2019

PHILRICE R&D HIGHLIGHTS

CLIMATE RESILIENCY FOR ENHANCED AGRICULTURAL TRADE AND EFFICIENCY FOR RICE (CREATE RICE) PROGRAM

Contents

PROGRAM

Climate Resiliency for Enhanced Agricultural Trade and Efficiency for Rice (CREATE RICE)

Program leader: Ricardo F. Orge

Executive Summary

CREATE Rice Program was established to develop technologies and innovations to help rice farmers better respond to the challenges of trade liberalization (ASEAN economic integration) and climate change. It is composed of four projects that seek to enhance farmers' market competitiveness and resilience to climate change.

The first project aimed to develop technologies that can help farmers manage climate change-related challenges while the second project focused on diversified and integrated rice-based farming system models that are highly productive and climate-resilient. Complementarily, the third project provided added income opportunities for farmers through processing of value-added products and by-products derived mostly from the farming system models of the second project. The last project aimed to develop and evaluate packages of technologies that can further reduce cost of production and increase yield and income so farmers can compete globally.

In 2019, pilot-testing of two resilience-enhancing technologies - Capillarigation System and *Kwebo* - for smallholder rice-based farmers were conducted. Farmers gave positive feedback on both technologies in terms of acceptability, among other factors. Another technology, an improved bag dryer was performance-tested, and was slated for pilot-testing after some design refinements. Housed inside the Kwebo, the improved bag dryer integrated the whole system of handling, drying, and storage of *palay*, which significantly lessened the exposure time of grains to high moisture conditions, like when there are typhoons and floods, causing rapid quality deterioration.

Other climate change adaptation technologies are still undergoing a series of field tests and design refinements. One is a new generation power tiller that addresses climate change-related challenges, on top of its typical functions.

Another is the long-range sprinkler irrigation system designed to improve water use efficiency and yield of aerobic rice culture. Lastly, rice lines are being field tested under various field conditions to come up with new rice varieties tolerant to climate-related stresses.

Four highly productive climate change-resilient farming systems models (FSMs) established in 2018 at the Palayamanan Farm at PhilRice CES were sustained in 2019. Among these is the highly intensified production system (HIPS), which generated a net margin of P53,737.00, equivalent to P56.56/m^2 annually. Another one, the triangular pyramid vegetable production model using a bamboo frame, generated a gross margin of P106.05, equivalent to P35.47/m^2. The rice+duck+vegetable production model generated an annual income of P66,006.69, equivalent to P39.38/m^2. The vegetable+swine production model generated a gross margin of P7,473.43, equivalent to P1,868.36/head of swine and were inputted into the system. Nutritious value-added products, which can give additional income for farmers were also developed during the period. One of them is the ready-to-eat GABA rice meal with pork adobo. The meal is rich in protein, fiber, fat, ash, and carbohydrates, and safe to consume up to 11 months. Likewise, three instant 'am' products enriched at a 6% concentration with carrot, sweet potato, and banana were developed. Three rice malt-based beverages with soybean, sesame, and peanut milk comparable with a commercial malt drink were also developed.

Part of the package of technologies developed for various value-added products was the development/improvement of food processing equipment using the carbonizer-generated heat. This would allow farmers' associations/cooperatives to easily transfer and mainstream their business operations. These included the improved prototype of the multi-purpose dryer, which can be used in drying various Palayamanan-based products. Likewise, an improved prototype of the continuous-type rice hull carbonizer and heat recovery attachment equipped with a steam generator was also developed.

Package of cost-reducing technologies (POT) for mechanized rice farming was tested. Results showed that the POT based on mechanized transplanting achieved the highest yield of 7.71t/ha with an input cost of P7.45/kg for DS and 4.69t/ha at P5.69/kg for WS. Secondly, the POT based on manual transplanting achieved a yield of 7.75t/ha at input cost of P7.38/kg for DS and 4.23t/ha at input cost of P5.98/kg for WS (partially lodged). Lastly, the POT for mechanized direct seeding using the plastic drum seeder achieved a yield of 6.34t/ha at P7.45/kg for dry season and 4.20t/ha (lodged crop) at input cost of P6.30/

kg for wet season. Labor cost was computed based on the 10% share in the community. Computation of machine rental and dry paddy price of P13.00/kg for DS and P17.00/kg for WS was based on the prevailing price during the harvesting season, which was significantly lower than previous season.

With these accomplishments, the CREATE Rice Program made significant advancements toward helping enhance the climate change resilience and market competitiveness of men and women farmers. The program also contributed to the targeted outcomes of (a) increased productivity, cost-effectiveness, and profitability of rice farming in a sustainable manner, (b) improved rice trade through efficient post production, better product quality, and reliable supply and distribution system, and (c) enhanced value, availability, and utilization of rice, diversified rice-based farming products, and by-products for better quality, safety, health, nutrition, and income.

PROJECT 1

Managing Climate-related Stresses for a Resilient Rice and Rice-based Production System

KS Pascual

This project developed technologies that would help farmers adapt to extreme climate events and minimize the risk of losing investments made in rice and rice-based farming. The project has seven component studies with the following objectives: (1) develop a sprinkler irrigation system to maximize the utilization of water, paddy bag drying system for postharvest handling and drying system for typhoon-affected *palay*, and multipurpose mini-tractor that can operate both in favorable and in adverse field conditions; (2) pilot test a multipurpose and typhoon-resistant farm structure (*Kwebo*), and a do-it-yourself irrigation system called Capillarigation in select farmers' organizations; (3) develop breeding lines with multi-stress tolerance, and (4) improved alternate wetting drying (AWD) technique to enhance water productivity under water-scarce environment.

In 2019, the performance of the sprinkler irrigation system was assessed thru a series of field tests. The system was enhanced to achieve the designed wetted area of 2500m^2 (0.25ha). Using a 12-mm diameter nozzle, the sprinkler targeted a longer throw of radius of 28.7m and produced larger wetted area of 2,588m^2 as compared with an 8-mm diameter nozzle. The improved prototype is ready for on-farm trial under aerobic rice system in the 2020 DS. Based on the test run results of the previous design, the drying bag was modified by reducing its capacity from 500kg to 400kg and the thickness of *palay* that can be accommodated to 20cm to minimize significant difference in the moisture content (MC) of grains relative to their location inside the drying bags. Performance tests resulted in the reduced MC of *palay* from 18.3% to 10.6% after a 6-hour operation at a temperature of 40-55.4°C. The process consumed 168kg of rice hull with biochar recovery of 30%. The improved drying system yielded a capacity of 250kg/h at a moisture reduction of 21.5kg/h.

The *Makisig* or '*Makina para sa pabago-bagong Klima at Sari-saring Gawain sa bukid*', was improved to navigate fields with rice stubbles and standing water at specific soil condition. Considering women as possible users, its first prototype was equipped with electronic ignition system for easy starting. Mechanisms that transmit power from engine to the screw wheels were improved while some components were replaced.

Two farmers' associations primarily engaged on rice and vegetable production were trained on establishing *Kwebo* and Capillarigation. They also evaluated both technologies. Two *kwebo* units were constructed for storage of inputs and equipment and mushroom growing. Two Capillarigation Systems were established on-farm (one in a learning site and one in a backyard garden) while another was setup in the meeting area to serve as demo area. Positive feedback was gathered for both technologies.

Target population environments were characterized through genotypic responses of ten varieties in three sites. All test sites exhibited two abiotic stresses (drought and salinity) that can be grouped into two mega environments: higher-yielding and low-yielding. Grain yield performance of elite breeding lines was evaluated across variable rainfed environments. Availability of basic seeds of 10 varieties and 22 elite lines was ensured thru seed increase producing >2kg of seeds each genotype. Elite breeding lines with wide and location-specific adaptability were also identified. Combined analysis of variance of 10 varieties under four environments resulted in highly significant differences among genotype, environment, and its interaction, indicating the possibility of selecting stable genotypes.

Two-season field experiments on the effect of biochar and AWD were completed in farmer's field. Results showed that incorporating biochar in AWD had no effect on the grain yield, and water use and productivity. However, water productivity in AWD was significantly higher by 74% relative in continuously flooded (CF) regardless of biochar rate. Increasing the rate of biochar (2-10t/ha) under CF also increases the water holding capacity by 10-18% compared with no biochar.

Development of a Sprinkler Irrigation System for Rice and Rice-based Crops

AT Remocal, KS Pascual, RF Orge, and DA Sawey

This study aimed to design and fabricate a prototype of a sprinkler irrigation system than can cover a service area of 0.25ha in one setting. Major components were fabricated (Figure 1) and appropriate component parts such as the engine and nozzle size were selected to meet the design criteria. A commercially available impact rain gun sprinkler head was used with a trajectory angle of 23° and a 207-483 kPa (30-70psi) operating pressure. It was connected to a 2-in galvanized iron (GI) pipe and supported by a collapsible 1.5-m stand. Field tests showed that a 3-in water pump produced higher pressure and a bigger nozzle size (14mm) obtained longer radius of throw. This was supported by using stronger material (e.g., polyethylene pipe) for drawing water from the source, which resulted in reduced leaks and high pressure observed from ordinary hose material (Figure 2). Initial data on the uniformity of distribution showed that the system is desirable with an equal distribution coefficient of 89%. The target service area of the sprinkler irrigation system was achieved; however, further field trials are recommended to optimize the available capacity of the system. Based on the final design, the estimated cost of the system is at P6,448.75, excluding the water pump.

Figure 1. Fabricated sprinkler head assembly

First prototype of the sprinkler system (left, Lay-flat hose) compared with the improved system (right, PE hose)

Development of a Paddy Bag Drying System

DA Sawey, RF Orge, and JB Lagmay

This study aimed to produce a working prototype of a climate-responsive rice postharvest handling and drying system for typhoon-affected *palay*. Specifically, it aimed to improve the design of the system's grain handling and drying component and to test and evaluate the system's performance on drying paddy grains. The eight units drying bags were further improved. The thickness of *palay* that the bag could accommodate was reduced to 20cm leading to a lower capacity of 400kg. This was done to minimize significant difference in the moisture content of grains relative to their location inside the drying bags. Performance of the improved drying bags was evaluated. Four drying bags were filled with freshly harvested *palay* (NSIC Rc 222 and Rc 160) and were positioned inside the *Kwebo* (Figure 3). The unoccupied holes intended for other bags were covered maintaining a static pressure of 25-30mm. Results of test runs showed that the drying system performed its function reducing the moisture of *palay* from 18.3% to 10.6% after a 6-hour operation at a temperature of 40-55.4°C. The process involved 168kg rice hull and a biochar recovery of 30%. The drying system yielded a capacity of 250.1kg/h at a moisture reduction of 21.5kg/h. The excess harvest that could not fill one drying bag full was sun dried. The paddy was dried after 8 hours and moisture content was reduced from 17.5% to 11.2%. Germination rate and milling recovery were determined. Germination rates of bag-dried samples were 94 and 97% while sun-dried samples were both at 96%. NSIC Rc 222 samples had a milling recovery of 72.6%, regardless of drying method. The sun-dried NSIC Rc 160 had a higher milling recovery of 73.5% over the bag-dried at 71.9%.

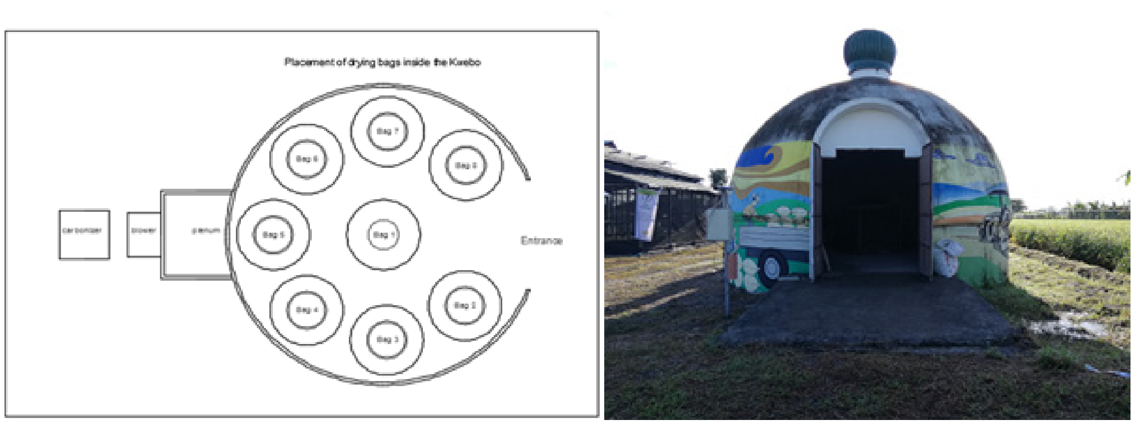


Figure 3. Placement of drying bags (left) inside the Kwebo dryer (right). Bags 1, 2, 7, and 8 were filled with fresh palay and the other holes were closed.

Development of a Multipurpose Mini-Tractor for Climate Change Adaptation

RF Orge, DA Sawey, and JB Lagmay

This study aimed to develop a riding-type mini-tractor that can operate both in favorable and adverse field conditions (i.e., deep mud or water-submerged fields), performing farming operations that are beyond the capability of the existing hand tractors like digging canals for conveying water, constructing small ponds for harvesting rainwater, and drilling shallow tube wells. Designs of existing power tillers and small farm tractors were critically reviewed, noting their basic operating components and provisions for attachments to carry out farming operations (plowing, harrowing, leveling). After coming up with the design criteria generated from informal discussions with select male and female farmers during field days, field visits, and training; prototype was fabricated and field tested. Test run results showed problems on the machine's power transmission and steering systems. Named as *Makisig ('Makina para sa pabago-bagong Klima at Sari-saring Gawain sa bukid')*, the prototype is powered by a 9.7kW (13hp) gasoline engine and equipped with a pair of screw wheels. In 2019, a pair of oil-bath chain and sprocket transmission boxes were designed to replace some belt and pulley drives resulting in a significant improvement on the machine's mobility. The improved prototype (Figure 4) can now navigate in fields with rice stubbles where the saturated soil was not so sticky and soft (depth of foot print not exceeding 10cm), with 1.5kph speed. Design modifications are still on-going to improve mobility when the machine operates in fields with sticky soils and deep hard pans.

Figure 4. The first prototype (Makisig 1) after making some design improvements

Establishment of Kwebo in Select Farmers' Cooperative

KC Villota, RF Orge, and DA Sawey

This study demonstrated the construction of *Kwebo*, a multi-purpose typhoon-resistant farm structure, in select farmers' cooperatives (FCs) and gather feedback from them. Two FCs, Ugat-uhay Farmers' Association (UUFA) in Zaragoza, Nueva Ecija and Ambalatungan Vegetable Growers Organizations (AVGA) in Santiago City, Isabela, were identified. FC members were trained (Figure 5) to fabricate 60mm x 3,657.6mm long basic construction unit (BCU) needed for the construction of *Kwebo*. UUFA fabricated 360 units for Kwebo with 45m^2 area for mushroom growing while AVGA fabricated 210 units for structure with 20m^2 area to serve as storage to safe keep inputs and equipment. These BCUs were used as reinforcement of the structure built by the farmers. UUFA completed construction of Kwebo (Figure 6) in 154 days with 3-5 laborers per day. AVGA, on the other hand, is still finishing or plastering the structure (Figure 6). Based on feedback gathered from 6 members of two FCs involved in construction, *Kwebo* can be constructed by unskilled workers and they recommended the structure in their community due to its usefulness as storage of products, especially during strong winds and typhoons.

Figure 5. Training of farmer-members of UUFA on the fabrication of BCUs

Figure 6. Constructed Kwebo project sites in Santiago City, Isabela (left) and Zaragoza, Nueva Ecija (right)

Pilot-Testing of the Capillarigation System in Select Farmers' Cooperatives

DA Sawey, RF Orge, and KC Villota

This study aimed to pilot-test the Capillarigation technology on farmers' fields and home yards that grow rice-based crops. UUFA of Zaragoza, Nueva Ecija and the AVGA of Santiago City, Isabela were identified as project partners. Twenty farmers from these associations were trained on the operating principle of the Capillarigation System, its advantages, and a demonstration of its fabrication and installation (Figures 7-8). After the training, three setups were established: one in Santiago City, Isabela (in a farm being developed into a learning site) (Figure 9a) and two in Zaragoza, Nueva Ecija (in a backyard garden planted with pepper and tomato and in the meeting area to serve as demo area) (Figures 9b-c). Materials and technical assistance were provided. Using a custom-designed survey questionnaire, feedback was gathered from three male and two female users after one growing season from the time of establishment. Results showed that all respondents agreed with the advantages of Capillarigation technology as indicated in the assessment statements. Four statements that got the lowest rating will be the basis of improvement of the system. All respondents recommended the technology in their community to reduce labor cost on watering and to increase water use efficiency. During rainy season, when the field setup of Capillarigation system is not possible, farmers may opt to use the system in vertical gardening.

Figure 7. Demonstration and establishment of Capillarigation System in Ambalatungan, Santiago City, Isabela

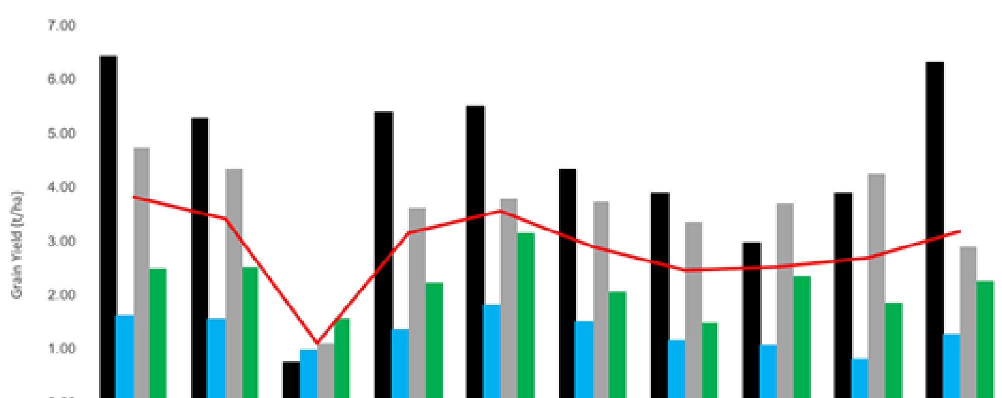
Figure 8. Demonstration on establishment of Capillarigation System in Mayamot, Zaragoza, Nueva Ecija

Figure 9. Capillarigation system setup in (left) Santiago City, Isabela (farm being developed as a learning site); and in Zaragoza, Nueva Ecija (center) backyard garden, and (right) meeting area

Multi-Stress Test of Breeding Lines in Rainfed Lowland

JMNiones, NV Desamero, VAC Marcelo, MCJ Cabral (PhilRice CES), VC Lapitan, MAR Orbase (PhilRice Bicol), CU Seville, CJ Parina (PhilRice Negros), AY Alibuyog, and BS Pungtilan (PhilRice Batac)

Most of the rainfed lowland rice areas exhibit multiple abiotic stresses such as flooding, drought, and salinity within the same cropping season. While progresses have been made in developing lines tolerant to a single abiotic stress, varieties adapted to combat multiple stresses are yet to be established. This study aimed to evaluate and identify climate change-resilient rice varieties with a minimum of two abiotic multi-stress tolerance under multi-environment trials in rainfed lowland areas. Three on-farm sites experiencing a cycle of abiotic stresses throughout the cropping season were identified in Suso, Sta. Maria, Ilocos Sur; Ponong, Magarao, Camarines Sur; and Camaba-og, Hinigaran, Negros Occidental. Ten varieties adapted to favorable and abiotic stresses – NSIC Rc 222 and Rc 160 (Irrigated lowland), N22 and IR52 (heat), PSB Rc14 and IR64 (drought), PSB Rc68 and NSIC Rc 194 (submergence), IR29 and PSB Rc90 (saline) – were used. Two abiotic stresses (drought and salinity) occurred in all three sites. The three test sites and one control environment (PhilRice CES) were grouped into two distinct mega-environments. The first mega-environment (higher-yielding) was composed of PhilRice CES, Magarao, and Hinigaran while the lower-yielding environment was the Sta. Maria site. The yield of varieties across these environments (Figure 10) was analyzed using GxE analysis. NSIC Rc 222 (3.80t/ha), the highest-yielding variety, was identified as most adapted to the first mega-environment. PSB Rc 90 (3.19t/ha), on the other hand, was adapted to the second mega-environment and had the most unstable yield across sites. Moreover, PSB Rc14 and NSIC Rc90 were identified as high-yielding and stable using yield stability index. Data collection for the subsequent trial consisting of 28 entries is currently ongoing and is expected to be finalized by January 2020.



	NSIC Rc222 (IL)	NSIC Rc160 (IL)	N22 (HT)	IR52 (HT)	PSB Rc14 (DRD)	IR64 (DRD)	PSB Rc68 (SUB)	NSIC Rc194 (SUB)	IR29 (SAL)	PSB Rc90 (SAL)
CES	6.45	5.29	0.77	5.41	5.52	4.33	3.90	2.98	3.89	6.33
Ilocos Sur	1.61	1.55	1.00	1.37	1.82	1.52	1.17	1.07	0.82	1.26
Camarines Sur	4.76	4.35	1.13	3.63	3.79	3.75	3.38	3.71	4.25	2.89
Negros Occidental	2.49	2.53	1.59	2.25	3.16	2.06	1.49	2.37	1.87	2.26
Avg	3.83	3.43	1.12	3.17	3.57	2.92	2.49	2.53	2.71	3.19

Figure 10. Mean grain yield (t/ha) of 10 varieties in four target population environments

Enhancing the Water Productivity of AWD through Use of Biochar and Timing of Irrigation

KS Pascual, AT Remocal, LS Caguiat, and FS Grospe

Improving the water productivity of rice to address issues related to water scarcity and climate change is important for food security. This study aimed to enhance the water productivity of rice through the use of biochar and improved timing of irrigation. Field experiments were conducted in farmer's field with groundwater as source of irrigation located in Sta. Clara, Cuyapo, Nueva Ecija during 2019 dry and wet seasons (DS and WS) (Figure 11). Two water management <W> (continuously flooded and safe AWD) and four biochar rates <B> (0, 2, 5, 10t/ha) were laid out in a strip-plot design in three replications. Grain yields, and water use and productivity were determined. There were neither significant effects of the treatments nor interaction among treatments on the grain yields. Grain yields ranged from 7.22-7.37t/ha in DS and 3.92-4.15t/ha in WS regardless of water management. Increasing the rate of biochar incorporated in the soil (Figure 12) did not also affect the grain yields of rice relative to the control. The soil pH, OM, and P did not vary with the addition of biochar. However, soil OM and P were significantly lower in AWD than in CF. In DS, water savings in AWD was 76% and the water productivity increased by 74% relative to CF regardless of biochar rate. In general, this study suggests that incorporation of biochar in AWD had no effect on the grain yield, water use, and water productivity.

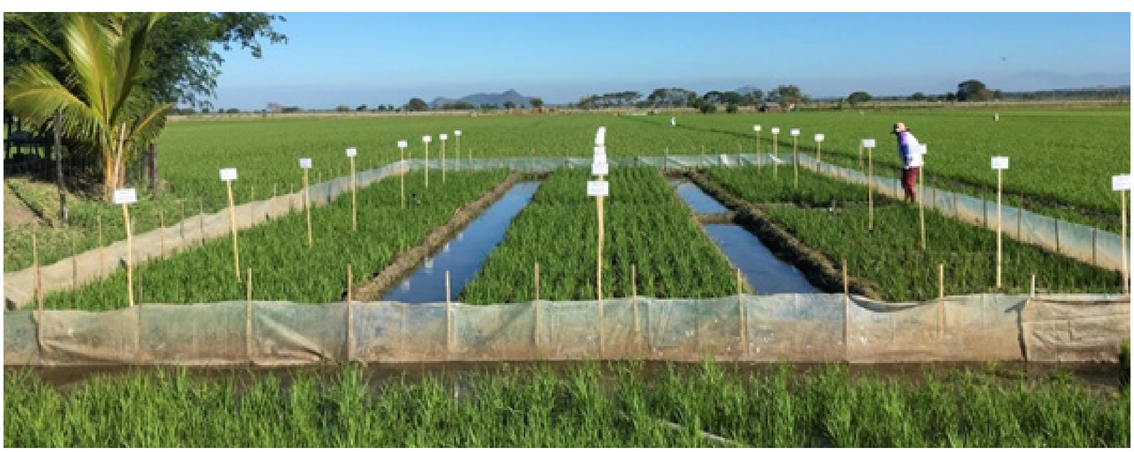


Figure 11. Experimental set up at the farmer's field

Figure 12. Incorporation of rice husk biochar during last harrowing and soil leveling

Palayamanan Smart: Development of Farming Systems Models for Extreme Climate Events

RG Corales (January to May 27, 2019) / MD Malabayabas (May 28 to December 2019)

The project developed highly profitable climate-resilient farming systems models (FSMs) that can increase productivity and provide farmers diversified sources of income especially during adverse climate events. In 2019, four highly productive climate change-resilient FSMs were continually implemented at PhilRice CES Palayamanan Farm. The highly-intensified production system (HIPS) composed of raised beds planted with leafy vegetables; sinks planted with rice and taro; bunds; and trellis planted with other cash crops generated net margin of P53,737equivalent to P56.56/m^2. The 2019 income was higher than in 2018 due to several cycles of vegetables planted in the raised beds and harvest from taro. The triangular pyramid vegetable production model using bamboo frames had a gross margin of P106.05 equivalent to P35.47/m^2 for a short period of time and small space. The integration of rice with duck and other cash crops generated an annual gross income of P66,006.69 equivalent to P39.38/m^2. Moreover, the vegetable+swine production model generated a gross margin of P7,473.43 equivalent to P1,868.36/head of swine. The latter model showed that the modified cage structure has no effect on the growth of swine. Value-adding of harvest from the different models may be considered in the succeeding year to further increase the income.

The adaptability of developed and ready-to-deploy FSMs like the floating garden was assessed in Small Water Reservoir Irrigation Project (SWRIP) in Matingkis, Science City of Muñoz, Nueva Ecija from January to July 2019. The project partner-recipient was composed of 70% male and 30% female led by the barangay councils, Senior Citizens Association, the *Samahan ng Magsasaka sa Matingkis (Sama-Sama)*, and members of the DSWD 4Ps Organization. They established six bamboo raft floating gardens with different materials. Among the floating garden models, the bamboo-raft bed type was the most stable where 29.31kg of upland kangkong was harvested in five planting cycles while okra, eggplant, cowpea, eggplant, and bush bean were adaptable in bamboo-raft potted garden.

Development of Highly Productive Climate-resilient Farming Systems Models

MD Malabayabas, RG Corales, JM Rivera, RF Orge, DA Sawey, DA Gabriel, and JT Sajor

The study focused on developing four highly profitable climate-resilient farming systems models (FSMs) to provide alternative and diversified sources of income for farming families especially during adverse climate events. Re-established in 2019 at PhilRice CES Palayamanan Farm, these models were Highly-Intensified Production System (HIPS), Triangular Pyramid Vegetable Production, Rice+Duck+Vegetable Production, and Vegetable+Swine Production. The HIPS model (Figure 13) composed of several sinks, raised beds, bunds, and trellis planted with rice and other cash crops generated a net margin of P53,737.00 (P56.56/m2) for a period of 10 months. This income was higher than that of 2018 due to several cycles of vegetables planted in the raised beds (P52,958.00) and harvest from taro or gabi (P11,058.00). The triangular pyramid vegetable production model (Figure 14) with a gross margin of P106.05 (P35.47/m^2) was suitable for a short period of time and small space. The rice+duck+vegetable production model (Figure 15) had a decent annual income of P66,006.69 (P39.38/m^2). Similar to the HIPS model, the inclusion of taro contributed in increasing the income. Lastly, the vegetable+swine production model (Figure 16) with a gross margin of P7,473.43 (P1,868.36/head of swine) showed that the modified cage structure has no effect on the growth of swine. Value-adding of harvest from the different models may be considered in the succeeding year to further increase the income.

Figure 13. HIPS model-Sorjan System showing variety of vegetables planted in raised beds with rice and taro planted in the sinks, malunggay tree in perimeter area, and vegetables in trellis

Figure 14. Triangular pyramid production model showing lettuce planted in horizontal bamboo poles and ginger planted in sacks placed at the base of the triangular structure

Figure 15. Rice-duck-vegetable production model

Figure 16. Swine-vegetable production model.
Upland kangkong were planted on top of the swine cage

Pilot-Testing of Rice-Based Farming Systems Models (FSMs) in Climate Vulnerable Rice-Based Communities

JM Rivera, RG Corales, MD Malabayabas, RF Orge, and DA Sawey

This study pilot-tested the developed and ready-to-deploy FSMs and assessed their adaptability in climate vulnerable rice-based farming communities. The floating garden was introduced and established as part of the 7-ha Small Water Reservoir Irrigation Project (SWRIP) in Matingkis, Science City of Muñoz, Nueva Ecija from January to July 2019 (Figure 17). This area has a big potential for establishing floating gardens not only for food production and income but for agro-ecotourism. The project partner-recipient was composed of 70% male and 30% female led by barangay councils, Senior Citizens Association, the *Samahan ng Magsasaka sa Matingkis (Sama-Sama)*, and members of the DSWD 4Ps Organization. Six 1.2mx5.5m bamboo raft floating gardens were established using bamboo slats with empty plastic bottles as floaters. The soil bed of a bamboo raft garden bed was a mixture of soil, manure, and carbonized rice hull. The bamboo raft potted plant garden model involved potted soil mixture of garden soil, manure, and carbonized rice hull in polypropylene bags. Bamboo floating raft aquaponics, on the other hand, used 1.5 or 2 L PET bottles half-filled with mixture of garden soil, manure, and carbonized rice hull. Both the bamboo raft garden bed and bamboo floating raft aquaponics were planted with upland kangkong and lettuce. The bamboo raft potted plant garden was cultivated with okra, eggplant, pepper, tomato, and bush bean. Among the floating garden models, bamboo raft bed-type was the most stable where 29.31kg of upland kangkong was harvested in 5 planting cycles (Figure 18). The bamboo raft pot-type involved lower input cost due to lesser materials used as compared with the bed-type.

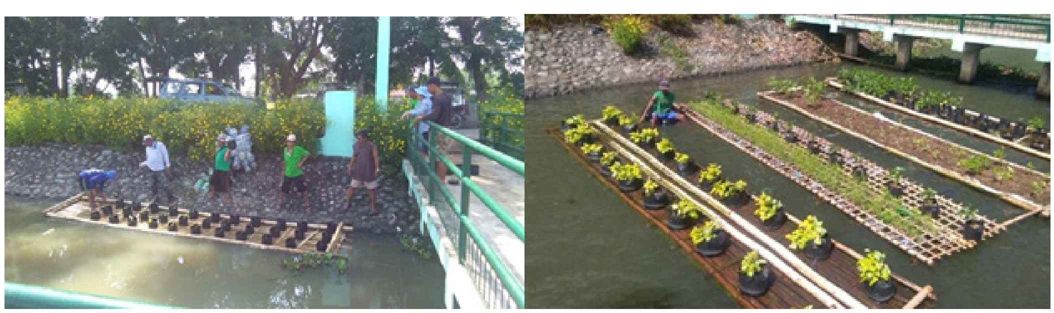


Figure 17. Planting and arranging plastic pots in bamboo raft model (left) and floating garden model set up (right) in SWRIP, Matingkis, Science City of Muñoz, Nueva Ecija

Figure 18. Harvesting (left) and the farmers with their harvest from floating garden models (right) in SWRIP, Matingkis, Science City of Muñoz, Nueva Ecija

Development of Value-Adding Technologies

MV Romero

In general, marketing crops in raw or fresh form is not very profitable because of their low market value. This is especially true with paddy rice, which is now sold for as low as P10.00/kg. An excellent way to help increase farmers' income is by adding value to their produce through processing, which translates to more premium price. Moreover, the by-products they generate from rice production (straw, hull, and bran) or other waste materials in their farms can be transformed into something with economic value or even contribute to reducing production cost. For some by-products with heating values, this could result in reducing their dependence on fossil-based energy source.

Aside from providing opportunities to generate additional income, this project also contributes to food and nutrition security in rice and rice-based farming households, shielding them from the impact of food and energy crises brought about by climate change and the possible economic depression they may encounter in case they are not yet prepared for the ASEAN economic integration.

This project aimed to develop value-adding technologies for rice, by-products, and other crops in the rice environment to help increase the income and improve the nutritional status of the members of the rice-based farming community. Five studies were implemented: (1) Upscale production of gamma-aminobutyric acid (GABA) rice and its potential as base ingredient for instant and ready-to-eat foods; (2) Rice-based complementary foods and beverage: Value-added products for enhanced nutrition and income among rice-based farm households; (3) Utilization of stabilized rice bran (SRB) as food ingredients for functional food products; (4) Formulation, characterization, and efficacy testing of nanosilica structured biofertilizer for rice production; and (5) Development of carbonizer attachments for recovering heat as source of energy for processing Palayamanan products.

Study 1 upscaled the production of GABA rice and its color, sensory properties, and consumer acceptability were compared with that produced at laboratory scale. No significant difference was observed between the two in terms of color and sensory properties. Higher consumer preference and acceptability was obtained with GABA rice from upscale production. Shelf-life of the upscaled GABA rice was also evaluated. The color, pH, water activity (Aw), and proximate composition did not change significantly and the samples remained acceptable even after 12 weeks regardless of storage temperature. The total plate and coliform counts were within acceptable limits and no yeast, mold, and E. coli were detected in all the samples during storage.

Ready-to-eat (RTE) GABA rice meal with pork adobo as viand was developed through a series of product formulations and thermal processing. The final product from the best formulation was characterized for proximate composition, sensory properties, consumer acceptability, and commercial sterility. Aside from having high amounts of protein, fiber, fat, ash, and carbohydrates, it had comparable sensory properties with that of the freshly prepared GABA rice adobo (control). The product was also found to be commercially sterile. Shelf-life evaluation showed that the RTE GABA rice meal is safe to consume up to 11 months as shown by its acceptable pH, water activity, and microbial load.

Study 2 focused on developing nutritious value-added beverage from combinations of rice and local agricultural crops intended for older infants, young children, and school children. Three instant am enriched with carrot, sweet potato, and banana at 6% concentration were developed. They exhibited good hydration properties suitable for reconstitution and acceptable Aw and moisture content (MC). Three rice malt-based beverages were also developed with soybean, sesame, and peanut milk. The most favored formulations contained 30% soymilk, 70% sesame milk, and 50% peanut milk. After optimization, the physicochemical, functional, microbial, and nutritional composition of the products were characterized. The enriched rice malt-based beverages were slightly acidic, had low titratable acidity, and mid-range soluble solids. They were comparable with a commercial malt drink. A 300-mL serving is loaded with essential nutrients such as vitamins, minerals, and energy for 6- to 12-year-old children for optimal growth and development. Instant enriched am is a more convenient, nutritious, and shelf-stable alternative to traditional am for older infants while rice malt beverage products are healthy alternatives to calorie-laden drinks.

In Study 3, oven heating, infrared heating, steam heating, and microwave heating were screened for their efficiency in stabilizing NSIC Rc 160 bran. The proximate composition, total phenolic content (TPC), DPPH radical scavenging activity (DPPH-RSA), free fatty acid (FFA) content, and lipase activity of the bran before and after stabilization at different temperatures and times were compared. Steam heating exhibited the highest reduction in lipase activity with 10-minute exposure time as the most efficient and effective (up to 90%) among the evaluated techniques. Consequently, it can effectively slow down the production rate of FFA in rice bran during storage. Furthermore, shelf-life evaluation of SRB confirmed the effectiveness of steam heating in extending the quality of rice bran as indicated by their unchanged sensory properties (light brown color, pleasant aroma, no off-odor), steady lipase activities, and low production of FFA for six weeks.

To maximize the utilization of SRB, rice bran juice and rice bran biscuit were initially formulated. Products are optimized to improve their quality.

Study 4 synthesized, formulated, and tested nano biofertilizer on irrigated rice. Characterization of nanosilica (nSi) and nano calcium oxide (nCaO) through SEM micrographs showed that the synthesized nSi was <30nm, while XRD analysis showed a broad peak at $2\Theta = 21° - 22°$ indicating that the synthesized silica nanoparticles was amorphous. XRD analysis confirmed the purity of nCaO. Through SEM analysis, nCaO had semi-hexagonal-shaped particles, confirming its crystallinity.

Treatment with Fish Amino Acid (FAA) alone proved to be the best treatment as it gave the highest numerical NPK values. The incorporation of phosphorus (P) and potassium (K) of the plant samples and bacteria in combination worked together, with Nitrogen (N), P, and K that were lower than the control (FAA). NPK of treatments with FAA and with additional L. plantarum were not significantly different with each other. Therefore, the best treatment in terms of NPK content is treatment with FAA alone and the best treatment that has the highest bacterial count was observed in treatment with FAA, P, K, silica and L. plantarum.

The last study explored the potential of providing additional income opportunities for the rice farming households/communities, making use of the PhilRice-developed continuous-type rice hull (CtRH) carbonizer. Heat recovery attachments (HRAs) for the carbonizer were developed to provide heat for food processing as well as source of renewable energy to satisfy household's basic needs. The design of the previously developed multi-purpose (MP) dryer was further improved, resulting in the fabrication of a new prototype with 100% food-grade stainless steel, including the carbonizer's chimney which serves as its heat exchanger. A new prototype of the HRA with accompanying steam generator was also developed, together with a new design of the CtRH carbonizer. Both were fabricated mostly of ferrocement material to lower down material and fabrication cost. This new design of the CtRH carbonizer was already tested to work satisfactorily in carbonizing chopped and dried branches of trees and is also expected to work in other agricultural wastes like rice straw, coco husk, and coco shell. Furthermore, a prototype of a low pressure steam-operated (LPS) water pump was also designed and fabricated. Results of the preliminary test run, using compressed air at $1kgf/cm^2$ (15psi) as temporary substitute of steam, showed that the prototype could pump water at 225L/h although it is still below the targeted discharge of $1m^3/h$.

These value-adding technologies developed from rice, diversified rice-based farming products, and by-products contribute to the outcome on enhanced value, availability, and utilization of rice, diversified rice-based farming products, and by-products for better quality, safety, health, nutrition, and income.

Upscale Production of Gamma-Aminobutyric Acid (GABA) Rice and its Potential as Base Ingredient for Instant and Ready-to-Eat Foods

RM Bulatao, MB Castillo, JPA Samin, and MV Romero

This study aimed to upscale the production of high-quality GABA rice with at least one-month shelf-life and to develop a ready-to-eat (RTE) GABA rice meal. Twenty-five kg of NSIC Rc 160 brown rice was germinated for the upscale production of GABA rice (Figure 19). The produced GABA rice was then compared with that of laboratory scale (1kg) in terms of color values, sensory properties, and consumer acceptability. The GABA rice produced from the upscale and laboratory scale were comparable in color values and sensory properties. However, GABA rice produced upscale had higher preference and acceptability than the laboratory scale. Shelf-life evaluation showed that the color values, pH, water activity, and proximate compositions (ash, protein and fat) of GABA rice did not change significantly after 12 weeks regardless of storage temperature. Sensory properties were not also affected during storage, except for the slight fermented odor detected on the 6th week of storage. All GABA rice samples stored for 12 weeks remained acceptable as shown by their high acceptability scores. Microbial analyses indicated higher total plate and coliform counts in GABA rice stored at refrigerated temperature than those of room temperature. Values are within the acceptable limit. Yeast, mold, and *E. coli* were not detected in all samples during storage.

An RTE GABA rice meal with pork adobo as viand (Figure 20) was developed using 1:1.5 vinegar and soy sauce ratio, 1:1 GABA rice and pork adobo, direct cooking of GABA rice with water (1:1.5), and thermal processing for 15min. The developed RTE GABA rice meal had high amounts of ash, protein, fat, fiber, and carbohydrate content, and was found to be commercially sterile. Sensory evaluation showed that RTE GABA rice meal had comparable sensory properties with that of the freshly prepared GABA rice adobo (control). Despite its high consumer acceptability (n=50), RTE GABA rice meal (6.3) had slightly lower acceptability ranking with that of the control (7.0). The RTE GABA rice meal is still safe to consume up to 11 months as shown by its acceptable pH, water activity, and microbial load.

Figure 19. GABA rice from NSIC Rc 160

Figure 20. RTE GABA rice meal with pork adobo as viand

Rice-Based Complementary Foods and Beverage: Value-Added Products for Enhanced Nutrition and Income among Rice-Based Farm Households

RGA Ramos, EH Bandonill, ESA Labargan, PR Belgica, AV Morales, RB Rodriguez, and MV Romero

The study was designed to develop nutritious and adaptable value-added beverage from a specific combination of rice and local agricultural crops intended for older infants, young children, and school children. Three instant am enriched with carrot, sweet potato, and banana were developed while three rice malt-based beverages were formulated from healthy combinations of soybean, sesame, and peanut milk. Formulation of the products was optimized by varying the levels of primary ingredients. Consumer acceptability was measured. Physicochemical, functional, microbial, and nutritional composition of the products were also characterized. Enriched instant am powders exhibited good hydration properties suitable for reconstitution and acceptable Aw and moisture content. Both carrot and sweet potato-enriched instant am were found acceptable at 6% concentration than banana. Meanwhile, optimum conditions and suitable rice varieties for malting were determined for the rice malt beverage. The optimized rice malt peanut and soy beverage was subjected to consumer test (n=50) against a commercial brand among children. Results showed that suitable malting conditions of recommended varieties were steeping for 24h, germination for 48h, and kilning at 95°C for 24 h. Rice malt with 30% soymilk, 70% sesame milk, and 50% peanut milk were the most favored formulations for rice malt-based beverages. The enriched rice malt-based beverages were slightly acidic, had low titratable acidity, and mid-range soluble solids. Rice malt enriched with peanut and soy were comparable with the commercial malt drink. A 300-mL serving is loaded with essential nutrients for 6- to 12-year-old children who need a solid source of vitamins, minerals, and energy for active and optimal growth and development. Rice malt beverage products are healthy alternative to calorie-laden drinks while the instant enriched am is a more convenient, nutritious, and shelf-stable alternative to traditional am for older infants. The beverages were safe and fit for consumption.

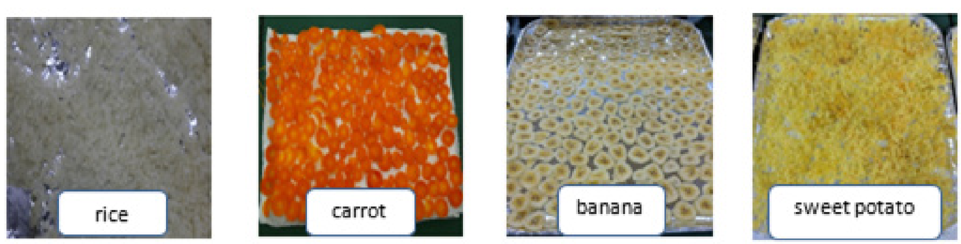


Figure 8. Different crops for production of instant *am* and instant enriched *am* powders

Photo credit: Princess R. Belgica

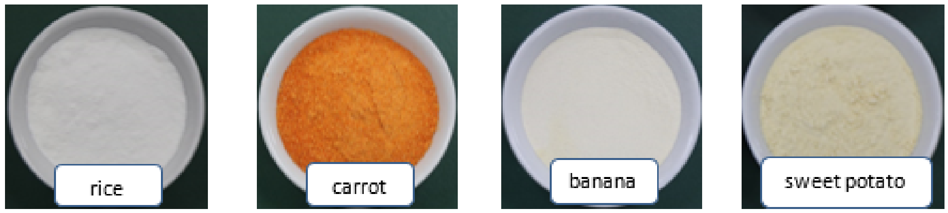


Figure 9. Instant *am* and instant enriched *am* powders *Photo credit: Princess R. Belgica*

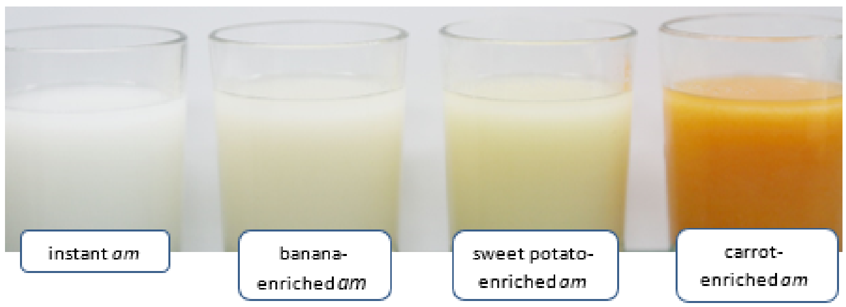


Figure 10. Reconsituted instant enriched “am” *Photo credit: Princess R. Belgica*

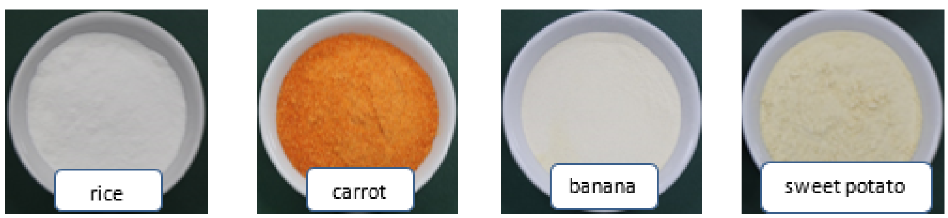


Figure 9. Instant *am* and instant enriched *am* powders *Photo credit: Princess R. Belgica*

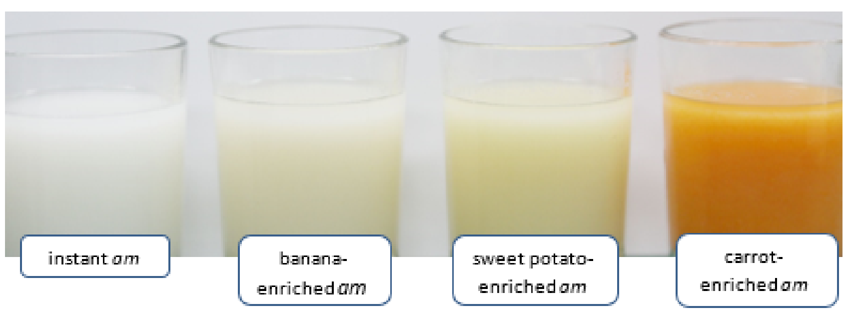


Figure 10. Reconsituted instant enriched “am” *Photo credit: Princess R. Belgica*

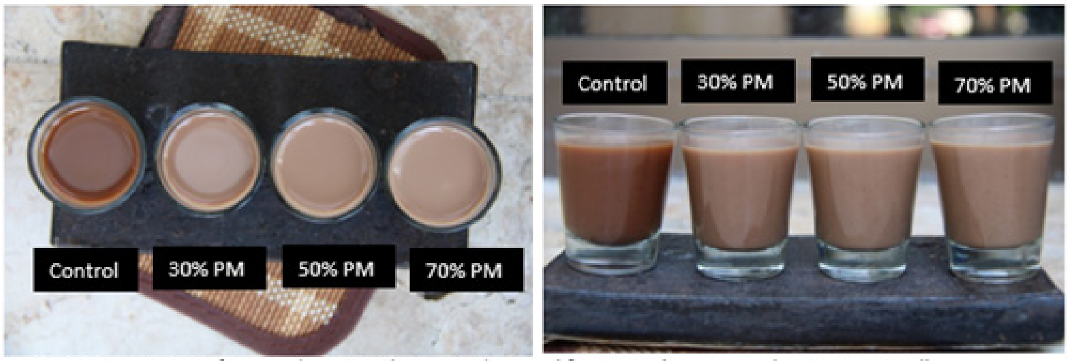


Figure 15. Treatments of rice malt-peanut beverage (top and front view) *PM=peanut milk

Photo credit: El Shaira A. Labargan

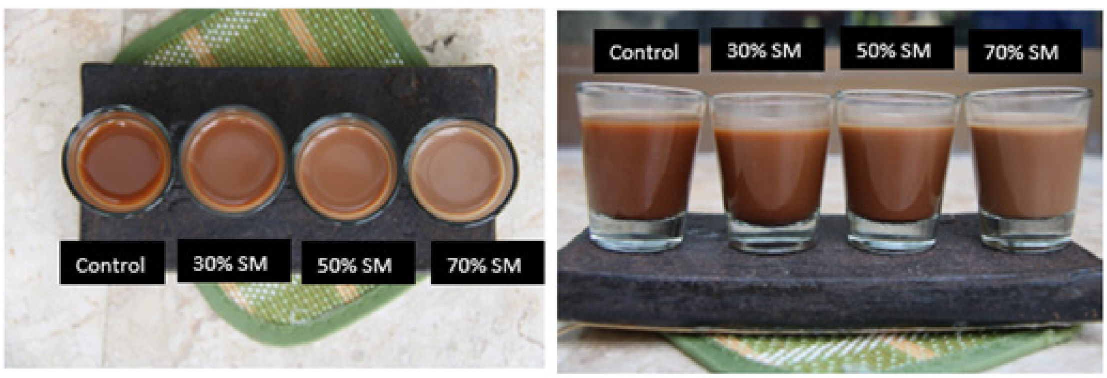


Figure 16. Treatments of rice malt-sesame beverage samples (top and front view) *SM= sesame milk

Photo credit: El Shaira A. Labargan

Figure 17. Rice malt-soy beverage product protoype

Photo credit: El Shaira A. Labargan

Utilization of Stabilized Rice Bran as Food Ingredient for Functional Food Products

JPA Samin, MB Castillo, RM Bulatao, and MV Romero

This study was conducted to stabilize and develop various food products from rice bran. Bran from NSIC Rc 160 was collected and subjected to different stabilization techniques such as oven, infrared, steam, and microwave heating (Figure 21). Optimization was carried out by exposing bran samples to different temperatures and times. To measure effectiveness of each stabilization technique, proximate composition, total phenolic content (TPC), DPPH radical scavenging activity (DPPH-RSA), free fatty acid (FFA) content, and lipase activity of bran were determined before and after stabilization. The shelf-life of stabilized rice bran (SRB) was evaluated using the most efficient stabilization technique stored in a plastic pouch at room (25-30°C) and refrigerated (4-8°C) temperatures. Sampling was done every two weeks for six months. SRB was characterized in terms of color values, FFA content, lipase activity, and sensory properties. Results showed that the proximate composition of rice bran was not significantly affected by various stabilization techniques, except for moisture content, which is expected due to the application of heat. For phytochemical properties, oven and microwave heating significantly increased the TPC and DPPH-RSA of bran after stabilization. There was minimal reduction in FFA content in the bran samples after stabilization. However, longer exposure of bran samples to higher temperatures had significantly lower FFA content after one month of storage. Among the techniques, steam heating exhibited the highest reduction in lipase activity with 10-minute exposure time as the most efficient and effective (up to 90%). This means that steam heating can effectively slow down the production rate of FFAs in rice bran during storage. Shelf-life evaluation of SRB confirmed the effectiveness of steam heating in extending the quality of rice bran as indicated by their unchanged sensory properties (light brown color, pleasant aroma, and no off-odor), steady lipase activities, and low production of FFA's for six weeks. Two products from stabilized rice bran – juice and biscuit – were initially formulated (Figure 22).

The study concluded that steam heating can be a cheap and effective technique in extending the shelf-life of rice bran, which can be used in developing healthy and nutritious food products for Filipino consumers.

Abbreviations and acronyms

AYT - Advanced Yield Trial
ABE - Agricultural and Biosystems Engineering
AEW - Agricultural Extension Worker
ATI – Agriculture Training Institute
AESA - Agro-ecosystem Analysis
AC - Amylose Content
BLB - Bacterial Leaf Blight
BLS -Bacterial Leaf Streak
BCA - Biological Control Agent
BS - Breeder Seeds
BPH -Brown Planthopper
BPI - Bureau of Plant Industry
CGMS - Cytoplasmic Genic Male Sterility
COF - Commercial Organic Fertilizer
CDA - Cooperative Development Authority
DAS - Days After Sowing
DAT - Days After Transplanting
DF - Days to Flowering
DM- Days to Maturity
DAR - Department of Agrarian Reform
DA-RFOs - Department of Agriculture-Regional Field Offices
DoF - Department of Finance
DOLE - Department of Labor and Employment
DTI - Department of Trade and Industry
DSR - Direct-seeded Rice
DS - Dry Season
FBS – Farmers' Business School
FC - Farmers' Cooperative
FSM - Farming Systems Models
FAA - Fish Amino Acid
FGD - Focused Group Discussion
FSP - Foundation Seed Production
FRK - Farm Record Keeping
GABA - Gamma-aminobutyric Acid
GT - Gelatinization Temperature
GAD - Gender and Development
GYT - General Yield Trial
GCA - Genetic Combining Ability
GIS - Geographic information system
GEMS - Germplasm Management System
GAS - Golden Apple Snail
GL - Grain Length
GQ - Grain Quality
GW - Grain Weight
GY - Grain Yield
GLH - Green Leafhopper
GOT - Grow Out Test
HR - Head Rice
HRA - Heat Recovery Attachment
HIPS – Highly-intensified Production System
HQS - High-quality Rice Seeds
HON - Hybrid Observational Nursery
HPYT - Hybrid Preliminary Yield Trial
ICT - Information and Communication Technology
IEC - Information Education Communication
IBNM - Inorganic-based Nutrient Management
ICM - Integrated Crop Management
IPM - Integrated Pest Management
JICA - Japan International Cooperation Agency
IRRI - International Rice Research Institute
IA - Irrigators' Association
KP - Knowledge Product
KSL - Knowledge Sharing and Learning
LCC - Leaf Color Chart
LFT - Local Farmer Technicians
LGU - Local Government Units
LPS - Low Pressure Steam-operated
LE-CYPRO - Lowland ecotype Cyperus rotundus
MFE - Male Fertile Environment
MSE - Male Sterile Environment
MAS - Marker-assisted Selection
MRL - Maximum Root Length
MR - Milled Rice
MER - Minimum Enclosing Rectangle
MOET - Minus-One Element Technique
MC - Moisture Content
MAT - Multi-Adaptation Trials

MCRTP - Multi-crop Reduced Till Planter
MET - Multi-environment Trial
MYT - Multi-location Yield Trial
NAAP - National Azolla Action Program
NCT - National Cooperative Test
NFA - National Food Authority
NRAM - National Rice Awareness Month
NSIC - National Seed Industry Council
NSQCS - National Seed Quality Control Services
N - Nitrogen
NBSP - Nucleus and Breeder Seed Production Project
NFGP - Number of Filled Grains Panicle
ON - Observation Nursery
OSIS - One-Stop Information Shop
OBNM - Organic-based Nutrient Management
PL - Panicle Length
PW - Panicle Weight
PVS - Participatory Varietal Selection
PWD - Person with Disabilities
PHilMech - Philippine Center for Postharvest Development and Mechanization
PRISM - Philippine Rice Information System
PhilRice - Philippine Rice Research Institute
PSA - Philippine Statistics Authority
PTC - PhilRice Text Center
P - Phosphorus
PVS - Plant Variety Selection
K - Potassium
QTL - Quantitative Trait Loci
RCBD - Randomized Complete Block Design
RSP - Registered Seed Production
RBB - Rice Black Bug
RCEF - Rice Competitiveness Enhancement Fund
RCEP - Rice Competitiveness Enhancement Program
RCM - Rice Crop Manager
RHGEPS - Rice Hull Gasifier Engine Pump System
RPH - Rice Planthopper
RSTC - Rice Specialists' Training Course
RTV - Rice Tungro Virus
RBFHS - Rice-based Farming Household Survey
KQ - Kernel Quality
SV - Seedling Vigor
ShB - Sheath Blight
ShR - Sheath Rot
SMS - Short Messaging Service
SNP - Single Nucleotide Polymorphism
SWRIP- Small Water Reservoir Irrigation Project
SRB - Stabilized Rice Bran
SUCs - State Universities and Colleges
SB - Stem Borer
TESDA - Technical Education and Skills Development Authority
TDF - Technology Demonstration Farm
TRV - Traditional Rice Varieties
TOT - Training of Trainers
TPR - Transplanted Rice
URBFS - Upland Rice-Based Farming
WS - Wet Season
WCV - Wide Compatibility Variety
YSB - Yellow Stem Borer

Editorial team

We are a government corporate entity (Classification E) under the Department of Agriculture. We were created through Executive Order 1061 on 5 November 1985 (as amended) to help develop high-yielding and cost-reducing technologies so farmers can produce enough rice for all Filipinos.

With a "Rice-Secure Philippines" vision, we want the Filipino rice farmers and the Philippine rice industry to be competitive through research for development in our central and seven branch stations, coordinating with a network that comprises 59 agencies strategically located nationwide.

We have the following certifications: ISO 9001:2008 (Quality Management), ISO 14001:2004 (Environmental Management), and OHSAS 18001:2007 (Occupational Health and Safety Assessment Series).

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