ARTICLE

Grain quality of rice in selected retail stores and supermarkets in the Philippines

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Abstract—All open-bin milled and brown rices sold in selected rural retail stores and urban retail stores and a supermarket near the Philippine Rice Research Institute (PhilRice) Central Experiment Station and six PhilRice branch stations and some areas in Metro Manila were collected in 2012–2013 and their market labels and selling price per kg were noted. The samples were analyzed for grain quality at PhilRice Los Baños to describe the grain quality profile of rice in the Philippine retail market and determine the changes in local market trends in rice grain quality relevant to the last survey in 2000. Out of 388 nonwaxy milled rice samples collected, 217 were intermediate apparent amylose content (AC, mean of 20.9%), followed by 141 high AC, and 30 low AC, while 36 glutinous (waxy) rice samples were also collected. However, high-AC rice dominated in Nueva Ecija, Laguna and Camarines Sur. In general, nonwaxy milled rices in the market were long-grained and had slender shape. Mean grain length was 6.7 mm, mean grain shape (length-width ratio) was 3.1, and mean percent chalky grains was 14% (milled rice basis). Field test for apparent amylose type classification required 40% more iodine for staining the grains due to the oxidized state of the sample surface, which reacted with the iodine and tended to underestimate AC type. This iodine-staining method estimated AC type adequately (81.4 %) with most of the errors being borderline AC values of 17±1% and 22±1%. Gelatinization temperature (GT) indexed by alkali spreading value was more intermediate–high than low. Brown rice and waxy rice were available in most markets surveyed. Waxy rice, particularly shorter-grained, was more expensive than nonwaxy rice and mainly had low GT. Brown rice was mainly intermediate AC with mean AC value lower than that of milled rice (19.1% vs 20.9%), and had varying GT. Majority of the imported rices were Thai and Japanese, with low AC and low GT. The existing grain quality profile and trends in the Philippine retail market may have significant implications on rice varietal improvement and rice commercialization programs in the country, particularly on future breeding objectives for grain quality and in selecting good quality inbreds and hybrids for varietal promotion, respectively.

Keywords—alkali spreading value, apparent amylose content, field test for amylose type, gelatinization temperature, Instron cooked rice hardness, milled rice physical properties, price, retail store, supermarket

INTRODUCTION

Apparent amylose content (AC), the linear fraction of starch, is the major determinant of Philippine rice grain quality (Juliano 2010). It is classified into waxy (glutinous), low, intermediate, and high. Low-AC nonwaxy rice varieties have soft cooked rice while varieties with higher AC tend to have dry, flaky and harder cooked rice with separated grains, higher volume expansion and water absorption than low-AC rice. Moreover, stickiness is negatively correlated with AC and waxy rices, essentially having zero amylose, generally result in more sticky cooked rice than nonwaxy rices (Juliano 2007; 2010). Filipinos generally prefer soft cooked rice corresponding to intermediate- to low-AC, but those engaged in labor-intensive jobs (*e.g.*, crop plantation laborers and farmers) prefer rices which are slowly digested and have longer staying power corresponding to high-AC varieties (Juliano 2010; 2016).

The mean AC of Philippine market rices in the 1980's was high (Juliano et al. 1989) and due to the Philippine breeding objective for intermediate AC, mean AC of market samples became intermediate in the 2000's and now include some low-AC rices (Mangaoang et al. 2002; Juliano 2010; 2016). A few low-AC hybrid varieties have been released and the preference of sensory evaluation consumer panel in the National

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Cooperative Tests (NCT) has shifted from intermediate AC to low AC (Tuaño et al. 2014). In addition, survey of farmers' specialty rices in 2009–2012 showed the distribution of nonwaxy rices to be 37% low AC, 51% intermediate AC and only 12% high AC (Tuaño et al. 2015). To date, there has been no report on the grain quality characteristics of Philippine market rices, both milled and brown rices, since the previous market survey in 2000 (Mangaoang et al. 2002). Determining grain quality trends in the Philippine retail market is essential in supporting government efforts to: 1) develop new rice varieties acceptable to farmers and consumers; 2) popularize and commercialize good quality public inbred and hybrid varieties in the country; and 3) serve as guide in updating national quality standards for rice. High milling recovery, good physical attributes and soft cooked rice texture are considered in the release of new varieties and in the selection of which to promote and commercialize, aside from high grain yield and other agronomic characteristics desirable to Filipino farmers. The breeding program also needs some kind of feedback mechanism as to how fast a certain rice variety gets adopted by the farmers, reaches the market and the consumers. Also, the flow of newly released varieties having relatively lower AC, from the breeders to the consumers, has to be monitored since continuous lowering in AC has some nutritional implications especially to milled-rice eating population.

Glycemic index studies on Philippine milled rice showed that low-AC rice has high glycemic index and its consumption may increase the incidence of type 2 diabetes. Intermediate-AC rice tends to have medium glycemic index and would be preferred nutritionally over low-AC rice. High-AC rice tends to have medium or low glycemic index (Trinidad et al. 2013; 2014). In addition, satiety response tends to be higher for intermediate- than for low-AC cooked rice (Felix et al. 2013; 2016).

Brown rice has become common in some retail markets in the country but more expensive than milled rice. Its cooking and eating quality have been recently studied using Philippine released modern varieties. Corpuz (2013) reported that low-AC brown rice, such as NSIC Rc160, is the most acceptable cooked brown rice. It has been found that only waxy and low-AC rices had a significant drop in glycemic index when consumed as cooked brown rice. Intermediate- and high-AC brown rices tend to have medium to low glycemic index and the lowering of glycemic index from milled to brown rice was narrow and not significant (Trinidad et al. 2013; 2014). A survey in 2009 in Luzon showed that the average monthly consumption of brown rice per household was low while annual production output of 10 brown rice producers was approximately 396 metric tons. Main reasons of low brown rice consumption among Filipinos were its high price, unavailability in retail stores, poor eating quality and limited information on its nutritional importance (Pabuayon and Quilloy 2011).

A survey of open-bin rices in selected rural and urban retail stores and a supermarket near PhilRice stations was undertaken in 2012–2013. These were subjected to grain quality evaluation to describe the grain quality profile of Philippine market rices and confirm the changes in grain quality trends and preferences for rice by consumers since the last survey in 2000 (Mangaoang et al. 2002). Moreover, correlations among grain properties and market prices were determined. A rapid iodine-staining field test for AC type was developed using Philippine released varieties (Tuaño et al. 2009) and intended for milled rice quality classification in the market. Its applicability to actual retail market milled rice samples was also tested.

MATERIALS AND METHODS

Rice Samples

Open-bin rice samples (100–250 g) were collected from selected retail stores and supermarkets near PhilRice Central Experiment Station and branch stations (*i.e.*, within the station's municipality/public market and nearby towns) by PhilRice staff and sent by courier to PhilRice Los Baños for grain quality analysis. In each public market, two to three distant retail stores having the highest number of rice samples sold in their open-bins were selected. All open-bin rice samples in these stores were collected including brown rice samples, if available. In supermarkets, all open-bin rice samples were also collected whether presented with local or imported variety names/market labels. Samples from Metro Manila were obtained by PhilRice Los Baños staff from selected supermarkets and public markets in Quezon City and Manila. For Ilocos Norte and Nueva Ecija, sampling was done twice in some stores and supermarkets within six months and labeled Set 1 and Set 2 (Table 1). Price per kg and market labels/names and related descriptions were recorded. Portions of the collected brown rice samples (100 g each) were polished using McGill mill no. 2 and the resulting milled rice samples were used for grain quality analysis.

Apparent Amylose Type by Iodine-staining, Apparent Amylose Content, and Alkali Spreading Value

Apparent amylose content (AC) type was determined by the iodine-staining method developed by Tuaño et al. (2009), except the iodine concentration was increased from 0.010% (1.5 mL 0.2% iodine in 2.0% KI in 30 mL distilled water) to 0.014% (2.1 mL 0.2% iodine in 2.0% KI in 30 mL distilled water) to give allowance for higher surface fat oxidation of market milled rice samples. Only the major AC type of each sample was recorded relative to standard rice checks of known AC types that were stained similarly along with the market samples. AC type was verified by actual AC analysis of milled rice flour (60-mesh) in ammonium buffer by the amylose-iodine blue color read at 620 nm, using potato amylose as standard (Juliano et al. 2012) and classified into waxy 0–2%; low AC 10.1–17.0%, intermediate AC 17.1–22.0% and high AC > 22.0% (Tuaño et al. 2014; 2015). For waxy rice samples, absorbance was read after 2 h color development instead of 20–60 min to reduce amylopectin-iodine interference (Tuaño et al. 2014). Gelatinization temperature (GT) type was estimated by the alkali spreading value (ASV) from the digestion of triplicate six whole grains of milled rice in 1.7% KOH for 23 h at room temperature (Little et al. 1958) and classified as low GT for ASV 5.5–7.0, intermediate GT for ASV 3.5–5.4 and high GT for ASV ≤ 3.4. Waxy and low-AC rices do not have intermediate GT, but considered as high GT (Tuaño et al. 2014).

Grain Dimensions and Chalkiness

Length and width (in mm) of 10 whole milled rice grains were measured in duplicate using a photoenlarger magnifying 10X and grain shape was determined by the calculated length-width ratio (L/W). Chalky grains (> 50% of the grain having chalky/opaque portion) were manually separated in duplicate 30-g sample and expressed as percent chalky grains (milled rice basis) (Tuaño et al. 2015).

Instron Hardness of Freshly Cooked Rice

Milled rice (20 g) was cooked in 24 mL distilled water in 150 mL beakers for 20 min, four beakers in a rice cooker, with 200 mL distilled water in the outer pot. The beaker with cooked rice (with water uptake ratio of 1.1–1.2) was covered with aluminum foil, transferred into a sealed polyethylene plastic

Table 1. Summary of properties of nonwaxy milled rice samples in selected Philippine rural and urban retail stores and supermarkets collected in 2012–2013.

Province, market and store	*n*	AC type (dist'n)[a]	AC (%) (dist'n)[a]		ASV[b] (dist'n)[a]		Instron hardness (kg cm^{-2})		Grain length[c] (mm)		Grain shape[d] (L/W)		Chalky grains (%)	
		L-I-H	Mean	L-I-H	L-IH	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Ilocos Norte Set 1														
San Nicolas PM, store 1	4	0-2-2	22.7 H	0-1-3	2-2	5.3 I	1.9 – 3.2	2.6	6.6 – 7.0	6.8 L	3.0 – 3.4	3.2 S	7 – 15	11
San Nicolas PM, store 2	4	0-2-2	22.2 H	0-2-2	3-1	5.6 L	2.5 – 3.0	2.7	6.6 – 6.9	6.8 L	3.0 – 3.4	3.2 S	5 – 12	10
Batac PM, store 1	5	0-3-2	22.1 H	0-2-3	4-1	5.6 L	2.4 – 3.6	2.9	6.5 – 6.8	6.7 L	2.9 – 3.4	3.2 S	7 – 11	9
Batac PM, store 2	4	0-4-0	20.8 I	0-4-0	1-3	5.2 I	1.9 – 3.1	2.4	6.5 – 6.8	6.6 L	3.0 – 3.3	3.1 S	7 – 12	10
*Robinson's San Nicolas	3	0-1-2	21.8 I	0-2-1	0-3	5.3 I	2.2 – 2.6	2.4	6.9 – 7.2	7.0 L	3.1 – 3.4	3.3 S	7 – 11	9
TOTAL	**20**	**0-12-8**	**21.9 I**	**0-11-9**	**10-10**	**5.4 I**	**1.9 – 3.6**	**2.6**	**6.5 – 7.2**	**6.8 L**	**2.9 – 3.4**	**3.2 S**	**5 – 15**	**10**
Ilocos Norte Set 2														
San Nicolas PM, store 1	4	0-4-0	20.2 I	0-3-1	4-0	6.1 L	2.1 – 3.0	2.5	6.8 – 7.1	6.9 L	3.1 – 3.4	3.3 S	9 – 14	11
Batac PM, store 1	4	0-4-0	20.4 I	0-3-1	3-1	5.4 I	1.9 – 2.4	2.1	6.6 – 6.9	6.8 L	3.0 – 3.3	3.2 S	10 – 19	16
*Robinson's San Nicolas	8	0-8-0	20.2 I	0-8-0	5-3	5.7 L	2.0 – 2.6	2.4	6.6 – 6.8	6.7 L	3.1 – 3.3	3.2 S	6 – 26	16
TOTAL	**16**	**0-16-0**	**20.3 I**	**0-14-2**	**12-4**	**5.7 L**	**1.9 – 3.0**	**2.3**	**6.6 – 7.1**	**6.8 L**	**3.0 – 3.4**	**3.2 S**	**6 – 26**	**14**
Isabela														
San Mateo PM, store 1	8	2-6-0	18.8 I	2-6-0	3-5	5.4 I	2.1 – 3.4	2.7	6.7 – 7.1	6.9 L	2.8 – 3.3	3.2 S	11 – 20	16
San Mateo PM, store 2	3	0-3-0	19.3 I	0-3-0	0-3	5.1 I	2.7 – 2.9	2.8	6.6 – 7.0	6.8 L	3.1 – 3.3	3.2 S	12 – 18	15
*SM Santiago City	7	1-5-1	19.8 I	1-6-0	2-5	5.5 L	1.7 – 3.9	2.5	4.9 – 7.8	6.7 L	1.7 – 3.8	3.1 S	4 – 32	14
TOTAL	**18**	**3-14-1**	**19.3 I**	**3-15-0**	**5-13**	**5.4 I**	**1.7 – 3.9**	**2.6**	**4.9 – 7.8**	**6.8 L**	**1.7 – 3.8**	**3.2 S**	**4 – 32**	**15**
Nueva Ecija Set 1														
San Jose City PM	8	1-7-0	20.1 I	1-7-0	2-6	5.3 I	1.9 – 2.8	2.5	6.5 – 6.9	6.7 L	2.6 – 3.3	3.0 I	8 – 24	15
Muñoz PM	14	0-6-8	22.5 H	0-3-11	0-14	4.4 I	2.4 – 3.2	2.6	6.4 – 7.0	6.6 L	3.0 – 3.3	3.2 S	6 – 30	22
*Puregold Cabanatuan	5	0-1-4	22.5 H	0-1-4	0-5	4.9 I	2.3 – 2.6	2.5	6.5 – 6.8	6.7 L	3.0 – 3.2	3.1 S	10 – 15	12
TOTAL	**27**	**1-14-12**	**22.1 H**	**1-11-15**	**2-25**	**4.8 I**	**1.9 – 3.2**	**2.6**	**6.4 – 7.0**	**6.7 L**	**2.6 – 3.3**	**3.1 S**	**6 – 30**	**16**
Nueva Ecija Set 2														
San Jose City PM	8	0-6-2	21.2 I	0-5-3	2-6	5.5 L	1.6 – 2.5	2.1	6.7 – 7.0	6.9 L	3.0 – 3.2	3.2 S	5 – 29	15
Muñoz PM	13	0-8-5	22.8 H	0-3-10	5-8	5.5 L	1.7 – 2.5	2.2	6.6 – 7.1	6.9 L	3.2 – 3.4	3.3 S	6 – 16	10
*Puregold Cabanatuan	6	0-4-2	21.1 I	0-4-2	0-6	5.0 I	2.1 – 2.6	2.3	6.7 – 7.1	6.8 L	3.1 – 3.3	3.2 S	13 – 23	17
TOTAL	**27**	**0-18-9**	**22.0 I**	**0-12-15**	**7-20**	**5.3 I**	**1.6 – 2.6**	**2.2**	**6.6 – 7.0**	**6.9 L**	**3.0 – 3.4**	**3.2 S**	**5 – 29**	**14**
Metro Manila														
Galas market, QC, store 1	8	0-8-0	20.7 I	0-7-1	1-7	5.3 I	2.1 – 2.7	2.4	6.7 – 7.1	6.9 L	3.0 – 3.4	3.2 S	4 – 23	9
Galas market, QC, store 2	33	1-22-10	21.4 I	1-22-10	20-13	5.7 L	1.8 – 3.2	2.5	6.6 – 7.2	6.8 L	2.8 – 3.4	3.2 S	4 – 42	15
Balintawak market, QC	10	0-10-0	19.8 I	0-10-0	5-5	5.4 I	1.7 – 2.9	2.2	5.6 – 7.0	6.7 L	2.6 – 3.4	3.1 S	4 – 15	9
*Puregold Central, QC	3	0-2-1	21.0 I	0-3-0	1-2	5.1 I	2.0 – 2.5	2.3	6.9 – 7.2	7.0 L	3.1 – 3.4	3.2 S	6 – 10	9
*SM North EDSA, QC	8	2-6-0	18.8 I	2-6-0	3-5	5.7 L	1.5 – 2.9	2.2	4.9 – 7.3	6.5 L	1.6 – 3.6	3.0 I	3 – 18	11
*SM San Lazaro, Manila	18	3-5-10	19.9 I	3-8-7	5-13	5.3 I	1.4 – 3.2	2.3	4.8 – 7.2	6.6 L	1.7 – 3.5	3.1 S	3 – 28	15
*SaveMore, Aurora, QC	13	0-5-8	22.6 H	0-2-11	3-10	5.4 I	2.0 – 3.2	2.4	6.6 – 7.0	6.8 L	3.0 – 3.4	3.2 S	12 – 36	19
TOTAL	**93**	**6-58-29**	**20.9 I**	**6-58-29**	**38-55**	**5.5 L**	**1.4 – 3.2**	**2.3**	**4.8 – 7.3**	**6.8 L**	**1.6 – 3.6**	**3.1 S**	**3 – 42**	**12**
Laguna														
Los Baños Garrett's store	9	1-5-3	21.6 I	0-5-4	5-4	5.6 L	1.8 – 4.4	2.7	6.6 – 7.3	6.8 L	3.0 – 3.2	3.1 S	4 – 26	14
Los Baños BM, store 1	9	0-5-4	22.6 H	0-2-7	6-3	5.7 L	1.9 – 2.7	2.3	6.7 – 7.2	6.8 L	3.0 – 3.2	3.1 S	5 – 32	16
Los Baños BM, store 2	10	0-9-1	20.6 I	0-8-2	4-6	5.3 I	1.8 – 3.3	2.4	6.6 – 7.0	6.8 L	3.1 – 3.3	3.2 S	7 – 30	13
*Robinson's Los Baños	6	1-4-1	20.1 I	1-4-1	5-1	5.8 L	1.5 – 2.7	2.2	4.9 – 7.1	6.6 L	1.7 – 3.3	3.0 I	6 – 16	10
*SaveMore, Los Baños	14	2-2-10	21.7 I	2-0-12	10-4	5.7 L	1.6 – 3.1	2.4	5.0 – 7.1	6.6 L	1.7 – 3.4	3.1 S	5 – 21	15
*Waltermart Los Baños	5	0-5-0	19.1 I	0-5-0	3-2	5.6 L	1.7 – 2.0	1.8	6.6 – 7.0	6.8 L	3.0 – 3.3	3.1 S	8 – 28	15
*SM City Sta. Rosa	21	2-6-13	22.2 H	3-2-16	7-14	5.5 L	1.6 – 3.1	2.5	4.7 – 7.0	6.6 L	1.7 – 3.4	3.1 S	2 – 31	16
TOTAL	**74**	**6-36-32**	**21.5 I**	**6-26-42**	**40-34**	**5.6 L**	**1.5 – 4.4**	**2.4**	**4.7 – 7.3**	**6.7 L**	**1.7 – 3.4**	**3.1 S**	**2 – 32**	**14**
Camarines Sur														
*LLC Supermart, Iriga City	6	0-2-4	22.5 H	0-2-4	1-5	5.1 I	2.2 – 2.8	2.6	6.4 – 6.9	6.6 L	2.9 – 3.3	3.1 S	8 – 22	14
*SM City Naga	12	2-5-3	21.4 I	2-2-8	4-8	5.4 I	1.5 – 2.8	2.3	5.0 – 7.0	6.6 L	1.7 – 3.3	3.1 S	3 – 27	16
TOTAL	**18**	**2-7-9**	**21.8 I**	**2-4-12**	**5-13**	**5.3 I**	**1.5 – 2.8**	**2.4**	**5.0 – 7.0**	**6.6 L**	**1.7 – 3.3**	**3.1 S**	**3 – 27**	**15**
Negros Occidental														
Bacolod LM, store 1	11	0-5-6	21.9 I	0-6-5	4-7	5.4 I	2.4 – 3.4	2.7	6.4 – 6.9	6.6 L	3.0 – 3.3	3.1 S	3 – 25	14
Bacolod LM, store 2	9	0-4-5	21.8 I	0-5-4	3-6	5.3 I	2.7 – 3.3	2.9	6.6 – 6.9	6.7 L	2.9 – 3.1	3.0 I	8 – 23	14
Bacolod CM, store 1	7	0-3-4	21.6 I	0-5-2	1-6	5.2 I	2.7 – 3.0	2.8	6.6 – 6.9	6.7 L	2.9 – 3.2	3.0 I	6 – 29	17
Bacolod CM, store 2	7	0-3-4	22.3 H	0-2-5	2-5	5.7 L	2.5 – 3.4	2.9	6.6 – 7.0	6.8 L	3.0 – 3.3	3.1 S	4 – 24	16
*SM City Bacolod	14	2-12-0	20.3 I	2-12-0	10-4	5.7 L	1.8 – 3.2	2.6	4.8 – 6.8	6.4 L	1.7 – 3.1	2.9 I	4 – 19	12
TOTAL	**48**	**2-27-19**	**21.4 I**	**2-30-16**	**20-28**	**5.4 I**	**1.8 – 3.4**	**2.8**	**4.8 – 7.0**	**6.6 L**	**1.7 – 3.3**	**3.0 I**	**3 – 29**	**15**
Agusan del Norte														
Cabadbaran Dennis store	11	4-6-1	19.1 I	1-10-0	0-11	4.7 I	2.0 – 3.2	2.8	6.5 – 7.3	6.9 L	3.0 – 3.4	3.2 S	5 – 23	13
Butuan JFG Merchandising	5	3-2-0	16.2 L	3-2-0	0-5	4.6 H	1.7 – 2.2	2.0	6.5 – 6.9	6.7 L	3.0 – 3.2	3.1 S	6 – 24	13
Butuan SJGRCC	9	3-5-1	17.4 I	3-5-1	1-8	5.2 I	1.4 – 2.7	2.0	6.5 – 7.0	6.8 L	3.0 – 3.2	3.1 S	7 – 32	16
Butuan Pin-Apple Market	7	3-4-0	18.4 I	2-5-0	0-7	4.9 I	1.6 – 2.9	2.2	5.5 – 7.0	6.7 L	2.2 – 3.3	3.0 I	9 – 21	16
Butuan German store	2	1-1-0	19.0 I	0-2-0	1-1	5.2 I	1.7 – 2.0	1.8	6.9 – 6.9	6.9 L	3.3 – 3.3	3.3 S	9 – 15	12
Butuan Herman's store	4	0-4-0	18.4 I	0-4-0	2-2	5.3 I	2.1 – 2.3	2.2	6.8 – 7.0	6.9 L	3.1 – 3.3	3.2 S	8 – 19	15
*Puregold Butuan	5	1-4-0	18.5 I	1-4-0	0-5	4.6 I	1.9 – 2.4	2.2	5.5 – 7.2	6.4 L	2.1 – 3.3	2.8 I	17 – 29	21
*Robinson's Butuan	4	1-3-0	19.2 I	0-4-0	1-3	5.5 L	1.9 – 3.6	2.4	6.8 – 7.2	7.0 L	3.2 – 3.3	3.3 S	9 – 18	14
TOTAL	**47**	**16-29-2**	**18.2 I**	**10-36-1**	**5-42**	**4.9 I**	**1.4 – 3.6**	**2.2**	**5.5 – 7.2**	**6.8 L**	**2.1 – 3.4**	**3.1 S**	**5 – 32**	**15**
OVER-ALL TOTAL	**388**	**36-231-121**	**20.9 I**	**30-217-141**	**144-244**	**5.4 I**	**1.4 – 4.4**	**2.4**	**4.7 – 7.8**	**6.7 L**	**1.6 – 3.8**	**3.1 S**	**2 – 42**	**14**

AC - apparent amylose content; ASV - alkali spreading value; AC type was determined by the iodine staining field test for AC. [a]dist'n - distribution. [b]Gelatinization temperature type by ASV - low (L) GT for ASV 5.5–7.0; intermediate (I) GT for ASV 3.5–5.4; high (H) GT for ASV ≤ 3.4. [c]Grain length (mm) - extra long (EL) ≥ 7.5; long (L) 6.4–7.4; medium (M) 5.5–6.3; short (S) < 5.4. [d]Grain shape (length-width ratio, L/W) - slender (S) > 3.0; intermediate (I) 2.0–3.0; round (R) < 2.0. PM - public market; BM - Bgy. Batong Malake; QC - Quezon City; LM - Libertad market; CM - central market. *Supermarket

bag, and cooled for 1 h at room temperature. Instron hardness of freshly cooked rice was measured on 17 g cooked milled rice in an Ottawa Texture Measuring System 10-cm² cell according to Tuaño et al. (2011) using Instron 3343 controlled through the BlueHill V.2.0 software. For Instron hardness of freshly cooked brown rice, samples were soaked in water for 30 min before cooking with 1.1–1.2 water uptake ratio and were treated similarly as in cooked milled rice above.

Simple linear correlation coefficients were calculated among the various grain properties and price of the market samples to determine relationships among these parameters.

RESULTS AND DISCUSSION

Apparent Amylose Content and Gelatinization Temperature Types

Out of 388 nonwaxy milled rices, only 316 (81.4%) were correctly classified using the field test for AC type: 49 were underestimated and 23 were overestimated. The iodine-staining field test reported 36 low AC, 231 intermediate AC and 121 high AC (Table 1). Overall, low- and intermediate-AC types were overestimated and high-AC type was underestimated. Wrong AC typing ranged from 5.6% (Isabela) to 29.6% (Nueva Ecija set 2) for the various sample sources. Most of them involved AC values 17±1% and 22±1% or borderline AC cases as verified through iodine colorimetric AC of particular samples (data not shown). However, field test AC type and colorimetric AC were still highly significantly correlated (Table 2). Also, selling price of nonwaxy milled rice correlated significantly and negatively with field test AC type.

The original protocol of Tuaño et al. (2009) used 0.01% iodine staining solution to stain grains of pure samples (*i.e.*, samples of true-to-type Philippine varieties free from contaminating grains of other varieties) to determine AC type. Grains were evenly stained except those samples with high proportions of chalky grains which were disregarded while scoring for AC type relative to standard rice checks of known AC. These samples were properly harvested, processed and aged prior to analysis (Tuaño et al. 2009). In contrast, the present study involved market milled rice samples which might have come from mixture of rough or milled rice and were probably stored or exposed as milled rice relatively longer than the pure samples in the previous study. This might have caused the grain surface fat to be oxidized resulting in faint color of the stained grains at the same iodine staining solution concentration. Increasing concentrations of the iodine staining solution (0.011–0.016%) were tested (data not shown). The 0.014% iodine staining solution was considered optimum to identify AC type with 81.4% of the market samples correctly typed as verified by AC using iodine colorimetric method (Table 1). The major AC type of market milled rice samples not having homogeneously stained grains was the one recorded for this set. Samples with stained grains of varying color intensities suggested the possibility of these samples coming from varietal mixture or blends. Market milled rice samples composed of different rice varieties, or having grains of similar size and shape but different AC and age after milling, would result in unevenly stained grains (Juliano 2010).

Intermediate-AC type continued to be the predominant AC type in the Philippine retail market based on actual colorimetric AC values. Out of 388 nonwaxy milled samples, 217 were intermediate-AC, 141 were high-AC, 30 were low-AC (including imported *Jasmine* and Japanese rices) (Table 1), and 35 were milled waxy rices (including imports from Thailand and Vietnam) (Table 3). High-AC rice predominated in Nueva Ecija, Laguna and Camarines Sur but intermediate-AC rice was predominant in Ilocos Norte, Isabela, Metro Manila, Negros Occidental and Agusan del Norte (Table 1). Mean AC was 20.9% close to high AC lower limit (22%). Popularity of recently released high-yielding NSIC Rc varieties with high AC such as NSIC Rc222, NSIC Rc238 and NSIC Rc240 (PhilRice Los Baños 2014, unpublished) may have contributed to the high incidence of high-AC rices in the market. Also, the high-AC intermediate-GT PSB Rc10, commonly cultivated and consumed by households and farmers employed in labor-intensive jobs, because of its slower rate of digestion and high satiating capacity (Juliano 2010; 2016), may have contributed to the presence of some high-AC rices in Bicol, Negros and Agusan markets, although mislabeled. PSB Rc10 was included among specialty rices recently collected nationwide (Tuaño et al. 2015), confirming farmers' preference for this variety in some regions despite the release of modern rice cultivars with intermediate and low AC. National Food Authority (NFA) rices collected had varying AC and the lowest selling price (PhP 27.00–28.00 per kg). They were represented by four samples from Ilocos Norte (17.6–21.6% AC) and one sample from Manila (22.6% AC) with mean AC of 20.4%. To check whether these were representative of the imported NFA rices, recently acquired samples of NFA rice imported from Vietnam (n = 13) were analyzed. They had AC ranging from 20.3% to 24.8% with only two samples having intermediate AC (20.3% and 21.1%) (PhilRice Los Baños 2014, unpublished). Intermediate–high GT rices were predominant in the market especially among intermediate- and high-AC milled rices (Table 1) and the main AC-GT combination was intermediate-AC intermediate-GT. AC and price were significantly negatively correlated. ASV was significantly positively correlated with price considering all samples and local samples but it did not affect price when retail store samples alone were considered (Table 2).

The study demonstrated that despite the introduction of low-AC varieties such as NSIC Rc160 and many low-AC hybrid rices, the Philippine retail market is still populated with intermediate-AC rices corresponding to the preference of majority of the Filipinos, and some high-AC rices as well. However, consumer panel sensory evaluation tests in the NCT showed the recent preference for low-AC over intermediate-AC cooked rice [Rice Varietal Improvement Group (RVIG) 2008–2012, unpublished; Tuaño et al. 2014]. But it should be noted that these samples have been stored for over two months after harvest. Freshly harvested low-AC rice would be too sticky for most Filipino consumers when cooked. Nutritionally, intermediate-AC rice has medium glycemic index which could help in reducing the incidence of type 2 diabetes (Trinidad et al. 2013; 2014).

Grain Length, Grain Shape and Chalkiness

The market milled rice samples were mainly long grains (6.4–7.4 mm) and slender in shape (L/W > 3.0) (Table 1). Percent chalky grains varied widely from 2% to 42% with the means being comparable across all areas sampled (Table 1). Ilocos Norte set 1 samples showed the lowest range and mean percent chalky grains while the rest had relatively wider variations. Among retail stores, milled rice samples labeled *"maalsa"* obtained from store 2 in Galas market, Quezon City were noted to have the highest percent chalky grains and sold at very low price. They were sold at PhP 29.00 and PhP 28.00 per kg with 42% and 39% chalky grains, respectively. Both had long grains with slender shape and borderline AC (6.7 mm with L/W 3.2 and 21.7% AC; and 6.8 mm with L/W 3.1 and 22.2% AC, respectively). These results implied that the appearance of

Table 2. Correlation coefficients among properties of nonwaxy milled rices, waxy rices and brown rices in selected Philippine rural and urban retail stores and supermarkets, 2012–2013.

Parameters	Nonwaxy milled rice samples				Waxy rice samples[b]	Brown rice samples[c]
	All samples	Local samples[a]	Retail store samples	Supermarket samples		
	(*n* = 388)	(*n* = 363)	(*n* = 230)	(*n* = 158)	(*n* = 36)	(*n* = 26)
Field test AC[d] type vs AC by iodine colorimetry	0.76 **	0.71 **	0.72 **	0.80 **	n/a	0.83 **
Price vs AC[d] by iodine colorimetry	-0.39 **	-0.23 **	-0.55 **	-0.54 **	0.17 ns	-0.13 ns
Price vs field test AC[d] type	-0.29 **	-0.13 *	-0.40 **	-0.44 **	n/a	-0.30 ns
Price vs grain length	-0.36 **	-0.06 ns	0.24 **	-0.43 **	-0.30 ns	-0.13 ns
Price vs grain shape	-0.39 **	-0.11 ns	0.02 ns	-0.47 **	-0.29 ns	-0.04 ns
Price vs percent chalky grains	-0.28 **	-0.19 **	-0.32 **	-0.50 **	0.10 ns	-0.11 ns
Price vs Instron cooked rice hardness	-0.29 **	-0.20 **	-0.32 **	-0.31 **	-0.24 ns	0.19 ns
Price vs ASV[e]	0.29 **	0.12 *	0.00 ns	0.61 **	0.45 **	-0.17 ns
Grain length vs grain shape	0.91 **	0.81 **	0.69 **	0.96 **	0.84 **	0.86 **
Percent chalky grains vs ASV[e]	-0.42 **	-0.39 **	-0.41 **	-0.49 **	0.37 *	-0.14 ns
ASV[e] vs Instron cooked rice hardness	-0.13 **	-0.05 ns	-0.05 ns	-0.22 **	-0.53 **	-0.07 ns
AC[d] vs Instron cooked rice hardness	0.51 **	0.46 **	0.48 **	0.58 **	0.28 ns	0.56 **

** - significant correlation at 1% level; * - significant correlation at 5% level, ns - not significant. n/a - not applicable since waxy grains do not stain with the reagent in the field test for AC method. [a]Excluding samples with imported/foreign variety names/labels. [b]Including one sample sold as pigmented waxy brown rice. Milled rice properties were used in the correlation. [c]Nonwaxy brown rice samples only. Samples were milled and analyzed for grain quality and field test AC type. [d]AC - apparent amylose content. [e]ASV - alkali spreading value.

Table 3. Labels and range of grain properties of 36 waxy rice samples in selected Philippine rural and urban retail stores and supermarkets, 2012–2013.

Market label/description	No. of samples	Price (PhP kg^{-1})		Mean length	Mean shape	Mean % chalky	Apparent amylose content (AC, %)		Alkali spreading	Instron hardness
		Range	Mean	(mm)	(L/W)[a]	grains	Range	Mean	value (ASV)	(kg cm^{-2})
Black rice[b]	1	60.00	60.00	6.3	2.4	93	1.7	1.7	5.0	1.0, 1.1[c]
Dikit/super *dikit*	2	49.00,50.00	49.50	6.2	2.9	97	1.3,1.4	1.4	5.8,6.4	0.8,0.8
Malagkit	11	42.00–80.00	53.65	6.2	2.8	94	1.0–1.8,3.5	1.6	5.1–6.5	0.8–1.3
Malagkit Mindoro	1	60.00	60.00	6.1	3.0	99	1.2	1.2	6.5	0.7
Pingky's *Malagkit*	1	106.00	106.00	6.1	2.8	98	1.2	1.2	6.3	0.8
Malagkit Sungsong/Sungsong	3	80.00–110.00	90.00	5.0	1.8	93	1.1,1.4,4.8	2.4	6.3–6.5	0.8–1.0
Malagkit bilog	1	70.00	70.00	4.7	1.7	97	1.2	1.2	6.5	0.7
Malagkit haba	2	50.00,65.00	57.50	6.4	2.6	97	1.2,1.4	1.3	6.4,6.7	0.9,0.9
Malagkit Thailand	5	89.00–91.00	89.40	6.4	2.8	97	1.2–1.5	1.4	6.1–6.6	0.6–1.0
Malagkit Vietnam	5	80.00–87.00	81.40	6.3	2.6	97	1.1–1.5,2.1	1.4	5.9–6.8	0.9–1.1
Pilit	1	50.00	50.00	6.4	2.6	93	2.5	2.5	5.0	0.9
Pilit Cadidit	1	60.00	60.00	6.8	3.2	98	1.0	1.0	5.4	1.0
Pilit Magnolia	2	45.00,50.00	47.50	6.8	3.2	96	1.2,1.7	1.4	5.3,5.6	1.0
Mean or over-all range		**42.00–110.00**	**67.10**	**6.2**	**2.7**	**95**	**1.0–4.8**	**1.6**	**6.1**	**0.9[d]**

[a]L/W - length-width ratio or grain shape. [b]Sold as pigmented waxy brown rice. Sample was milled and analyzed for grain quality properties. [c]Instron hardness of freshly cooked brown rice. [d]Excluding waxy brown rice sample.

Table 4. Labels and range of grain properties[a] of 27 brown rice samples in selected Philippine rural and urban retail stores and supermarkets, 2012–2013.

Market label/description	No. of samples	Price (PhP kg^{-1})		Mean length	Mean shape	Mean % chalky	Apparent amylose content (AC, %)		Alkali spreading	Instron hardness[c]
		Range	Mean	(mm)	(L/W)[b]	grains	Range	Mean	value (ASV)	(kg cm^{-2})
Black, waxy	1	60.00	60.00	6.3	2.4	7	1.7	1.7	5.0	1.1
Brown, nonwaxy	10	36.00–56.50	48.80	6.7	3.1	17	18.1–21.4	19.9	3.7–6.0	1.9–2.8,3.4
Brown, organic	6	56.50–75.00	59.40	6.6	3.0	17	15.8–21.5	19.4	5.1–5.8	2.1–2.8,3.4
Red[d]	7	37.50–57.00	42.90	6.5	2.9	24	17.9–21.7	19.4	4.3–7.0	2.0–3.6
Red, organic	2	50.00,91.50	70.75	6.2	2.8	13	12.0,19.0	15.5	3.0,6.6	1.7,3.4
Black, organic	1	71.00	71.00	6.6	3.0	14	17.6	17.6	4.1	2.0
Mean or over-all range[e]		**36.00–91.50**	**53.05**	**6.6**	**3.0**	**18**	**12.0–21.7**	**19.1**	**5.1**	**2.6**

[a]Brown rice samples were milled and analyzed for grain quality properties except for Instron hardness. [b]L/W - length-width ratio or grain shape. [c]Instron hardness of freshly cooked brown rice. [d]Five samples from Agusan del Norte. [e]Excluding waxy brown rice sample.

milled rice in bulk, particularly percent chalkiness, mainly affects market price of rice in retail stores. Presumably, amount of broken chalky grains might also be high in these samples and affected their selling price since chalkiness contributes to grain breakage during milling and lowers market price of rice (Fitzgerald and Resurreccion 2009; Juliano 2010). This trend on price vs percent chalky grains was also observed among supermarket milled rices with higher correlation coefficient than the rest of the sub-sample sets (Table 2). Grain length and shape were highly significantly positively correlated. Price also correlated negatively with grain length and shape while percent chalky grains correlated negatively with price and ASV (Table 2). Correlation coefficient between percent chalky grains and price was higher in supermarket samples with more rices having few chalky grains than rice samples in retail stores with a wide variation in percent chalky grains, though both were significant (Tables 1 and 2).

Waxy and Brown Rices

Waxy (glutinous) rice and brown rice were available in most retail markets, except in Ilocos Norte set 1 and Nueva Ecija, and the pigmented waxy sample from Isabela was sold in brown rice form (Tables 3 and 4). AC of waxy rices mainly ranged from 1.0% to 2.0% with mean AC of 1.6%. Four samples were still classified as waxy based on the distribution of opaque grains despite having AC > 2.0% ranging from 2.1% to 4.8% (Table 3). They had high percentage of nonwaxy translucent-grain impurities (data not shown) which affected their AC, though AC values remained very low and Instron cooked rice hardness

showed typical values for waxy rices (≤ 1.0 kg cm^{-2}) (Table 3). *Malagkit Sungsong* with short grain was more expensive than the more recent long-grain modern waxy rice cultivars. Imported waxy rice from Thailand was more expensive than that from Vietnam (Table 3). Grain length and shape were highly significantly correlated among waxy rices while ASV was positively and significantly correlated with price and percent chalky grains (Table 2). Interestingly, ASV showed a significant negative correlation with Instron cooked rice hardness (Table 2). This may be due to the relatively harder texture of cooked waxy rices with ASV 5.0, which are already high GT and usually yield higher Instron hardness values than low-GT waxy rices (ASV 6–7), especially upon staling (Tuaño et al. 2011; 2014).

Brown rice was also not available in Nueva Ecija markets. This is probably due to its large volume of brown rice production (*i.e.*, ~67% share of the total production) mainly intended for interprovincial trading. Only 5.6% of the volume of Nueva Ecija's brown rice produce was sold within the province while 94.4% was sold outside the province, including the National Capital Region (Pabuayon and Quilloy 2011). Brown rice is usually more expensive than nonwaxy milled rice. Of the 27 brown rice samples collected, 24 were intermediate-AC and only two were low-AC and one was waxy (Table 4). Like the nonwaxy milled rices, brown rices in the market were mainly long grain with slender shape and mean percent chalky grains of 18%. Instron hardness of freshly cooked nonwaxy brown rices ranged from 1.7 kg cm^{-2} to 3.6 kg cm^{-2} with mean Instron hardness of 2.6 kg cm^{-2} (Table 4). Organic brown rice was sold in Galas market, Quezon City (store 2) and in seven supermarket chains and was more expensive than non-organic rice. Organic milled rice was sold in six supermarket chains surveyed (data not shown). Only field test AC type vs AC, grain length vs grain shape, and AC vs Instron hardness had significant correlations among the 26 nonwaxy brown rice samples collected (Table 2).

Specialty and Imported Rices

Selected common-name local varieties were summarized in Table 5. *Sinandomeng*, which was not even a released or named variety in the Philippines, had the most number of market samples (n = 44) labeled after it. *Sinandomeng* from Central Luzon was mainly IR64-type intermediate-AC rice, whereas *Sinandomeng* from Laguna was presumably a Korean line with low AC (Tuaño et al. 2011; 2014). This may explain the wide range of AC of the *Sinandomeng* samples in the market. Market samples labeled with traditional variety names *Dinorado*, *Milagrosa* and *Wagwag* probably represented variety types rather than the true-to-type cultivars, together with more recent C4-63G and IR64, in conformity with the earlier results of Juliano et al. (1989). The identification of true-to-type rice varieties among market milled and brown rice samples is next to impossible. Different varieties of similar size and shape may be milled together or blended. Market labels refer to grain type rather than to actual cultivar (Juliano 2010). For instance, *Milagrosa* is actually short grain, and *Dinorado* and *Wagwag* are medium grains, instead of long grains as observed in this study. *Rosanna* was only reported in Negros and mainly had intermediate AC. Surprisingly, the low-AC variety NSIC Rc160, which was released in 2007, had nine samples labeled after it having a wide AC range (14.6–22.9%, mean of 20.2% classified as intermediate AC). *Jasmin*, which may be a locally grown Thai *Jasmine* or *Khao Dawk Mali* 105, had only two samples sold below PhP 50.00 per kg. NFA rice samples varied in AC from 17.6% to 22.6% but still had mean AC of 20.4% classified as intermediate (Table 5). More imported *Jasmine* rice was sold in supermarkets since the local crop cannot duplicate the extremely dry conditions in northern Thailand (Table 6). M3 from Agusan del Norte was also short grain, similar to the M3 specialty rice from Maguindanao (Tuaño et al. 2015). The rest had similar grain dimensions as Philippine released PSB/NSIC Rc varieties. The two *Zion* rices from Butuan City differed in AC and ASV but both remained soft-textured on cooking based on AC-GT combination as shown by their Instron hardness values (Table 5). Price correlated negatively with Instron cooked rice hardness (Table 2). Correlation between price and grain length was positive for retail market samples but negative for supermarket samples (Table 2), probably because of imported Japanese rices in supermarkets having short round grains sold at high price. Grain length and shape did not affect price among local samples.

The imported rices had the typical grain dimensions and AC of Japanese rice and Thai *Jasmine* rices, and had few chalky grains (Table 6). California rice had long slender grain instead of the typical medium bold grain. It had relatively lower mean selling price and higher mean AC than the rest of the imported rices. Excluding California rice from this set would lower the mean AC of imported rices from 18.5% to 17.4%. Red *Dinorado* had lower AC than nonpigmented *Dinorado*. *Milagrosa* and *Wagwag* market samples in this study were long grain rices but true *Milagrosa* is short grain while *Wagwag* is short to medium grain, verifying that market labels refer to variety type rather than to actual variety. Farmers' nonwaxy specialty rices (n = 214) collected nationwide in 2009–2012 were 37% low AC, 51% intermediate AC and only 12% high AC (Tuaño et al. 2015). Specialty rice samples in this study consisted of 8% low AC, 56% intermediate AC and 36% high AC, supporting the small contribution of specialty rices to the rice in the market.

Consumer demand studies also showed consumer preference for higher head rice yield and more translucent grains (Unnevehr et al. 1985; 1992). Consumers prefer soft cooked rice over hard cooked rice, but among lower income consumers, preference is for rice that is "more filling". In the 1987 survey, the most common cited reason for buying a specific rice variety in the market was high volume expansion of the cooked rice (49%), followed by reasonable price (45%), whiteness and translucency (43%) and softness and good taste (34%) (Abansi et al. 1990). Similar consumer demand and preference survey in conjunction with market samples grain quality survey such as this study, but on a nationwide scale covering all regions of the country, is warranted in the future and may be undertaken with fixed year interval to monitor the flow of varieties from the breeding program to the retail market.

CONCLUSION AND RECOMMENDATIONS

Results of this study showed the prevalence of intermediate-AC type of rice in the Philippine retail market, both milled and brown rice forms. Philippine market milled rices were mainly of the long and slender grain type with a wide variation in percent chalky grains which affected market price of rice more than grain dimensions alone. Main GT type was intermediate for nonwaxy rices and low for waxy rices. AC-GT combination was mainly intermediate-AC intermediate-GT among nonwaxy market milled rices. Field test AC type, AC, ASV and Instron cooked rice hardness also affected market price of nonwaxy milled rice especially the imported rices and those available in supermarkets. Similarly, these grain quality parameters influenced market price of waxy rices. Mean AC of market milled rice samples in the country will continue to be intermediate AC for some time because of the widespread cultivation of high yielding PSB/NSIC rice varieties that are high AC and their popularity to laborers due to their longer

Table 5. Range of grain properties of 30 common local variety names of nonwaxy milled rices[a] in selected Philippine rural and urban retail stores and supermarkets collected in 2012–2013.

Market label/description	No. of samples	Price (PhP kg^{-1})		Mean length	Mean shape	Mean % chalky	Apparent amylose content (AC, %)		Alkali spreading	Instron hardness (kg cm^{-2})	
		Range	Mean	(mm)	(L/W)[b]	grains	Range	Mean	value (ASV)	Range	Mean
Angelica/Angelika/Super *Angelica*	18	32.00–40.00	35.50	6.8	3.2	11	18.1–23.4	21.1	4.6–6.3	1.7–3.0	2.3
Azucena	1	36.00	36.00	6.8	3.2	8	22.9	22.9	6.3	2.3	2.3
Bigante	4	35.00–38.00	36.50	6.8	3.1	13	18.6–23.2	20.8	4.5–6.3	1.7–2.5,3.6	2.5
C4	18	31.00–40.00	36.30	6.6	3.1	21	18.8–24.9	22.5	5.0–5.8	1.7–2.8	2.4
C-28	3	28.00–31.00	29.00	6.7	3.2	18	20.9–23.5	21.0	4.0–5.2	2.3–2.9	2.6
Dinorado/Denorado	26	36.00–50.00	43.00	6.9	3.2	12	12.6,17.4–24.2	20.8	4.7–6.6	1.7–2.9	2.3
GMA Rice/Ginintuang Masaganang Ani	5	36.50–38.50	36.90	6.4	3.1	19	21.4–24.8	22.9	4.8–5.8	2.2–2.6,3.1	2.5
Gold Cup/Golden Cup	6	34.00–48.50	42.25	6.8	3.2	13	19.4–23.2	21.4	5.5–6.1	2.2–2.9,3.3	2.7
GS Supreme	3	35.50–37.50	36.20	6.6	3.2	20	21.1–23.0	22.1	5.2–5.3	2.2–2.9	2.5
Ifugao	3	40.00–45.00	43.30	6.9	3.2	7	17.6–22.1	19.7	4.7–5.4	1.8–2.3	2.1
IR28/IR-28	3	30.00–34.00	32.70	6.8	3.2	10	23.4–24.8	24.0	4.3–5.7	2.3–2.5	2.4
IR64/IR-64/R-64	32	28.00–42.00	33.70	6.7	3.1	15	18.2–23.6	22.0	3.9–6.8	1.9–3.5	2.7
Jasmin/Jasmine	2	45.00,48.00	46.50	6.9	3.1	11	15.3,20.9	18.1	5.1,5.7	2.1,2.5	2.3
Kokuyo	2	42.00,43.00	42.50	6.9	3.2	7	18.9,19.3	19.1	5.5,6.1	2.2,2.6	2.4
Land of Promise	3	40.50–49.00	43.50	6.8	3.1	16	18.5–19.7	19.1	4.9–5.2	2.1–2.3	2.2
M3	2	37.50,43.50	40.50	5.5	2.2	18	17.0,18.6	17.8	4.4,4.9	2.0,2.4	2.2
Masipag	3	33.00–46.00	39.00	7.0	3.2	22	17.7–21.3	19.2	4.9–5.1	2.0–2.7	2.3
Milagrosa	2	33.00,40.00	36.50	6.7	3.1	8	20.4,21.7	21.0	5.6,5.8	1.9,2.4	2.2
NFA/NFA Rice	5	27.00–28.00	27.20	6.7	3.2	12	17.6–22.6	20.4	4.9–6.3	2.6,3.0–3.1	2.9
Noble Star/Noblestar	4	44.50–45.50	44.75	6.7	3.2	16	20.9–23.4	22.2	5.1–5.7	2.1–2.5	2.3
Passion/Passion Rice	5	39.50	39.50	6.5	3.0	24	20.9–25.0	23.1	4.2–5.8	2.4–3.2	2.9
Rc18	2	38.95,39.25	39.10	6.9	3.3	13	17.0,17.4	17.2	3.9,4.9	2.2,2.5	2.4
Rc82/Super 82	4	34.00–38.75	37.20	6.8	3.3	8	18.2–21.8	20.5	4.2–5.7	2.0–2.3,3.0	2.4
Rc160/160	8	32.00–45.00	38.10	6.8	3.2	11	14.6,17.9–22.9	20.2	4.8–6.2	1.7–2.5	2.1
Rosanna Negros	4	40.00	40.00	6.8	3.1	13	20.7–21.7	21.4	5.3–6.1	2.6–2.9	2.7
Rumble	7	25.00–31.00	26.70	6.7	3.1	22	20.2–23.3	22.5	4.2–5.6	2.3–2.8	2.5
Sinandomeng	44	32.00–48.00	37.20	6.8	3.2	13	17.5–24.6	21.4	4.2–6.6	1.7–2.9,3.2	2.4
Tonner/Super *Tonner*/*7-Tonner*	1	48.50	48.50	5.5	2.2	29	18.5	18.5	3.9	2.4	2.4
Tonner/Super *Tonner*/*7-Tonner*	12	29.00–49.50	39.55	6.8	3.2	12	15.9–22.4	19.4	3.6–6.5	1.6,1.9–2.7	2.2
Wagwag/Wag Wag	2[c]	39.00,53.50	46.25	5.6	2.4	11	21.1,22.8	22.0	6.0,6.6	2.7,3.2	3
Wagwag/Wag Wag	3	30.00–37.75	33.95	6.8	3.2	21	18.0–21.3	19.9	4.4–5.5	2.1–2.2,3.1	2.5
Zion	2	39.50,45.00	42.25	6.7	3.2	16	10.5,20.9	15.7	4.7,6.6	1.4,2.2	1.8
Mean or over-all range		**25.00–53.50**	**37.40**	**6.7**	**3.1**	**14**	**10.5–25.0**	**21.2**	**5.3**	**1.4–3.6**	**2.4**

[a]Priced ≤ PhP 50.00 kg^{-1}. [b]L/W - length-width ratio or grain shape. [c]One medium-grained *Wagwag* sample sold at Php 53.50 kg^{-1}.

Table 6. Labels and range of grain properties of 25 imported and 17 local specialty milled rices[a] in selected Philippine rural and urban retail stores and supermarkets collected in 2012–2013.

Market label/description	No. of samples	Price (PhP kg^{-1})		Mean length	Mean shape	Mean % chalky	Apparent amylose content (%)		Alkali spreading	Instron hardness (kg cm^{-2})	
		Range	Mean	(mm)	(L/W)[b]	grains	Range	Mean	value (ASV)	Range	Mean
Imported Rices											
California	3	45.50–53.00	48.00	6.9	3.0	15	20.1–23.8	22.1	5.1–5.9	2.1–2.7	2.2
Japanese	5	80.00–118.50	78.50	4.9	1.7	4	15.2–16.9	16.3	7.0	1.5–1.7	1.6
Koshihikari	2	65.50,124.50	95.00	4.8	1.7	4	15.2.17.6	16.4	7.0	1.4,1.8	1.6
Sasanishiki	2	65.50,72.00	68.75	4.8	1.7	4	15.4,16.2	15.8	7.0	1.6.1.7	1.7
Jasmine	8	59.50–64.00	61.00	7.1	3.4	8	15.6–21.3,23.0	18.2	5.0–6.3,7.0	2.1–2.5,3.9	2.4
Thai *Jasmine*	2	56.00,70.00	63.00	7.2	3.4	9	16.5,19.3	17.9	5.9,6.7	1.6,2.0	1.8
Thai *Hom Mali*	3	66.50–70.00	67.70	6.8	3.2	13	15.3–21.5	18.4	3.5–5.7	2.0,2.5	2.3
Mean or over-all range		**45.50–124.50**	**64.60**	**6.3**	**2.8**	**9**	**15.2–23.8**	**18.5**	**3.5–7.0**	**1.4–3.9**	**2.1**
Local Specialty Rices											
Dinorado/Denorado	4	51.50–57.00	53.25	6.7	2.9	13	18.5–21.6	20.3	4.9–5.8	1.8–2.6	2.3
Milagrosa	6	51.50–53.50	52.45	6.8	3.2	13	16.4,18.4–23.1	20.8	4.7–5.7	2.1–2.9	2.4
Wagwag Cagayan	1	53.5	53.50	6.3	3.1	11	21.3	21.3	5.8	3.0	3.0
White organic/White healthy organic	6	54.50–61.50	55.70	6.8	3.2	14	21.4–23.2	22.0	4.9–6.3	2.2–2.6,3.2	2.5
Mean or over-all range		**51.50–61.50**	**53.85**	**6.7**	**3.2**	**13**	**16.4–23.2**	**21.0**	**5.5 L**	**1.8–3.2**	**2.5**

[a]Priced > PhP 50.00 kg^{-1} except California. [b]L/W - length-width ratio or grain shape.

satiating capacity (Felix et al. 2013). Iodine-staining method for AC classification was applicable to market milled rice samples, however, age of milled rice must be considered and colorimetric AC method in ammonium buffer should be used for samples with borderline AC and for imported rices. Considering rice eating quality, AC-GT combination could complement the current market milled rice classification in addition to grain appearance, grain dimensions and degree of milling.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

CONTRIBUTIONS OF INDIVIDUAL AUTHORS

APP Tuaño and BO Juliano conceptualized the study. APP Tuaño and MJC Regalado coordinated and implemented the sample collection. APP Tuaño performed the experiments. APP Tuaño and BO Juliano analyzed the results and wrote the paper. All authors reviewed the final manuscript prior to submission.

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ABBREVIATIONS

ASV	alkali spreading value
AC	apparent amylose content
CM	central market
GT	gelatinization temperature
KI	potassium iodide
KOH	potassium hydroxide
L/W	length-width ratio
LM	Libertad market
n	number of samples
NCT	National Cooperative Tests
NFA	National Food Authority
NSIC	National Seed Industry Council
PhilRice	Philippine Rice Research Institute
PM	public market
PhP	Philippine peso
PSB	Philippine Seed Board
QC	Quezon City
Rc	rice
RVIG	Rice Varietal Improvement Group