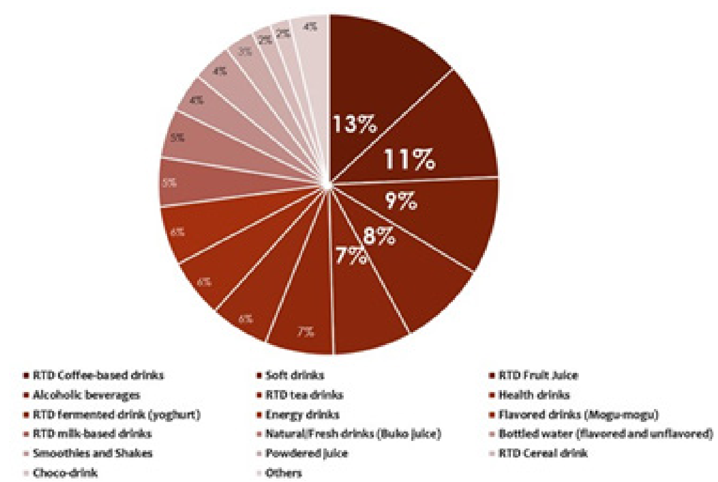

Figure 8. Drinks/beverages commonly bought by consumers, according to FGD participants (n=24).

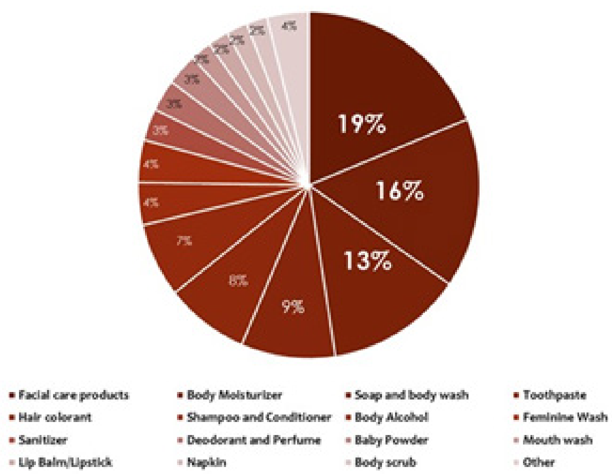

Figure 9. Hygiene and beauty products commonly bought by consumers, according to FGD participants (n=24).

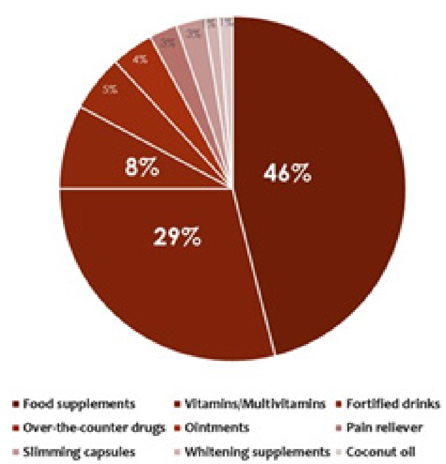

Figure 10. Pharmaceutical/Nutraceutical products commonly bought by consumers, according to FGD participants (n=24).

Therapeutic potential of pigmented rice germplasms deposited at PhilRice genebank against some chronic diseases

RM Bulatao, HF Mamucod, RP Tubera, JPA Samin, MB Castillo, IJV Balmeo, MC Ferrer, and XA Caguiat

There has been an immense interest on the use of natural ingredients for functional food and antioxidant supplement mainly due to consumers' demand for healthier products. Consumers are now becoming smarter and vigilant in choosing their diet because of the negative health impact of artificial food ingredients and antioxidants. Pigmented rices are good sources of essential nutrients and phytochemicals, which are known to have health-promoting properties. Thus, pigmented rice could be a great potential for the development of functional and pharmaceutical products. In PhilRice, more than ten thousand rice germplasms are currently deposited at PhilRice genebank. Most of these are traditional pigmented rices, which may have therapeutic potentials. Currently, these germplasms are being characterized for agro-morphological properties, grain quality, and biotic and abiotic stress resistance. However, the nutritional content, antioxidant property, and therapeutic activity of these rice germplasms have not yet been evaluated. Thus, this study was conducted.

Activities:

- Eighty eight (88) pigmented rice germplasms were collected from PhilRice genebank. Relevant information about the seed samples such as the pericarp color, accession name and number, and collection site were obtained.

- The rice germplasms were characterized for their milling potentials (brown rice (BR), total milled rice (TMR), and head rice (HR) recoveries), physical attributes (grain dimensions and chalky grains), and physicochemical properties (amylose, protein, and alkali spreading value).

- Polished and unpolished forms of pigmented rice germplasms were evaluated for their chromametric (L*a*b*) values, proximate properties (moisture, ash, fat, and protein content), phytochemical content [total anthocyanin content (TAC), total phenolic content (TPC), and total flavonoid content (TFC)], and antioxidant activity (2,2-diphenyl-1-picrylhydrazyl (DPPH), 2′-azinobis(3-ethylbenzothiazoline-6-sulphonic acid) diammonium salt (ABTS), and ferric reducing antioxidant power (FRAP) assays).

Results:

- Pigmented rice germplasms had poor to good BR (74.2-81.2%), grade 2 to premium TMR (62.8-76.8%), and grade 3 to premium HR (34.3-72.2%) recoveries. About 91.6%, 97.2%, and 94.4% of the total samples passed the recommended values for BR, TMR, and HR recoveries, respectively. Pigmented rice samples had grain lengths that varied from short to long and shape that ranged from short to intermediate. The chalky grains ranged from 0.7-27.4%, wherein 52.5% of the samples passed the recommended value, which is 5.0% (Figure 11a).

- Amylose content (AC) of pigmented rice accessions ranged from 0.3 to 24.4%. Twenty one samples were classified as intermediate AC, 20 low, 12 very low, six high, and six waxy (Figure 11b). The protein content ranged from 6.0 to 9.8%, with Red Tonner and Quinizon having the highest and lowest values, respectively. The alkali spreading value ranged from 2.3 to 6.0, which corresponds to gelatinization temperatures of high to intermediate.

- Polished Malido red (CN14407) had the highest L* value indicating that it had the lightest grain color among the accessions. Polished Red blondie (CN14388) obtained the highest a* and b* values suggesting that it had the reddest and yellowest grains among the samples. For the unpolished samples, Malapay (CN13609) had the highest L* and b* values while Dinorado (CN14277) had the highest a* value.

- Polished pigmented rice samples had 7.6-11.6% moisture content. Their ash, fat, and protein content were 7.6-11.6%, 0.2-1.0%, and 8.0-9.8%, respectively. For their unpolished form, the samples had moisture content of 7.6-12.5%. Their ash, fat, and protein content ranged 1.1-2.0%, 1.2-1.5%, and 6.0-9.8%, respectively.

- Polished Tapol (CN5627) obtained the highest TAC, TPC, TFC, and FRAP antioxidant activities. Polished Tininta (CN1501) had the highest DPPH and ABTS radical scavenging activities. For the unpolished form, Tininta (CN1501) had the highest TAC and TPC, while Tapol (CN5627) had the highest TFC, DPPH, ABTS, and FRAP antioxidant activities.

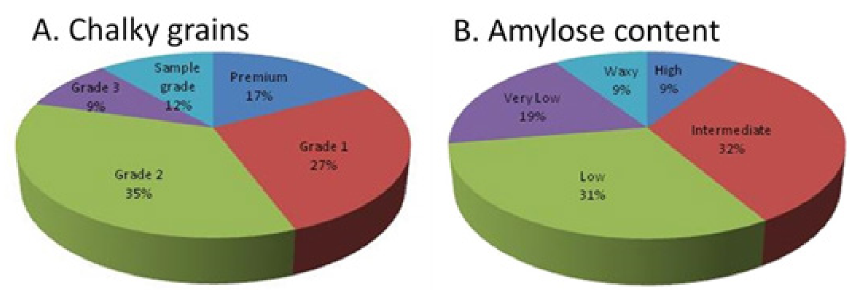

Figure 11. Proportion of 88 pigmented rice accessions at PhilRice genebank in terms of (a) percent chalky grains and (b) amylose classification.

Abbreviations and acronymns

ABA – Abscicic acid
Ac – anther culture
AC – amylose content
AESA – Agro-ecosystems Analysis
AEW – agricultural extension workers
AG – anaerobic germination
AIS – Agricultural Information System
ANOVA – analysis of variance
AON – advance observation nursery
AT – agricultural technologist
AYT – advanced yield trial
BCA – biological control agent
BLB – bacterial leaf blight
BLS – bacterial leaf streak
BPH – brown planthopper
Bo - boron
BR – brown rice
BSWM – Bureau of Soils and Water Management
Ca - Calcium
CARP – Comprehensive Agrarian Reform Program
cav – cavan, usually 50 kg
CBFM – community-based forestry management
CLSU – Central Luzon State University
cm – centimeter
CMS – cystoplasmic male sterile
CP – protein content
CRH – carbonized rice hull
CTRHC – continuous-type rice hull carbonizer
CT – conventional tillage
Cu – copper
DA – Department of Agriculture
DA-RFU – Department of Agriculture-Regional Field Units
DAE – days after emergence
DAS – days after seeding
DAT – days after transplanting
DBMS – database management system
DDTK – disease diagnostic tool kit
DENR – Department of Environment and Natural Resources
DH L– double haploid lines
DRR – drought recovery rate
DS – dry season
DSA - diversity and stress adaptation
DSR – direct seeded rice
DUST – distinctness, uniformity and stability trial
DWSR – direct wet-seeded rice
EGS – early generation screening
EH – early heading
EMBI – effective microorganism-based inoculant
EPI – early panicle initiation
ET – early tillering
FAO – Food and Agriculture Organization
Fe – Iron
FFA – free fatty acid
FFP – farmer's fertilizer practice
FFS – farmers' field school
FGD – focus group discussion
FI – farmer innovator
FSSP – Food Staples Self-sufficiency Plan
g – gram
GAS – golden apple snail
GC – gel consistency
GIS – geographic information system
GHG – greenhouse gas
GLH – green leafhopper
GPS – global positioning system
GQ – grain quality
GUI – graphical user interface
GWS – genomwide selection
GYT – general yield trial
h – hour
ha – hectare
HIP - high inorganic phosphate
HPL – hybrid parental line
I - intermediate
ICIS – International Crop Information System
ICT – information and communication technology
IMO – indigenous microorganism
IF – inorganic fertilizer
INGER - International Network for Genetic Evaluation of Rice
IP – insect pest
IPDTK – insect pest diagnostic tool kit
IPM – Integrated Pest Management
IRRI – International Rice Research Institute
IVC – in vitro culture
IVM – in vitro mutagenesis
IWM – integrated weed management
JICA – Japan International Cooperation Agency
K – potassium
kg – kilogram
KP – knowledge product
KSL – knowledge sharing and learning
LCC – leaf color chart
LDIS – low-cost drip irrigation system
LeD – leaf drying
LeR – leaf rolling
lpa – low phytic acid
LGU – local government unit
LSTD – location specific technology development
m – meter
MAS – marker-assisted selection
MAT – Multi-Adaption Trial
MC – moisture content
MDDST – modified dry direct seeding technique
MET – multi-environment trial
MFE – male fertile environment
MLM – mixed-effects linear model
Mg – magnesium
Mn – Manganese
MDDST – Modified Dry Direct Seeding Technique
MOET – minus one element technique
MR – moderately resistant
MRT – Mobile Rice TeknoKlinik
MSE – male-sterile environment
MT – minimum tillage
$mtha^{-1}$ - metric ton per hectare
MYT – multi-location yield trials
N – nitrogen
NAFC – National Agricultural and Fishery Council
NBS – narrow brown spot
NCT – National Cooperative Testing
NFA – National Food Authority
NGO – non-government organization
NE – natural enemies
NIL – near isogenic line
NM – Nutrient Manager
NOPT – Nutrient Omission Plot Technique
NR – new reagent
NSIC – National Seed Industry Council
NSQCS – National Seed Quality Control Services
OF – organic fertilizer
OFT – on-farm trial
OM – organic matter
ON – observational nursery
OPAg – Office of Provincial Agriculturist
OpAPA – Open Academy for Philippine Agriculture
P – phosphorus
PA – phytic acid
PCR – Polymerase chain reaction
PDW – plant dry weight
PF – participating farmer
PFS – PalayCheck field school
PhilRice – Philippine Rice Research Institute
PhilSCAT – Philippine-Sino Center for Agricultural Technology
PHilMech – Philippine Center for Postharvest Development and Mechanization
PCA – principal component analysis
PI – panicle initiation
PN – pedigree nursery
PRKB – Pinoy Rice Knowledge Bank
PTD – participatory technology development
PYT – preliminary yield trial
QTL – quantitative trait loci
R - resistant
RBB – rice black bug
RCBD – randomized complete block design
RDI – regulated deficit irrigation
RF – rainfed
RP – resource person
RPM – revolution per minute
RQCS – Rice Quality Classification Software
RS4D – Rice Science for Development
RSO – rice sufficiency officer
RFL – Rainfed lowland
RTV – rice tungro virus
RTWG – Rice Technical Working Group
S – sulfur
SACLOB – Sealed Storage Enclosure for Rice Seeds
SALT – Sloping Agricultural Land Technology
SB – sheath blight
SFR – small farm reservoir
SME – small-medium enterprise
SMS – short message service
SN – source nursery
SSNM – site-specific nutrient management
SSR – simple sequence repeat
STK – soil test kit
STR – sequence tandem repeat
SV – seedling vigor
t – ton
TCN – testcross nursery
TCP – technical cooperation project
TGMS – thermo-sensitive genetic male sterile
TN – testcross nursery
TOT – training of trainers
TPR – transplanted rice
TRV – traditional variety
TSS – total soluble solid
UEM – ultra-early maturing
UPLB – University of the Philippines Los Baños
VSU – Visayas State University
WBPH – white-backed planthopper
WEPP – water erosion prediction project
WHC – water holding capacity
WHO – World Health Organization
WS – wet season
WT – weed tolerance
YA – yield advantage
Zn – zinc
ZT – zero tillage

List of Tables

List of Figures

Department of Agriculture
Philippine Rice Research Institute

PhilRice Central Experiment Station; Maligaya, Science City of Muñoz, 3119 Nueva Ecija
Tel: (44) 456-0277 • Direct line/Telefax: (44) 456-0112 • Email: prri.mail@philrice.gov.ph
PhilRice Text Center: 0920-911-1398 • Websites: www.philrice.gov.ph; www.pinoyrice.com

BRANCH STATIONS:

PhilRice Agusan, Basilisa, RTRomualdez, 8611 Agusan del Norte;
Telefax: (85) 343-0768; Tel: 343-0534; 343-0778; Email: agusan.station@philrice.gov.ph
PhilRice Batac, MMSU Campus, Batac City, 2906 Ilocos Norte;
Telefax: (77) 772- 0654; 670-1867; Tel: 667-1508; Email: batac.station@philrice.gov.ph
PhilRice Bicol, Batang, Ligao City, 4504 Albay; Tel: (52) 284-4860; Mobile: 0918-946-7439 ;
Email: bicol.station@philrice.gov.ph
PhilRice Isabela, Malasin, San Mateo, 3318 Isabela; Mobile: 0908-895-7796; 0915-765-2105;
Email: isabela.station@philrice.gov.ph
PhilRice Los Baños, UPLB Campus, Los Baños, 4030 Laguna; Tel: (49) 536-8620; 501-1917;
Mobile: 0920-911-1420; Email: losbanos@philrice.gov.ph
PhilRice Midsayap, Bual Norte, Midsayap, 9410 North Cotabato;
Tel: (64) 229-8178; 229-7241 to 43; Email: midsayap.station@philrice.gov.ph
PhilRice Negros, Cansilayan, Murcia, 6129 Negros Occidental;
Mobile: 0932-850-1531; 0915-349-0142; Email: negros.station@philrice.gov.ph
PhilRice Field Office, CMU Campus, Maramag, 8714 Bukidnon;
Mobile: 0916-367-6086; 0909-822-9813
Liaison Office, 3rd Floor, ATI Bldg, Elliptical Road, Diliman, Quezon City; Tel: (02) 920-5129

SATELLITE STATIONS:

Mindoro Satellite Station, Alacaak, Sta. Cruz, 5105 Occidental Mindoro; Mobile: 0908-104-0855
Samar Satellite Station, UEP Campus, Catarman, 6400 Northern Samar; Mobile: 0948-800-5284