Department of Agriculture

PHILRICE®

PHILIPPINE RICE RESEARCH INSTITUTE

2021

DA-PHILRICE R&D HIGHLIGHTS

RICE CHEMISTRY & FOOD SCIENCE DIVISION

Content

DIVISION

Rice Chemistry & Food Science Division

Rosaly V. Manaois

EXECUTIVE SUMMARY

The Rice Chemistry and Food Science Division (RCFSD) helps increase 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 evaluates grain quality 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 to support the development of appropriate and best technologies for Filipino farmers.

The Division contributes to the strategic outcomes of the Institute, mainly on increased productivity, cost-effectiveness, and profitability of rice farming in a sustainable manner (Outcome 1); enhanced value, availability, and utilization of rice diversified rice-based farming products, and by-products for better quality, safety, health, nutrition and income (Outcome 3); and advanced rice science and technology as continuing sources of growth (Outcome 5).

RCFSD implemented four core-funded and three extra-core-funded projects. Centralized screening for grain quality and health-promoting properties of rice, aimed to provide faster and more reliable data on rice grain quality characteristics. Through this project, the RCFSD performed its core function, which is evaluating the grain quality characteristics of early generation breeding lines to assist breeders in screening rice lines for advanced trials.

This year, a maximum of 1,936 samples were evaluated for GQ as requested by breeders and other researchers from 2,006 rice samples received for analysis. The generated data helped breeders in the early selection of rice lines with desired traits depending on

EXECUTIVE SUMMARY

their breeding objectives. In addition, the Division also provided the much-needed GQ data for NCT promising lines under an RCEF-funded component project.

The second core project evaluated the potential of Philippine rice and rice-based crops› nutrition, health, and wellness. Local rice varieties were explored for their starch digestibility and in vitro glycemic indices (GI) in the quest to determine varieties with low GI for diabetes prevention. In addition, fermented rice bran (FRB) of several varieties, including red and black rice samples, were tested for their anti-adipogenic potential to address the increasing prevalence of overweight and obesity in the country.

Food products enriched with FRB were developed and tested. In addition, market surveys were conducted for foods with low GI and those supplemented with FRB to provide insights on 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 data acquisition and processing modes. The near-infrared reflectance spectrophotometer (NIRS) was tested for physicochemical properties determination (moisture content, AC, protein content (PC), and alkali spreading value) for subsequent routine use. In addition, a Rice ICT-Based Sensory System (RISS) prototype for sensory analysis of rice and rice-based food products was created to automate sensory evaluation data acquisition. Moreover, the Rapid Visco Analyzer was optimized for evaluating the pasting properties of rice for routine testing. A database of grain quality of 325 rice varieties approved for commercial release from 1990 to 2020 was developed using the NCT data.

The Division's three extra-core funded projects delved on the evaluation of GQ of advanced rice lines under the NCT Project, the market studies on red mold rice (RMR) as a natural dietary supplement, and the evaluation and enhancement of brown rice (BR) quality and shelf-life. In the first project, advanced rice lines were profiled for their GQ and those passing the standard were recommended as potential promising varieties.In the second project, the quality and shelf-life of BR were tested and improved through the creation of rice clusters that could give insights into the varieties› suitability for BR production and the use of a hermetic storage system (SACLOB) for BR storage was evaluated.

The last core-funded project ensured the generation of quality laboratory outputs. Through this project, operations and processes of PhilRice laboratories were centralized for a harmonized and unified laboratory management system that improves the efficiency and promotes cost-effectiveness in the Central Experiment Station.

PROJECT 1

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

Evelyn H. Bandonill, Amelia V. Morales, Marissa V. Romero, Xavier Greg I. Caguiat, Marilyn C. Ferrer, Raffy B. Rodriguez, Lynnden C. Lucas, RC Huliganga, Jenina Patria S. Villar, Oliver D. Soco, Rommel D. Camus, Tolentino S. Rivera , Victor M. Mata

Grain quality remains one of the essential selection criteria in the rice breeding program. Demand for fast and reliable information on rice grain quality has increased significantly along with heightened breeding activities. This project was implemented to enhance the development of high-yielding varieties, address the growing need for fast and reliable information on rice grain quality, and meet the increasing demand for quality rice. In 2021, the following are the significant accomplishments of the project:

From 590 pre-NCT lines and other rice samples received, 520 samples were evaluated for complete GQ and 70 for amylose content (AC) based on specific analyses requested by the breeders. These were harvested from 2020 DS and WS until 2021 DS, which came from the following groups: Rainfed-Stressed and Non-stressed (73 entries), AFACI (46), HT-MINCER (24), Irrigated Lowland (IL) Mutation Breeding (68), Preliminary Yield Trial (PYT) Transplanted (19), PYT Special Purpose (21), Rainfed Lowland/Adverse Environment (92), IL Direct-Seeded Rice-WS (88), IL Direct-Seeded Rice-DS (128), Benguet State, BS and EM early maturing (21), and Lake Sebu, South Cotabato (10).

There were 791 rice germplasm collections/accessions received for GQ assessment; in which all samples were analyzed for AC while 790 were evaluated for gelatinization temperature (GT). Of the 791 samples evaluated, 460 met the preferred classification for AC (intermediate) and 315 entries had the preferred intermediate classification for GT.

PROJECT 1

Data of these rice germplasm samples were submitted for inclusion in the GeMS, which will be used in the breeding program and for other purposes.

Two sets of advanced CMS-based parental lines, 56 and 259 entries from the 2020 WS, were evaluated for grain quality. These were composed of maintainer and restorer lines. Of the 56 advanced CMS-based parental lines, 70% (39 entries) had Grade 1 to Premium milled and head rice recoveries. PR41325-4, PR41326-6, and PR41326-11 were slightly aromatic and tasty when cooked. From this set, 10 maintainer lines passed all the GQ parameters. Among the 259 advanced CMS-based parental lines, only 23% (59 entries) had Grade 1 to Premium milled and head rice recovery. Twenty-one restorer lines from this set passed the standards for milling potential, physical attributes, and physicochemical properties.

Two sets of advanced CMS-based parental lines were evaluated for GQ during the 2021 dry season. Among the first 158 restorer and maintainer lines analyzed for AC and GT only, the majority (51%) preferred the AC-GT combination, which was predicted to have a tender cooked rice texture. For the second set consisting of 152 restorer lines, only 23% (35 entries) had Grade 1 to Premium milled and head rice recovery.

PROJECT 2

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

Riza G. Abilgos-Ramos, Rosaly V. Manaois, Henry M. Corpuz, Rodel M. Bulatao, Amelia V. Morales, Jenina Patria S. Villar, Raffy B. Rodriguez, Joanna Christine A. Salinasal, Alcel B. Atanacio, Rommel D. Camus, Hanilyn A. Hidalgo, Darlene B. Oronan, AL Paradero, VG Lao

Rice, the Filipino's staple food, remains a significant source of macronutrients (i.e., carbohydrates and protein). It also serves as a source of micronutrients and other disease-preventing compounds. This project focused on determining the components of rice and its by-products essential to health. In 2021, the project's significant activities involved the evaluation of the potential health benefits of bioactive compounds from rice grains and rice-based crops and determining consumer knowledge, attitude, and practices (KAP) on low-glycemic index (GI) foods and fermented products. The following are the key accomplishments of the project:

Starch digestibility of NSIC Rc 160, 216, 222, Dinorado, and Ominio was evaluated. Raw polished forms recorded 0.05-0.44% resistant starch (RS) levels, while the unpolished samples had 0.07–2.03%. When cooked, polished and unpolished, samples had 0.06–1.06% and 0.13–0.68% RS, respectively. Freshly cooked NSIC Rc 160 and Ominio, respectively, classified as low-amylose and waxy varieties, had high in vitro GI. The rest of the samples were moderate. Physicochemical properties AC and GT significantly affected the RS level and GI in unpolished samples only.

Ethanolic extracts of black rice FRB showed high phytochemical content (total phenolic (TPC), total flavonoid (TFC), and total anthocyanin (TAC) content), antioxidant capacities (DPPH and ABTS radical scavenging activities, and FRAP), and potential inhibition of the differentiation of 3T3-L1 adipocytes into matured adipocytes indicating anti-adipogenic properties.

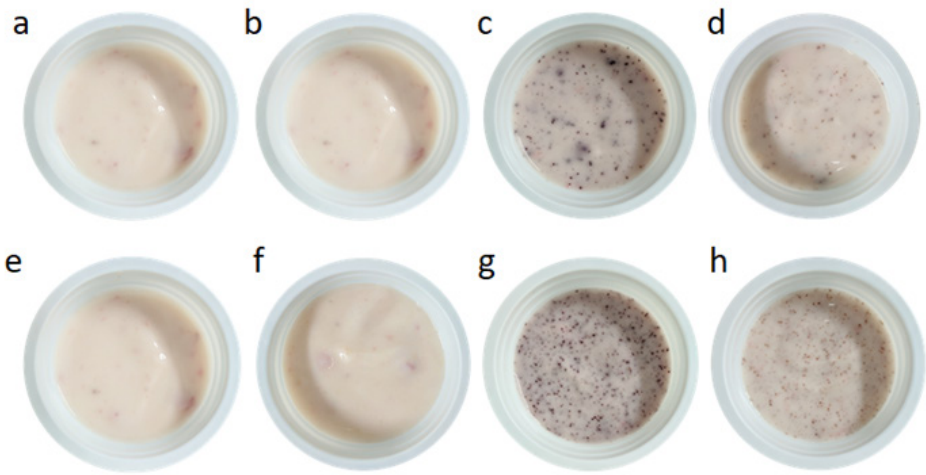
FRB-enriched plain and strawberry-flavored yogurt made of buffalo's milk was developed, with the optimum formulation having 1.20g of freeze-dried FRB in 220g yogurt.

PROJECT 2

An online survey to determine awareness of and demand for low-GI foods and unpolished rice among 236 respondents (18-40 yo, 63% female) showed that majority of the respondent (86.9%) had high level of awareness (3.8 Likert scales of 5) on unpolished rice and a high degree of liking for the taste of the product (70%). However, more than half (55%) were also unaware of foods with low GI scores.

Native delicacies, bakery products, and beverages were identified in a focus group discussion as having potential forFRB supplementation.

For the market survey on native delicacies, only 12% of the 200 respondents were aware of FRB and its health benefits such as cholesterol reduction and dietary fiber content. However, consumers with an income of PhP 10,001-20,000 showed willingness to buy the FRB-incorporated native delicacies.



control, (b) White rice, (c) Red rice, (d) Black rice; and with freeze-dried FRB (0.55% w/w): (e) control, (f) White rice, (g) Red Rice, (h) Black Rice

PROJECT 3

Research on Rice Quality and Safety

Henry M. Corpuz, Marissa V. Romero, Henry F. Mamucod, Evelyn H. Bandonill, Rosaly V. Manaois, Rodel M. Bulatao, Gerome A. Corpuz, Jenina Patria S. Villar, Lynnden C. Lucas, Ezra Spencer M. Delim, Katrina Ann M. Arceñas, Bernando S. Peralta, Jasper G. Tallada, Dexter John D. Luciano, and Luis Alejandre I. Tamani

Analysis of the grain quality (GQ) parameters of rice, which is a vital component of the rice breeding program, employs conventional methods that are time-consuming, tedious, expensive, and generates a large volume of toxic chemical waste. Therefore, fast, high-throughput, cost-reducing and reliable alternative methods are crucial to expedite the generation of GQ data useful for breeders, researchers, and other stakeholders. Moreover, GQ data generated from these analyses have accumulated over the years. Therefore, using relevant information from these data could be maximized through a database readily accessible by researchers and other stakeholders. Therefore, this project aimed to increase the productivity of the breeding programs for excellent quality rice through improved and efficient screening methods for rice eating and cooking quality and enhanced accessibility of rice GQ information

In 2021, the notable accomplishments of the project were the following:

Near-infrared reflectance spectroscopy (NIRS)-based automated method was optimized by creating calibration models for rapid and reliable analysis of rice physicochemical properties, including moisture content (MC), protein content (PC), amylose content (AC), and alkali spreading value (ASV). Prediction models based on flour spectra can measure the physicochemical properties of the samples more accurately than milled rice calibration models. Therefore, the NIRS calibration models developed for PC, ASV, and AC were suitable for screening purposes of rice samples. The MC, PC, and AC calibration models based on flour spectra achieved high prediction performance with 96.41, 96.50, and 95.95 % accuracy, respectively.

An automated ICT-based system for designing, conducting, analyzing, and generating sensory data was developed to expedite the data collection and analysis involved in conventional sensory evaluation. Developed with the Information Systems Division, the prototype of the Rice ICT-Based Sensory System (RISS) for rice and rice-based food products sensory analysis featured data collection

PROJECT 3

for raw and cooked milled rice that can be customized in terms of the researcher's name, date, and time of analysis, product to be evaluated, scorecard type to be used, number of samples, number of evaluators, randomized sensory codes, sensory attributes, and simple data analysis capabilities.

Optimization of the pasting property determination of rice using the Rapid Visco Analyzer was conducted for future use in routine testing.

A database of all grain quality parameters of 325 rice varieties approved for commercial release in the Philippines from 1990 to 2020 was developed using NCT data.

Table 1. Statistical results of the calibration models developed based on milled rice and flour spectral data.

Parameter	Milled Rice						Rice Flour					
	No.	SD	Calibration		Cross-Validation		No.	SD	Calibration		Cross-Validation	
			SEC	RSQ	SECV	1-VR			SEC	RSQ	SECV	1-VR
MC	660	0.47	0.39	0.61	0.40	0.61	680	0.54	0.32	0.5	0.35	0.64
PC	718	1.02	7.37	0.96	0.22	0.95	676	0.97	0.17	0.97	0.19	0.96
AC	919	2.53	1.30	0.86	1.52	0.84	868	2.58	1.10	0.86	1.21	0.85
GT	939	1.29	0.54	0.82	0.58	0.80	849	1.23	0.49	0.84	0.53	0.81

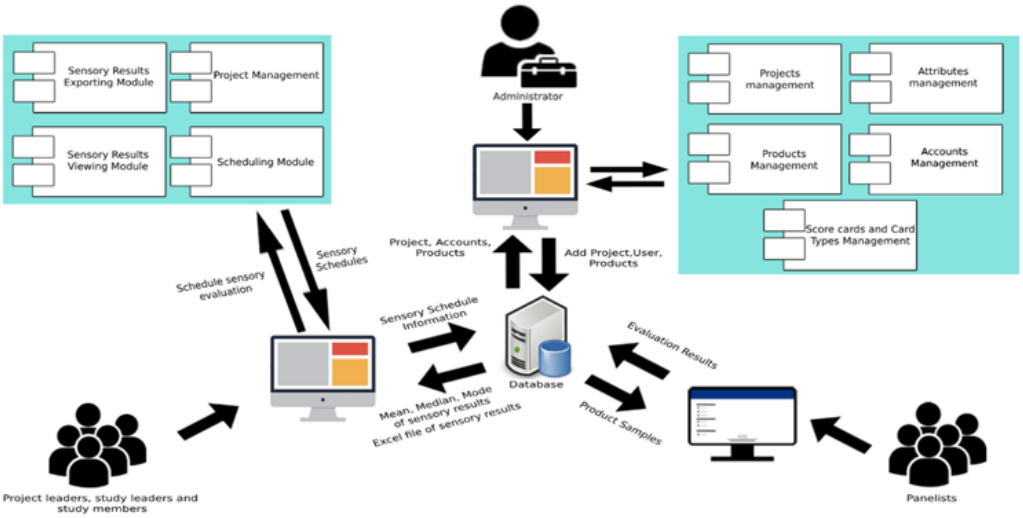


Figure 2. Conceptual diagram for Rice ICT-based Sensory System (RISS).

PROJECT 4

Centralized Laboratory Management

Roslay V. Manaois, Susan R. Brena, Rodel M. Bulatao, Christopher C. Cabusora, Ma. Johna C. Duque, Dindo King M. Donayre, Ma. Salome V. Duca, Annie E. Espiritu, Henry F. Mamucod, Teodora E. Mananghaya, and Evelyn M. Valdez

Quality laboratory outputs are critical in achieving the Institute's targets of developing high-yielding and cost-reducing technologies to help farmers produce sufficient rice for Filipinos. These outputs can be ensured if laboratories are well-managed by competent personnel; the critical laboratory equipment and measuring devices are functioning at their optimum level; and the systems comply with national and international standards, laws, and regulations. Hence, this project was implemented with laboratory operations and processes centralized and harmonized.

The following are the notable accomplishments of this project in 2021:

Critical laboratory equipment, instruments, and devices (EIDs) in research laboratories were calibrated based on calibration plans. The total number of EIDs calibrated types were: 16, ASPPD; 18, CBC; 13, CPD; 16, GRD; 29, PBBD; and 16, RCFSD. Four analytical balances, four top loading balances, four ovens, five refrigerators, and three freezers were also calibrated by in-house trained calibrators of RCFSD.

Several capacity enhancements activities for laboratory personnel were conducted or facilitated: orientation on the use of CO2 fire suppressant installed in the Central Chemical Storage Building, a webinar on "Related Laws and Regulations on Chemicals and Laboratory Wastes Management" for several licensed chemists, and "Safety in the Laboratory" webinar for some laboratory personnel.

A planning meeting to craft the institutional maintenance plan of safety devices in the Central Experiment Station was conducted and attended by laboratory managers, IMSSO, and Physical Plant Division.

A central chemical storage building has been formally utilized, wherein all new and unopened chemicals are now kept in designated rooms per laboratory.

PROJECT 4

Applicable chemical wastes were treated based on approved work instructions while hazardous wastes unsuitable for treatment on-site were turned over to IMSSO for hauling and treatment by an authorized external service provider.

Work instructions on the handling and storing of chemicals (WIM-RCF-004 Rev. 00) and treatment or disposal of hazardous chemical and biological wastes (WIM-RCF-003 Rev. 02) were prepared and updated, respectively, and are being implemented.

Compliance with national and local regulations was ensured. A list of controlled chemicals by PDEA was submitted every end of the semester, and a purchaser's license (PCC17-120121-0683) was applied and obtained from the PNP for chemicals categorized as explosives/explosive ingredients/controlled chemicals. TIn addition, the ASPPD soils laboratory was granted a license to operate as required by Presidential Decree 1435.

Initial arrangement has been made with ISD for the institutionalization of a centralized laboratory inventory system, which will be a centralized database of available chemicals in each division and will be accessible by authorized personnel.

Extra-core Project 1

Grain Quality Evaluation of NCT Rice Lines and Check Varieties

Evelyn H. Bandonill, Marissa V. Romero, Lynnden C. Lucas, Rochelle C. Huliganga, Jenina Patria S. Villar, Oliver C. Soco, Rommel D. Camus, EE Sajise, AdR Felix, Asha KM Bagunu, AA Danao, AD Peñaloza, AR Agarin

The National Cooperative Test (NCT) is a multi-environment network conducted to test the performance and stability of elite lines prior to recommendation as new varieties. Grain quality, yield, agronomic characteristics, insect pest, and disease resistance are essential factors in rice varietal development.

To identify promising NCT rice lines for possible recommendation in the deliberation of promising lines, 232 and 143 entries from the 2020 wet season (WS) and 2021 dry season (DS), respectively, were evaluated for milling recovery, physical attributes, physicochemical properties, Instron hardness, and cooking and eating quality.

Of the 232 2020 WS entries, 151, 9, and 149 promising lines passed the milling, physical, and physicochemical standards, respectively. Also, 81 promising lines passed almost all the grain quality standards. Health-promoting properties of Special Purpose-Pigmented samples ranged 268.53–718.06mg C3GE/kg for total anthocyanin content (TAC), 1.10-1.81mg GAE/g for total phenolic content (TPC), and 1.74-4.29mg/g for DPPH radical scavenging activity.

Of the 143 2021 DS entries, 85 had good milling recovery, seven had acceptable physical attributes, while 116 obtained the AC-GT combination with predicted tender to slightly tender cooked rice. Of the 143 entries, 37 top performers were identified for recommendation in the deliberation of promising entries.

Extra-core Project 2

Red Mold (*Monascus purpureus*) Rice as Natural Dietary Supplement: Market Studies

Riza G. Abilgos-Ramos, JF Ballesteros, Henry F. Mamucod, Amelia V. Morales, Alcel B. Atanacio

Red mold rice (RMR) is a traditional product resulting from the fermentation of rice with *Monascus purpureus*, a species of mold with known health-promoting properties against lifestyle-related diseases. Aside from being a food colorant and food enhancer, reports have cited that RMR has strong antioxidant properties and contains a cholesterol-lowering compound called mevinolin. In 2021, a species of *M. purpureus* (B2 isolate) which is highly efficient in producing pigments and biomass was isolated and characterized. The identity of the isolate was validated by the Philippine National Collection of Microorganisms of the Institute of Molecular Biology and Biotechnology based on its DNA sequences. In addition, a prototype of the PhilRice-produced RMR-based supplement was also developed using the optimized processing technology.

Description	Scientific Name	Max Score	Total Score	Query Cover	E value	Per. Ident	Acc. Len	Accession
Monascus purpureus strain CGMCC 3.5833 small subunit ribosomal RNA gene, partial sequence; internal transcri...	Monascus purpur...	1047	1047	97%	0.0	100.00%	863	MK359689.1
Monascus sp. (in: Fungi) strain CGMCC 3.4384 small subunit ribosomal RNA gene, partial sequence; internal tran...	Monascus sp. (in...	1047	1047	97%	0.0	100.00%	874	MN156547.1
Monascus sp. (in: Fungi) strain CGMCC 3.2636 small subunit ribosomal RNA gene, partial sequence; internal tran...	Monascus sp. (in...	1047	1047	97%	0.0	100.00%	877	MN156546.1
Monascus purpureus strain Han01 small subunit ribosomal RNA gene, partial sequence; internal transcribed spac...	Monascus purpur...	1047	1047	97%	0.0	100.00%	876	MN156545.1
Monascus purpureus strain CGMCC 3.5833 small subunit ribosomal RNA gene, partial sequence; internal transcri...	Monascus purpur...	1047	1047	97%	0.0	100.00%	877	MN156544.1
Monascus rutilus strain CGMCC 3.2636 small subunit ribosomal RNA gene, partial sequence; internal transcribed...	Monascus rutilus	1047	1047	97%	0.0	100.00%	854	MG654471.1
Monascus aurantiacus strain CGMCC 3.4384 small subunit ribosomal RNA gene, partial sequence; internal transc...	Monascus aurant...	1047	1047	97%	0.0	100.00%	840	MG654469.1
Monascus purpureus strain CBS 109.07 small subunit ribosomal RNA gene, partial sequence; internal transcribed...	Monascus purpur...	1047	1047	97%	0.0	100.00%	868	KY635851.1
Monascus purpureus gene for 18S ribosomal RNA, partial sequence, strain: CMU004	Monascus purpur...	1047	1047	97%	0.0	100.00%	600	LC057320.1
Monascus purpureus strain JCM 22619 internal transcribed spacer 1, partial sequence; 5.8S ribosomal RNA gene...	Monascus purpur...	1047	1047	97%	0.0	100.00%	603	JN942661.1

Figure 3. Phylogenetic tree constructed by Apical Scientific and Fungal DNA barcoding results by Apical Scientific

Extra-core Project 3

Evaluation and Enhancement of Brown Rice Quality and Shelf-Life

Marissa V. Romero, Rosaly V. Manaois, Rodel M. Bulatao, Maricar B. Castillo, Raffy B. Rodriguez, Katrina Ann Arceñas Carurucan, Ivan Jon V. Balmeo

This project aims to improve the quality and shelf-life of brown rice (BR) to ensure the availability and accessibility of affordable BR in the market, thereby contributing to rice self-sufficiency and providing rice consumers with a healthy, nutritious, and shelf-stable product.

Clustering based on apparent amylose content (AC) and gelatinization temperature (GT) was conducted to determine the rice varieties that will produce BR with a softer texture. Using K-means clustering analysis, rice varieties approved for commercial release by the National Seed Industry Council (NSIC) were grouped into four clusters. Cluster 1 had varieties with waxy/glutinous AC. Clusters 2 to 4 had varieties that represent the table rice. Cluster 2 varieties had a wide range of AC (from low to high), while Cluster 4 had varieties with low AC only. They had very soft to hard Instron hardness, with most varieties considered soft. Lastly, Cluster 3 varieties had similar AC classifications as those in Cluster 2, but the former had lower GT. The four clusters were applied in samples in their BR form, and the Instron hardness readings were verified. An increase in cooked rice hardness can be observed in all clusters. These clusters are featured in the book "Milled Rice Clustering of NSIC-Released Varieties based on Amylose Content and Gelatinization Temperature."

Table 2. Summary of characteristics of milled rice clusters.

Cluster	Amylose Content (%), Classification[1]	Alkali Spreading Value, Classification[2]	Instron Cooked Rice Hardness[3]
1	1.0–1.9, W	3.3–6.5, HI–L	**VS**
2	14.4–25.8, L–H	3.0–5.2, HI–L	VS, **S**–H
3	18.1–26.8, I–H	6.0–7.0, L	**S**–H
4	11.6–16.7, L	5.5–7.0, I–L	**VS**–**S**

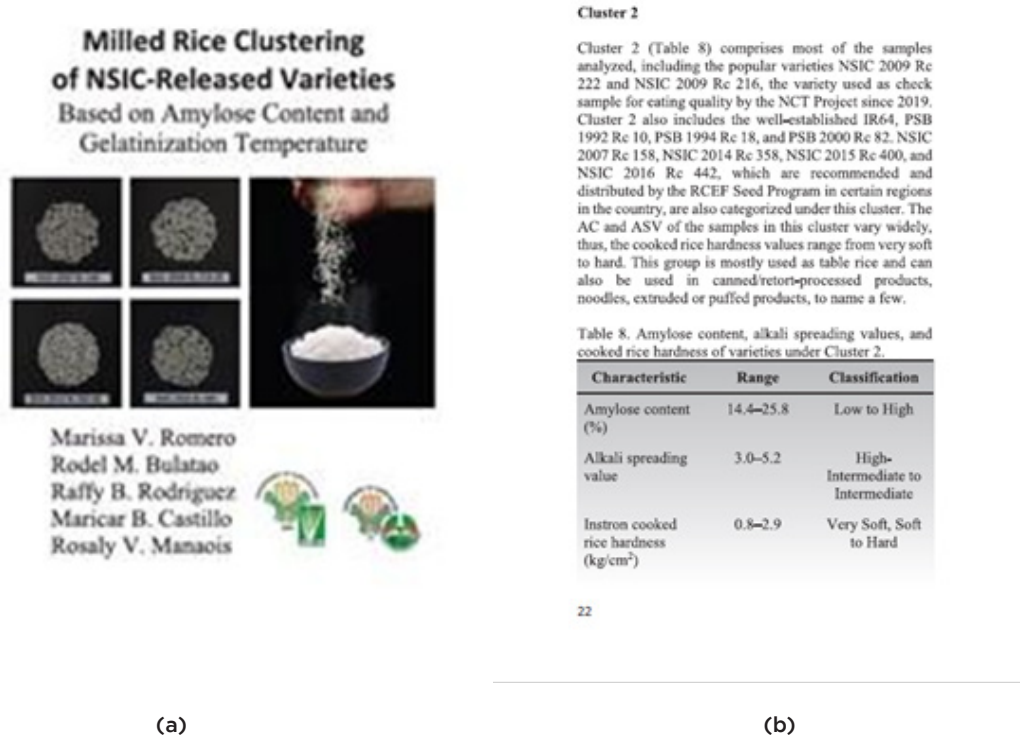
1*W (Waxy), VL (Very Low), L (Low), I (Intermediate), H (High),* ***2****L (Low), I (Intermediate), HI (High-Intermediate),* ***3****VS (Very Soft), S (Soft), H (Hard); Highlighted class indicates characteristic displayed by the majority of varieties falling within the same cluster*

Extra-core Project 3

Table 3. Summary of characteristics of brown rice clusters.

Cluster	Amylose Content (%), Classification[1]	Alkali Spreading Value, Classification[2]	Instron Cooked Rice Hardness[3]
1	1.0–1.9, W	3.3–6.5, HI–L	VS – **S**
2	14.4–25.8, L–H	3.0–5.2, HI–I	S – **M** – H
3	18.1–26.8, I–H	6.0–7.0, L	M – **H**
4	11.6–16.7, L	5.5–7.0, I–L	VS – **M**

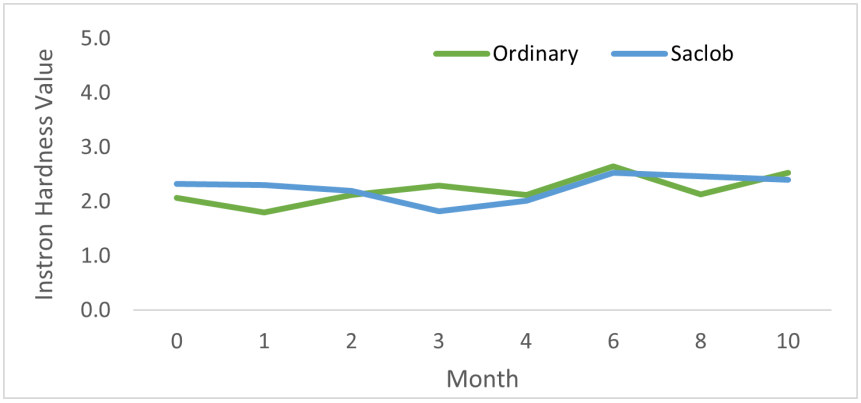
1*W (Waxy), L (Low), I (Intermediate), H (High),* **2***L (Low), I (Intermediate), HI (High-Intermediate)* **3***VS (Very Soft), S (Soft), M (Medium), H (Hard); Highlighted class indicates characteristic displayed by the majority of varieties falling within the same cluster*



(a) (b)

Figure 4. (a) Inside cover of the book "Milled Rice Clustering of NSIC-Released Varieties based on Amylose Content and Gelatinization Temperature" and (b) sample page of its contents

Extra-core Project 3



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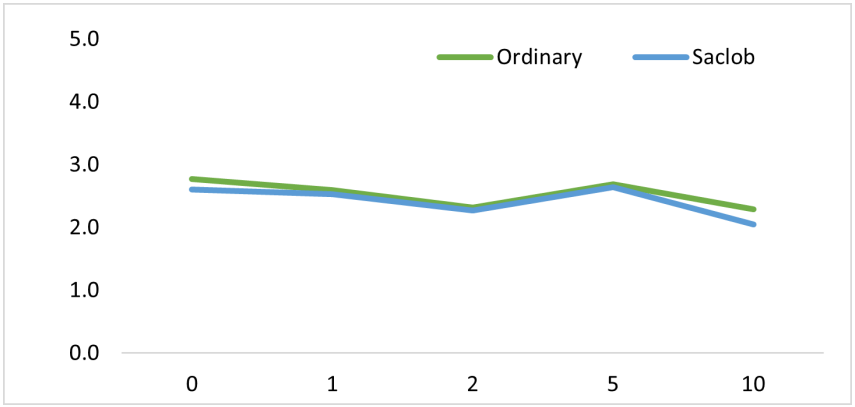

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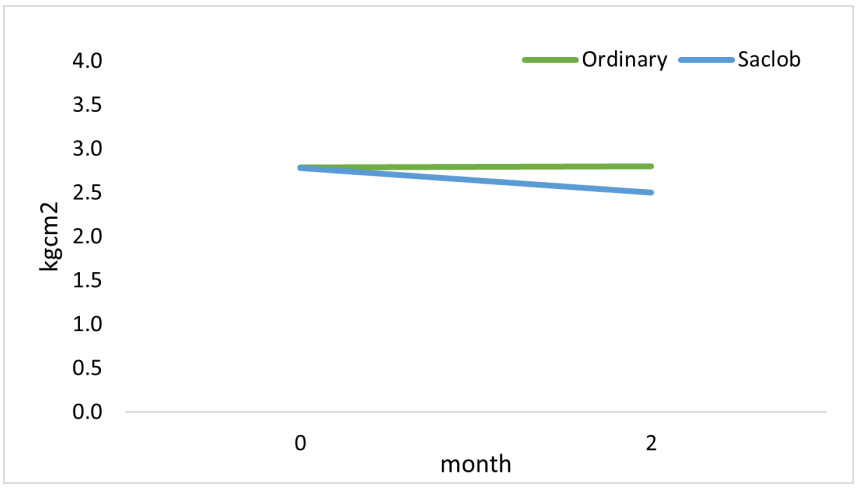

(c)

Figure 5. Instron hardness of cooked brown rice stored in ordinary sack and SACLOB conducted at (a) PhilRice-CES, (b) PhilRice-Isabela, and (c) PhilRice-Negros.