2022 PhilRice R&D Highlights

Rice Chemistry and Food Science Division

Philippine Rice Research Institute
Central Experiment Station
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DIVISION

Rice Chemistry and Food Science Division

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EXECUTIVE SUMMARY

The Rice Chemistry and Food Science Division (RCFSD) supports the goal of increasing the productivity and profitability of rice-farming systems by determining grain quality (GQ) characteristics of rice, developing technologies for other uses of rice and its by-products, and promoting these high-quality and value-added products to benefit consumers, farmers, and food manufacturers. It conducts the GQ evaluation of rice under the Institute's varietal development program, develops analytical methods for the efficient and accurate determination of rice grain properties for various stakeholders, and provides quality analytical services in support of the development of appropriate and best technologies for Filipino farmers. The RCFSD contributes to the outcomes of the Institute under its Strategic Plan 2017-2022.

In 2022, RCFSD implemented four core-funded, one RCEF-funded, and one extra core-funded projects. The first core-funded project aimed to provide faster and reliable data on rice GQ characteristics to assist breeders in developing high-yielding inbred and hybrid rice varieties and generate GQ descriptors of the PhilRice germplasm collections/accessions. There were 1,698 rice samples evaluated for GQ as requested by breeders and other researchers. The Division also provided the much-needed GQ data for NCT promising lines under a Rice Competitiveness Enhancement Fund (RCEF)-funded component project.

The second core project focused on the evaluation of nutrition, health, and wellness potentials of Philippine rice and rice-based crops. Local rice varieties were explored for their starch digestibility and in vitro glycemic indices (GI) in the quest to determine varieties with reduced GI for diabetes prevention. Fermented rice bran (FRB) from several varieties, including red and black rice samples, were tested for their anti-adipogenic potential as a means to address the increasing prevalence of overweight and obesity in the country. Food products enriched with FRB were developed and tested. Market surveys were conducted for foods with low GI and FRB-supplemented food products to provide insights into developing interventions, such as rice and rice-based products, for the management of non-communicable diseases and health promotion among

target populations. The third core-funded project was implemented to fast-track the evaluation of GQ parameters through rapid and reliable methods of GQ evaluation and more efficient modes of data acquisition and processing. The near-infrared reflectance spectrophotometer (NIRS) was continuously validated for physicochemical properties determination (moisture/amylose content (AC)/ protein contents, and alkali-spreading value) for subsequent routine use.

The prototype of the Rice ICT-based Sensory System (RISS) for rice and rice-based food products sensory analysis has been developed to automate sensory evaluation data acquisition. Moreover, the Rapid Visco Analyzer was optimized for evaluating the pasting properties and gelatinization temperature of rice for future use in routine testing. Finally, a database of grain quality covering 325 rice varieties approved for commercial release from 1990 to 2022 was developed using data from the NCT.

The last core-funded project supports all these research projects of RCFSD and other PhilRice research divisions by ensuring the generation of quality laboratory outputs. Through this project, some operations and processes of all PhilRice research laboratories have been centralized toward a harmonized and unified laboratory management system. This will improve efficiency and promote cost-effectiveness in the Central Experiment Station.

One extra-core funded project was implemented by the Division in partnership with the International Rice Research Institute (IRRI), which aimed to contribute to developing healthier rice varieties by identifying the characteristics of rice samples with low GI and high antioxidant activity to be used as donor lines for hybridization with other high-yielding and high-quality rice varieties.

CORE-FUNDED PROJECT 1

Centralized Screening for Grain Quality and Health-promoting Properties of Rice

Evelyn H. Bandonill, Amelia V. Morales, Raffy B. Rodriguez, Lynnden C. Lucas, Jenina Patria S. Villar, Rommel D. Camus, Victor M. Mata, Tolentino S. Rivera, Oliver C. Soco, Manuelito B. Anday, and Marissa V. Romero

This project continued to support the development of high-yielding rice varieties for inbred and hybrid breeding, as well as generated GQ descriptors of the PhilRice germplasm collections/accessions through GQ screening. There were 559 pre-National Cooperative Tests (NCT) lines and other rice samples received from the Genetic Resources Division (GRD) and Plant Breeding and

Biotechnology Division (PBBD) and harvested from 2021 dry season (DS) and wet seasons (WS) and 2022 DS that were evaluated for GQ and other parameters. The samples came from the following groups: Lake Sebu, South (10 entries), rainfed lowland/adverse environment (248 and 50), irrigated lowland direct-seeded rice (72), Benguet State University (12), and irrigated lowland mutation breeding (167). From the 559 samples assessed, 117 entries exhibiting good GQ were identified and recommended to the breeders for further trials, which will help in their selection process.

Moreover, from the 705 rice germplasm collections/accessions received for GQ evaluation, 269 met the preferred intermediate classification for AC as non-glutinous/table rice and 15 entries as waxy rice; 275 samples obtained the preferred intermediate classification for GT. Among the non-waxy samples, 105 rice germplasm had intermediate AC and GT. This also led to the submission of available GQ data of 705 samples in the Germplasm Management System (GeMS) that maximized the utilization of materials and information for breeding and other purposes.

Lastly, only 34 of the 434 advanced Cytoplasmic Male Sterility (CMS)-based parental lines from 2021 WS and 2022 DS received for evaluation were identified and recommended to the breeders for hybrid rice selection and further trials. However, 68 advanced CMS-based parental lines were projected to have tender cooked rice texture. These results contributed to the desired outcome of the project, which is enhanced breeding with excellent GQ, as well as enhanced delivery of GQ data to its target users.

CORE-FUNDED PROJECT 2

Nutrition, Health, and Wellness Potentials of Philippine Rice and Rice-based Crops

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This project evaluated local rice and rice-based crops and their by-products as potential sources of nutrition, health, and wellness for consumers. Consumer knowledge, attitude, and practices (KAP) on fermented products were determined. Food products with the potential to be incorporated with fermented rice bran (FRB) were identified, namely, native delicacies, bakery products, and beverages; and insights on developing interventions for rice and rice-based products were provided. Results showed that rice in polished form remains the

main source of carbohydrates in every meal of 10 to 40-year-old consumers. The majority of the 236 respondents had high awareness level on unpolished rice and rice products, but only 17% of them reported buying and consuming unpolished rice due to its limited market availability. Furthermore, most of the respondents were not aware of FRB and its health benefits. However, they were willing to buy native delicacies (with binagol, suman-latik, and bibingka as the prevalent responses), bakery products (pan de sal, loaf bread, and cookies), and beverages incorporated or enriched with FRB if these are made available in the market, due mainly to the products' healthfulness and delectability. These results can be used by product developers, potential technology adopters, and other stakeholders for FRB-incorporated native delicacies, bakery products, and beverages.

Information on the GI and starch digestibility of common rice varieties is needed to provide guidance on varieties available for consumers that have reduced GI and can be potential materials for the development of reduced-GI rice-based food products for disease prevention. RCEF varieties were screened for their in vitro GI; their physicochemical properties and pasting profile were assessed to determine the variation in in vitro GI in relation to these properties. All cooked non-pigmented rice samples had low resistant starch (RS) content ranging from 0.05-0.68%. These samples recorded moderate to high in vitro GI values (64.3-69.2). Rice with higher AC tends to have higher RS and lower in vitro GI; AC and RS also displayed a positive association. Three samples, including one red and one black rice, were chosen for the evaluation of in vivo GI and glycemic load. They had low RS content but with moderate in vitro GI, intermediate to high AC, and intermediate to low GT. Their amylopectin, available carbohydrate, dietary fiber and nutritional contents, and antioxidant activities were likewise measured. Clinical trials are being conducted at the University of the Philippines-Diliman.

The health-promoting properties of FRB were evaluated and FRB was tested in the development of innovative food products. Extracts of FRB of red Dinorado and black Ominio, which displayed high antioxidant activities, were assayed for their cytotoxicity. Results suggested that the non-toxic doses of both extracts were within 0.5-1mg/mL and 1-2mg/mL, respectively. The FRB extracts also exhibited antiadipogenic activity by suppressing fat accumulation via Oil Red O Assay. Lastly, to determine the mechanism underlying the anti-adipogenesis of the FRB extracts from black rice, expression levels of genes related to lipid metabolism were measured using RT qPCR. Upregulation was observed inC/EBP-beta and UCP1 or PPAR-alpha, while PPAR-gamma, AP2, Adiponectin, FAS, UCP1 or PPARalpha, and SREBP-1c gene were downregulated. Results suggest that the FRB extracts significantly decreased the activity of the mediator gene PPAR-gamma; thus, suppressing adipogenesis and lipid accumulation.

Two FRB-enriched functional foods, namely, scoop-type buffalo milk-based yogurt and salt bread, commonly known as pan de sal, were developed. Their

sensory acceptability generally decreased as more FRB powder was added. The products' microbial loads, measured in lactic acid bacteria count, aerobic plate count, and yeast count, were within acceptable limits for consumption and no coliform, *E. coli*, mold, or yeast were detected. The addition of a suitable amount of black and red FRB (2.5-5% for salt bread and 1-2% for scoop-type yogurt) enhanced the phytochemical content and antioxidant activity and slightly increased the dietary fiber, protein, and mineral contents without affecting their sensory characteristics.

CORE-FUNDED PROJECT 3

Research on rice quality and safety

Henry M. Corpuz, Evelyn H. Bandonill, Marissa V. Romero, Rosaly V. Manaois, Henry F. Mamucod, Rodel M. Bulatao, Jenina Patria S. Villar, Gerome A. Corpuz, Lynnden C. Lucas, Ezra Spencer M. Delim, Bernando S. Peralta, Ivan Jon V. Balmeo, and Katrina Ann A. Carurucan

Grain quality (GQ) is one of the major target traits in rice breeding programs besides yield and resistance to various pests and diseases. GQ ensures the availability of high-quality rice desired by farmers, seed producers, millers, consumers, and food industries. Rice GQ is evaluated based on milling recovery, physical attributes, physicochemical properties, and sensory characteristics. The cooking and eating quality of rice is mainly determined by its starch physicochemical properties such as amylose content (AC), alkali-spreading value (ASV), gelatinization temperature (GT), protein content (PC), and gel consistency. There is a need to automate and improve the conventional methods of determining rice sensory quality and physicochemical properties to fast-track the delivery of GQ data useful for the breeding program and other stakeholders.

Near-infrared reflectance spectroscopy (NIRS)-based prediction models were developed using diverse rice samples from approved varieties and elite lines (n= 739–985) to speed up the determination of rice physicochemical properties. Good calibration models were established for both milled rice and flour sets. The high coefficient of determination of prediction, and RPD, and standard error of prediction (SEP) scores and low SEP values obtained from the internal validation further confirmed the good predictive capacities of the milled rice and flour-based calibration models for moisture content (MC), crude protein content (PC), amylose content (AC) and alkali-spreading value (ASV).

Rice ICT-based Sensory Evaluation System (RISS) was developed to automate and digitalize the tedious paper-based sensory evaluation data collection and analysis. Eight units of computer terminals, powered by an NComputing device, were installed at the Division's Sensory Evaluation Room. The system

was pilot-tested and refined to improve its performance. RISS provides several advantages over the traditional sensory evaluation method.

The previously optimized RVA-based method for rice pasting properties analysis was further validated using 74 NCT rice lines (2021 WS). The pasting profile of the rice lines was evaluated and correlated with physicochemical properties, including AC, GT, Instron cooked rice hardness, and PC. AC was strongly and positively correlated with setback, suggesting that low-AC rices have a lower tendency to retrograde.

Quantitative measurement of rice gelatinization temperature using the RVA method was validated using 53 rice varieties. Method validation results showed that the GT values obtained from RVA and conventional methods were statistically comparable. This suggests that the RVA-based method can be used as a reliable alternative to the traditional method, which is subjective and does not provide the exact GT of starch.

The RCFSD has generated voluminous GQ data of all Philippine rice varieties and breeding lines submitted by various breeding institutions. To make the data available and accessible, the GQ information of varieties approved for commercial release from 1990 to 2022 was gathered, organized, and consolidated to create the database. All available data on milling recovery, physical attributes, physicochemical properties, cooking parameters, Instron hardness, laboratory sensory description, and sensory acceptability of 359 approved rice varieties (from PSB Rc 1 to NSIC 2022 Rc 686) were included in the database. In summary, the availability of modernized and automated rice GQ assessment methods (e.g., NIRS, RVA, and RISS) and accessible GQ information will help improve the local breeding program and ensure the availability of high-yielding varieties with excellent grain quality.

CORE-FUNDED PROJECT 4

Centralized Laboratory Management

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This project ensured that research laboratories of PhilRice produce quality outputs for the achievement of its targets on developing high-yielding and cost-reducing technologies. Several laboratory operations and processes have been centralized and harmonized. Critical laboratory equipment, instruments, and devices (EIDs) in all research laboratories were calibrated based on their calibration plans. Preventive maintenance of some lab EIDs was also conducted.

To sharpen the skills and competitiveness of laboratory personnel, they joined in-house training courses on basic operation and troubleshooting of newly acquired equipment and one calibration training on balances and enclosures organized by RCFSD. Attendance of lab personnel in external webinars and training courses was also facilitated, particularly those covering laboratory-related topics.

The Central Chemical Storage Building, equipped with a state-of-the-art smoke detector and CO2 fire suppression system, has been fully operationalized. The building houses all the chemicals including PNP- and PDEA-controlled chemicals used by five research divisions. Compliance with national and local regulations and requirements of the DA was ensured. The development of DA's 5-year National Strategic Development Plan (NSDP) was actively participated in and information was provided to the DA for its plans to rationalize and strengthen lab services. The ASPPD soils laboratory has been granted its License to Operate effective September 15, 2022–September 15, 2025. A prototype of the centralized laboratory inventory system was developed to become the database of available chemicals in each division and will be accessible by authorized personnel. In fulfillment of the Institute's corporate social responsibility, the laboratories accommodated and conducted selected laboratory analyses from internal and external clients, such as students, based on Institute guidelines.

RCEF-FUNDED PROJECT 1

Grain Quality Evaluation of NCT Rice Lines and Check Varieties

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The Grain Quality evaluation component of the National Cooperative Testing (NCT) Project continued to support the rice varietal improvement program by providing the grain quality data needed for recommendation of new rice varieties, aside from yield performance, agronomic characteristics, insect pest and disease resistance tests. To realize the objective of identifying promising lines for possible recommendation as rice variety, 207 and 166 entries from the 2021 WS and 2022 DS, respectively, were evaluated in terms of milling recovery, physical attributes, physicochemical and health-promoting properties, Instron hardness, cooking and eating quality. Of the WS entries, 106, 7, and 146 promising lines passed the standards for milling, physical, and physicochemical properties, respectively, wherein 54 lines passed all the GQ standards except for chalky

grains. Health-promoting properties of Special Purpose-Pigmented samples ranged 21.8-28.60mg C3GE/kg for total anthocyanin content (TAC) of the red-colored entries and 285.25 - 541.82 mg C3GE/kg for the black entries, 0.99-2.49mg GAE/g for total phenolic content (TPC) and 0.99-3.14mg/g for DPPH radical scavenging activity (DPPH). Of the DS entries, 72 had good milling recovery (MR), 14 had acceptable physical attributes, while 87 entries obtained AC-Gelatinization Temperature (GT) combination with predicted tender to slightly tender cooked rice; 54 entries had good grain quality.

EXTRA-CORE PROJECT 1

OneRicePH Module 4. Development of Rice with Low Glycemic Index (GI) and High Antioxidant Activity for Healthier Rice Niche Markets

Marissa V. Romero, Henry M. Corpuz, Evelyn H. Bandonill, Jenina Patria S. Villar, Ezra Spencer M. Delim, Bernando S. Peralta, and Tolentino S. Rivera

Increased consumption of processed food, including polished white rice, with high GI and low dietary fiber (DF) content, compounded by an increasingly sedentary lifestyle, has led to the elevated incidence of cardiovascular diseases, type 2 diabetes (T2D), and some forms of cancer. To help address these health concerns, this project aims to lower the GI content in white rice while maintaining the intermediate amylose level and changing other compositions such as antioxidant components, increasing moderate resistant starch and DF content without significantly altering its palatability. In addition, donor lines/rice varieties with low GI as well as with high antioxidants and anti-cancer potential were screened and identified.

There were 27 varieties with amylose content of 22.1% and above identified and obtained from PhiRice's Plant Breeding and Biotechnology Division and Genetic Resources Division. Six varieties were evaluated comprehensively for GQ and pasting properties and were submitted to IRRI for in-vitro GI screening; 21 samples were for SNP analysis. Two low/medium-GI donor lines were received from IRRI to be utilized in the development of chao fan and rice noodles prior to validation through in vivo GI test. Characterization of the physical quality, physicochemical, pasting, and sensory properties and hot water-soluble and insoluble blue value of the samples showed that the donor lines had medium to long and intermediate length and shape, intermediate to high amylose content, low GT; these also had slightly glossy to dull, separated, slightly smooth to rough,

and slightly tender to hard cooked rice. Their pasting properties showed that peak viscosity, breakdown, final viscosity, and setback generally characterize high-amylose rices.

Meanwhile, the top 50 pigmented rice varieties with the highest health-promoting properties were identified from previous data based on phytochemical and antioxidant properties. From which, the available 10 varieties composed of 5 red and 5 black rice were evaluated for their phenolic (0.59-3.7mg GAE/g), flavonoid (0.61-4.72mg RHE/g), and anthocyanin content (39.16-3257.14mg C3GE/kg) as well as total antioxidants as DPPH (0.72-5.16mg TE/g). Four of these pigmented rice samples (red Chor-chor-os, Dinorado, black Ominio, and Ballatinaw) were collected from Cotabato and Mt. Province.