2023 PhilRice R&D Highlights

RICE CHEMISTRY AND FOOD SCIENCE DIVISION

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Rice Chemistry and Food Science Division (RCFSD)

Henry M. Corpuz

EXECUTIVE SUMMARY

The Division supports the goal of increasing the productivity and profitability of rice-farming systems by determining grain quality (GQ) characteristics of rice, developing technologies on 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's new Strategic Plan 2023-2028, specifically on improving the productivity and income of rice farming communities (Outcome 1), and ensuring the availability and accessibility of affordable, safe, and nutritious rice for Filipino consumers (Outcome 2), and maintaining stable rice supply in the country (Outcome 3).

In 2023, 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 1,032 pre-NCT rice lines and genebank rice accessions evaluated for GQ based on the traits requested by breeders and other researchers. RCFSD also provided relevant GQ data of NCT promising lines under an RCEF-funded component project.

The second and third core projects focused on RCFSD's rice-based food product activities and primarily contributed to the attainment of outcomes 1 and 2. Project 2 delved into the value-addition of rice by developing and promoting rice-based food products to farming communities and target consumers for nutritional and health improvement and income generation. In this project, two groups of micro-, small, and medium-sized enterprises (MSMEs) and farmers' cooperatives/associations were assisted and capacitated on product

development and improvement, food packaging and labeling, and marketing strategies. Meanwhile, Project 3 concentrated on scaling up and commercializing nutritious and rice-based functional food products with income-generating potential. The technology and commercialization readiness levels of four rice-based food products (PhilRice Tapuy, Nutri Rice Milk, dried germinated brown rice, and fermented rice bran (FRB)-enriched food products) were re-assessed. A market survey and feasibility study were also conducted to determine consumer acceptability, marketability, and profitability of these priority products.

The fourth core-funded project was implemented to advance and expedite the assessment of consumer-preferred GQ properties through the development of fast and reliable methods using smart and digital technologies. The project also aimed to develop a web-based data management system to streamline the storage and accessibility of important rice grain quality information. The performance of the RVA-based method for rice gelatinization temperature analysis was validated using 146 rice samples. The Rice ICT-Based Sensory System (RISS) for rice and rice-based food products sensory evaluation was upgraded to extend the system's running time, improve the graphic design, and create an anchor for each sensory attribute. A smartphone-assisted application was developed using a machine learning algorithm to automate rice grain size and shape measurements. This innovation significantly improved the data collection process by reducing the analysis time from 10 to 2 minutes compared to the manual and caliper-based method. Lastly, the Rice Grain Quality Information System (RGQIS) was developed to consolidate, digitalize, and systemize the management of all rice grain quality data for future breeding activities.

One extra-core funded project was implemented by the Division in 2023. Implemented in partnership with the International Rice Research Institute and the University of the Philippines-Los Baños, this project aims to alleviate the increasing incidence of diabetes and cancer in the country by identifying and developing consumer-driven healthier rice with low glycemic index and high antioxidant activity.

RCF-231-000: Grain Quality and Health-promoting Properties of Rice

Evelyn H. Bandonill

This project aimed to enhance breeding and genebank operations and support the development of high-yielding rice varieties through the assessment of the grain quality and health-promoting properties of rice and rice varieties. It also hoped to increase the value of rice for better health in the future, advance rice science and technology, and enhance research capacity at PhilRice by evaluating the glycemic index (GI) and glycemic load (GL) of rice. Thus, out of the 522 pre-NCT rice lines and other rice samples from 2022 wet season (WS) and 2023 dry season (DS) received for grain quality evaluation, 42 entries exhibiting good grain quality were identified and recommended to the breeders which will help in their selection process. Meanwhile, from the 510 rice germplasm collections/accessions stored at PhilRice genebank, 288 met the preferred intermediate classification for amylose content (AC) and 117 for gelatinization temperature (GT) where 64 germplasm had both intermediate AC and GT, which were predicted to have good eating quality. In addition, four promising advanced CMS-based parentals were identified from the six samples submitted for complete GQ evaluation.

Understanding the glycemic index (GI) and other relevant characteristics of local rice varieties is crucial. This information will help consumers identify varieties with reduced GI, which can be valuable for developing rice-based food products aimed at disease prevention. Evaluation of 12 rice varieties for their in vitro GI and physicochemical and pasting properties showed that all milled rice samples exhibited medium in vitro GI (60.4-69.7) when cooked to obtain the soft texture preferred by Filipino consumers, as measured using an Instron® texture analyzer. Correlation analysis suggests that rice with higher AC tends to have higher resistant starch and lower in vitro GI when cooked to the desired soft texture. Furthermore, varieties that absorb less water while cooking (lower peak viscosity) have less cooked rice turning into paste (lower breakdown viscosity), making them potentially less susceptible to digestion (lower in vitro GI).

Additionally, cooked milled rice that becomes firmer upon cooling (higher setback and final viscosities) tends to have lower in vitro GI. Clinical feeding trials involving ten human participants at the UP-Diliman which assessed the glycemic index and glycemic load of one polished white rice and two unpolished pigmented rice varieties also determined the optimum cooking and serving size based on available carbohydrates for each sample. Other relevant characteristics of the samples, such as physicochemical and antioxidant properties, were also recorded.

Furthermore, DNA fingerprinting confirmed the genetic similarity of black rice to PhilRice Genebank accession numbers 15634 and 15990. Feeding trials for the two unpolished pigmented rice have been completed, and a makeup session for white rice is scheduled for 2024, pending approval of the application for an extension of the ethical clearance from the National Ethics Committee.

Meanwhile, the impact of varying levels of NPK fertilizers on the grain quality of five irrigated lowland rice varieties: NSIC Rc 436, Rc 438, Rc 440, Rc 442, and Rc 580 was determined in their 2023 dry season data. The varieties grown at PhilRice CES under continuous flooding conditions showed the following effects: (1) Rc 436: High NPK levels at full (F1) and half (F2) rates enhanced the whiteness of raw and cooked milled rice (MR), with F1 increasing MR size and F2 reducing broken grains; (2) Rc 438: Low NPK at half rate (F4) yielded the best head rice (HR) recovery while F2 produced MR with better cooking and eating qualities; (3) Rc 440: Low NPK at full rate (F3) improved HR yield and whiteness and eating quality of MR. F1 increased HR recovery while F4 enhanced MR whiteness and shortened its cooking time; (4) Rc 442: F1 raised HR yield while maintaining acceptable protein levels and eating quality of MR; (5) Rc 580: F1 enhanced HR recovery, protein levels, and cooking parameters of MR. F3 could best enhance the tenderness and smoothness of cooked MR. During the 2023 wet season, milling potentials of the same varieties were collected. Data processing and analysis, along with the determination of other parameters for the wet season samples, are underway.

RCF-232-000: Consumer-driven Rice-based Products for Farming Communities and Micro-to-small-scale Enterprises

Riza G. Abilgos-Ramos

This project wants to elevate the productivity of rice-farming communities and micro-to-small-scale enterprises by developing and promoting client-focused and nutritious rice-based products. Specifically, the project aimed to develop rice-based products based on the needs of MSMEs and farmers' cooperatives/associations and capacitate their members in processing and marketing their products. In this project, rice-based products were identified for improvement, and farming cooperatives were trained and assisted in terms of product development, food packaging, labeling, and marketing.

Secondary data on local rice-based food products were collected from books, brochures, and the web, including product names, origins, descriptions, cultural

significance, preparation status, status, and pictures. These products were categorized based on their family. Two chip products (rice cracker and rice kropek) of Baclay Agrarian Reform Beneficiaries Cooperative (BARBC), a Rice Business Innovations System (RiceBIS) cooperative in Milagros, Masbate were identified for improvement in terms of product packaging, labeling, and marketing. A site visit was conducted by the PhilRice team and representatives from the Department of Trade and Industry/Science and Technology in Masbate to document the processing of rice-based chips, provide feedback for product improvement and to identify the assistance that can be extended to the cooperative.

Nineteen members (5 women) of the Asosasyon ng Magsasaka para sa Pangkabuhayan, Pang-kaalaman, at Agriturismo (AMPPA) participated in the black rice brew production training hosted by K.D. Nature's Farm and DTI-Nueva Ecija. The training provided them with additional knowledge about food processing and value addition. The content of the guidebook titled "Food Developers Guide on Processing and Marketing Rice and Rice-Based Products" was finalized to provide and equip the target readers and users with information on safe food handling, processing, Good Manufacturing Practices (GMP), and marketing.

RCF-233-000: Consumer-driven Products for Rice-based Enterprises to Help Increase Income of Farmers in Support of Rice R4D

Henry F. Mamucod

The project was implemented to improve and commercialize RCFSD-developed high-quality and nutritious products, which in turn increase farmers' income and improve the health and nutrition of consumers. Specifically, it assessed and validated the technologies, identified issues and gaps associated with production and quality, and provided necessary interventions, opportunities, and strategies to address issues on technology transfer and commercialization.

The technology and commercialization readiness levels (TRL and CRL) of four rice-based food products PhilRice Tapuy, Nutri Rice Milk, dried germinated brown rice, and fermented rice bran (FRB) were assessed using two protocols. For Tapuy, the process of preparing laboratory-prepared starter culture (bubod) was validated using known strain, concentration, and ratio of yeast. The efficiency of bubod in producing quality rice wine was evaluated using the existing production process. Also, a feasibility study was conducted to determine the viability of Tapuy for upscale production. Furthermore, in order to generate new information on the

current local production and demand of rice wine, market surveys with seven rice wine producers were conducted. Information on the production (type, volume), marketing (distribution, segmentation, price, strategy), financial (starting capital, cost of production per batch), and organization (type of business, number of employees) aspects were gathered.

Fermented rice bran (FRB) and stabilized rice bran (SRB) were utilized to enrich the nutritional quality of buffalo milk-based (BMB) yogurt products. BMB yogurt enriched with FRB, BMB scoop-type, and yogurt drink co-fermented with SRB were developed, characterized, and upscaled in partnership with the Philippine Carabao Center at CLSU. Incorporation of FRB and co-fermentation of SRB significantly improved the phytochemical content, antioxidant activity, and nutritional value of the BMB yogurt products with sensory qualities comparable to the control. Moreover, the developed products were considered safe to consume due to the acceptable microbial count and absence of pathogenic bacteria. Market research was also conducted in Negros Occidental in collaboration with Northern Negros State College of Science and Technology to assess the marketability and profitability of BMB yogurt products. Information on the determinants of consumers' purchase intention towards these products (n=198) and their viability for commercialization (n=384) were generated. Age, household size, taste and flavor, and willingness to pay were identified as positive predictors, while family size was recognized as negative predictors. The consumers are willing to buy the product at PhP33.12 per 100-g cup, with monthly potential market demand of 24,760 cups. The project investment can be recovered in three years.

RCF-234-000: Modernized Rice Quality Assessments for the Development of High-yielding, Climate-resilient, and High-quality and Nutritious Rice

Henry M. Corpuz

Rice breeding programs in the Philippines are geared toward developing high-yielding, climate-resilient, disease-resistant, and nutritious rice varieties with consumer-preferred grain qualities to ensure food security and address the threat of climate change. Consumer acceptability of rice is dictated by the grain quality characteristics, which are categorized into milling recovery, physical attributes, physicochemical properties, cooking, and sensory qualities. Rice quality parameters are commonly determined through visual inspections and manual measurements. However, these approaches are time-consuming, subjective, prone to human error, and require enormous resources (e.g., labor,

time, and supplies). Hence, this project sought to modernize and automate the existing conventional methods to provide fast, real-time, high-throughput, and reliable provision of grain quality data useful for the breeding program and other stakeholders.

An RVA-based method (AACC Method 61-04.01) of determining rice gelatinization temperature (GT) was validated using 146 rice lines (2022 WS). The samples were processed and evaluated for GT using the RVA and NCT (alkali-spreading value) methods. The GT data obtained from both methods were statistically comparable. Thus, the RVA-based method is considered a good alternative analytical method because it provides actual and more accurate GT results than the NCT protocol, which is subjective and relies only on temperature range. The RVA-based method can be used to further distinguish rice samples that fall within the same GT classification.

RISS is an automated sensory evaluation system designed to provide an alternative to the tedious paper-based conventional method. The initial prototype was upgraded and tested to further improve its performance in analyzing the sensory characteristics of rice and rice-based food products. The running and idle times were extended from 1 to 9h to give the user ample time to finish the whole sensory evaluation process. In addition, graphics (e.g., font size and style) were also improved for readability.

Using a machine-learning algorithm, a smartphone-assisted application (app) was developed to automate rice grain size and shape measurements. This innovation significantly expedites the process, reducing measurement time from 10 to 2 minutes compared to the traditional caliper method. The app and a specially designed smartphone/tablet platform ensure precise measurements of rice grain dimensions. This setup enhances time efficiency, eliminates manual recording errors, conserves resources, and facilitates efficient data management. Performance test showed that the smartphone-assisted app gave a 98% accuracy in predicting unknown samples' (n=146) grain size and shape. This high level of accuracy amplifies the effectiveness and reliability of the developed app, especially when compared to traditional caliper-based measurements.

A web-based information system was created to organize and summarize comprehensive rice GQ information, including physical characteristics, milling properties, physicochemical attributes, cooking parameters, and sensory attributes among other interests. This consolidation aimed to create an online database and information system for storing, managing, accessing, and visualizing important data and trends related to grain quality. An analytical dashboard was established specifically to examine and understand data related to the quality of rice grains.

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 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 expedite identifying promising lines for possible recommendation as rice variety, the 215 entries from the 2022 wet season (WS) cropping were evaluated in terms of milling recovery, physical attributes, physicochemical and health-promoting properties, Instron hardness, cooking and eating quality. Promising lines, totalling 93, 7, and 94, passed the standards for milling, physical, and physicochemical properties, respectively; 58 promising lines passed all the GQ standards except for chalky grains. For the 197 2023 dry season (DS) entries evaluated for the various GQ parameters, 29 entries had good MR, 4 had acceptable PA, while 74 entries obtained the Amylose Content (AC)-Gelatinization Temperature (GT) combination with predicted tender to slightly tender cooked rice texture; 19 entries had good grain quality. In 2023, 30 2022 WS and 20 2023 DS promising lines were deliberated on-of which 3 rainfed lowland dry-seeded, 2 special-purpose pigmented, 11 hybrid, and 2 MAT entries were recommended as varieties for commercial release.

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, Baby Lymie D. Rosales, Mary Michelle M. Velasquez, Bernando S. Peralta, and Tolentino S. Rivera

Non-communicable diseases (NCDs) are the leading causes of death in the Philippines, bannered by coronary heart diseases, cancers, cerebrovascular diseases (e.g., stroke, aneurysm), and diabetes. Consumption of unhealthy diets (e.g., refined grains, processed foods, and sugary drinks) and physical inactivity are key risk factors in increasing NCDs. Since rice is the staple food of Filipinos,

breeding healthier rice with low GI and high antioxidants would be a sustainable, diet-based, and cost-effective strategy to manage the risks of NCDs.

In 2023, 71 approved rice varieties requested from PBBD and GRD of PhilRice were characterized for GQ and other physicochemical analyses. The following results were obtained: AC (12.2-27.3%), GC (26-100mm), breakdown (48.4-216.4), final viscosity (261.7-549.7), setback (102.4-258.5), HWS value (0.0114-0.3889), and HWI value (0.0904-0.2151). Of the 71 varieties, 69 available rice samples were submitted to IRRI for in vitro GI analysis, while 44 samples with minimal amount were seed-increased. Their RVA pasting profile and physicochemical properties were also evaluated. Furthermore, six PhilRice staff were capacitated on in vitro GI determination through briefing and hands-on demonstration.

The two low/medium-GI donors (IRRI 147 and IRRI 162) were used in the preparation of Chinese-style pork chao fan. The developed products were compared with a commercial chao fan through sensory evaluation. The products obtained moderate to very much liking in terms of aroma, overall appearance, color, separation/looseness of grains, taste/flavor, texture, and overall acceptability while the commercial chao fan had slight to moderate liking. Ranking them resulted in the following order: IRRI 162 (first), IRRI 147 (second), commercial chao fan (third). Furthermore, the initial shelf-life of chao fan using the low-GI donor line (IRRI 147) was evaluated. Further improvement of ready-to-eat forms of chao fan and final shelf-life evaluation are underway while appropriate packaging materials are being tested.

Meanwhile, 14 pigmented rice varieties were collected from various provinces and were evaluated for their L* a* b* color values, phytochemical contents, and antioxidant properties. Four forms (A: unpolished/raw; B: polished/raw; C: unpolished/cooked; and D: polished/cooked) of each rice sample were processed to determine the effects of polishing and cooking on the said parameters. Forms A of Dinorado red rice and Ominio and Ballatinaw black rices contained the highest phenolic contents and DPPH radical scavenging activity. Ethanolic extracts were prepared for analysis of their anti-proliferative activity against A549 human lung cancer cells and MRC5 human normal lung fibroblasts. Their potency was quantified and reported as half maximal inhibition concentration (IC50, mg/L). MTT assays revealed that only the unpolished forms A and C had significant effects on the proliferation of cancer cells. Form A of the black rice extracts both showed anti-proliferative effects on A549 cells (IC50: 200-300mg/L and 700-800mg/L, respectively) without compromising MRC5 normal cells (IC50: ~1000mg/L). On the other hand, form A of Dinorado extract inhibited the proliferation of A549 cells at IC50: 600-700mg/L and MRC5 cells at IC50: 700-800mg/L.