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Full Length Research Paper

Grain Quality Evaluation of Selected Rice Varieties in the Philippines

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In 14 selected rice samples, NSIC Rc 222 had high (14.70%) moisture content that lead to low grain or seed quality. Both PSB Rc 22 (77.0%) and M-19 (77.0%) of brown rice had good to premium milling recovery. Chalky grains of selected rice varieties within grade 1 to premium classification are Laon mahilab (5.0%), Vita rice (3%), Brown rice (3%), M-19 (2.0%), M-20 (1.0%), Matador long grain (1.0%) and Jasmine rice (0.0%). Rough rice had extra-long and slender classification whereas all of the milled rice and brown rice had long and slender classification. Rice varieties had high gelatinization temperatures are Iniput ibon, NSIC Rc 23, M1 14 DS, Sinandomeng, PSB Rc 22, NSIC Rc 122, M-19, M-20, Brown rice, and Laon mahilab however, NSIC Rc 240, Jasmine rice, Vita rice, and Matador long grain had low gelatinization temperature. Most of low gelatinization temperature rice had high amylose content, except for matador long grain whereas high gelatinization temperature rice had intermediate amylose content, low to intermediate, high amylose content and intermediate to high amylose content. Majority of the selected rice varieties had a value of 1.1 (50%) and 1.2 (50%) water uptake ratios (fresh) and most of staled water uptake ratio had a value of 1.2 (64%) and 1.1 (36%). Among the selected rice varieties, NSIC Rc 240 had high Instron hardness for staled (4.44) and fresh (6.99) than M-1 14 DS while PSB Rc 122 had lower RVA setback and consistency.

Keywords: brown rice, milled rice, gelatinization temperature, apparent amylose content, water uptake ratio, cooked rice hardness, RVA pasting viscosity

INTRODUCTION

Rice (*Oryza sativa* L.) is now grown worldwide and provides food for more than half of the world's population, especially those living in some of the most populous countries, such as China, India, and Japan. Polished rice or white rice, which primarily consists of starch, is produced through a series of mechanized processes including hulling and milling, and it is the predominant type of rice consumed worldwide (Hu et al. 2012).

Grain quality in rice is very difficult to define with precision as preferences for quality vary from country to country. The concept of quality varies according to the preparations for which grains are to be used. Consumers base their concept of quality on the grain appearance, size and shape of the grain, the behavior upon cooking, the taste, tenderness and flavor of cooked rice (Cruz and Khush, 2000). Yield of rice is closely related to milling quality including brown rice recovery, milled rice recovery, head milled rice recovery, brown rice weight and milled rice weight. It is important to breed new varieties with good milling quality (Shi and Zhu 1998).

Common physical properties of rice are size, shape, color, uniformity, and general appearance. Other factors contributes to general appearance of rice are cleanliness, free from other seeds, virtuousness, translucency, chalkiness, color, damaged and imperfect kernel (en.wikipedia.org/wiki/Grain_quality). The different variety of rice samples are evaluated for moisture content, gelatinization temperature, gel consistency, apparent amylose content, pasting properties, and textural and retrogradation properties. This study was conducted to evaluate the physical attributes, milling recovery, and physicochemical properties of different varieties of rice.

MATERIALS AND METHOD

Materials

Selected rice samples were grown at the Philippine Rice Research Institute (PhilRice) Central Experiment Station to represent the grain quality evaluation. The rice samples were analyzed in detail to ensure that typical properties were present in each variety.

Moisture Content

Rough rice was determined using a standard moisture meter calibrated an air oven method for 1 hr at 130°C. In some cases where grain quality laboratories were equipped with grain moisture meter or near infrared spectroscopy for flour or grain, these were used according to manufacturer's instructions. Moisture contents were reported as the average of duplicate determinations.

Milling Recovery

A duplicate sample of 125 grams of rough rice was dehulled in a shelling device or dehuller using a SATAKE testing husker. The dehulled rice (brown rice) were milled using a McGill or Dayton miller no. 2 for 30 seconds (with weight) and for another 30 seconds (without weight) as initial milling time. Separate the head rice from the broken grains using a cylindrical mechanical grader (SATAKE rice grader). Weigh the various components as brown rice and total milled rice. The brown rice and total milled rice was calculated as follows:

$$\%\ \text{Brown Rice} = \frac{\text{weight of brown rice (g)}}{125\ \text{g}}\ \text{x}\ 100\ \text{(Eqn. 1)}$$

$$\%\ \text{Total Milled Rice} = \frac{\text{weight of total milled rice (g)}}{125\ \text{g}}\ \text{x}\ 100\ \text{(Eqn. 2)}$$

The percentages obtained were classified based on a scheme developed from research experiences and readings. For each parameter, a recommended value or classification were used as reference for varietal recommendation.

Physical Attributes

Grain length and shape. Prepared a duplicate set of 10 whole milled grains and measured the length and width under a photo-enlarger or using a caliper. Classify the sample based on the average length and width ratio.

Chalky and immature grains. Prepared a triplicate 10 grams total milled rice samples and separate all chalky and immature grains and weigh separately. Calculate percentages of chalky and immature grains as follows and classify the grains.

$$\%\ \text{Chalky} = \frac{\text{weight of chalky grain (g)}}{10\ \text{g}}\ \text{x}\ 100\ \text{(Eqn. 3)}$$

$$\%\ \text{Immature Grain} = \frac{\text{weight of immature grain (g)}}{10\ \text{g}}\ \text{x}\ 100\ \text{(Eqn. 4)}$$

Physicochemical Properties

Gelatinization temperature (GT) type. GT types were estimated in the breeding program by the extent of alkali spreading value (ASV) of raw milled rice. Placed six whole grains in a 60 mm x 15 mm transparent plastic culture dish and make three replicates for each rice sample. Add 10 ml of 1.7% anhydrous potassium hydroxide (KOH) just enough to submerge the grain in solution. Arranged the grains evenly to prevent overlapping of the swollen and dispersed grains. Covered the dish and leave undisturbed for 23 hours at room temperature and rate visually using a 7-point numerical scale (Little et al. 1958).

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Apparent amylose content (AC). AC was determined according to the iodine colorimetric method. In preparation of dispersion of standard checks and unknowns, placed in separate 100 ml volumetric flasks the exact weights of 100 mg Avebe potato amylose V standard and 100 mg each of the unknown ground samples. Add 1.0 ml 95% ethanol to wet the powder and swirl very carefully to disperse clumps. Wet with 9.0 ml 1N NaOH to cover the sample. Let stand overnight for 18-24 hours and make up to 100 ml with distilled water and mix very well.

In preparation of working standards and standard curves, a 100 ml volumetric flask labeled as 0, 5, 10, 15, 25, and 35% amylose, pipet out the amylose standards and make up to 100 ml with 0.09N NaOH. Prepared a duplicate set of the standard solutions.

Pipet accurately 5.0 ml from each working standard and transfer it to 100 ml volumetric flasks. For blank, use 5.0 ml of 0.09 N NaOH and add 1ml 0.09N NH4Cl. Add 2.0 ml iodine solution (0.15% iodine in 1.5% KI), and make up to 100 ml with distilled water and mix very well. Read absorbance at 620 nm and determine the regression equation. Used this regression equation to obtain percentage of AC of the unknown samples and classify.

Cooked rice hardness. Weigh 20 grams of milled rice in a 150 ml beaker. Add 24 ml distilled water to make water to rice ratio of 1.2:1.0. Cover the beaker with foil and put it in a 6.0 cup capacity rice cooker with 200 ml outer pot water. Cooked for 20 min from turning the rice cooker on and turn off. Let it stay in cooker for 10 minutes. Put the beaker inside a resealable plastic bag to cool down for 1 hour at room temperature. Placed duplicate 17 grams of cooked rice in Ottawa Texture Measuring System (OTMS) 10 cm^2 cell. Press the cooked rice evenly with a 2.2x2.5 cm plunger before extrusion. Extrude cooked rice using Instron 3342 or 3343. Use 0-50 kg load cell.

Pasting characteristics. Pasting characteristics was assessed using the Rapid Visco Analyser (RVA) with viscosity readings expressed in Rapid Visco Units (RVU). Add 3.0 g of rice flour to 25 ml water in an RVA (rapid visco analyser). After manually stirring the mixture, attach the canister in the RVA for the programmed cooking. Run the standard program recommended by the American Association of Cereal Chemists as follows:

Initial heating for 1.5 min at 50°C
Heating to 95°C at 12°C/min
Maintaining at 95°C for 2.5 min
Cooling to 50°C at 12°C/min
Maintaining at 50°C for 0.9 min
Total run is 12.5 min

Record gelatinization temperature, peak viscosity (maximum viscosity that occurs prior to the cooling stage of test samples), breakdown viscosity or trough (minimum viscosity that occurs after peak) and the final viscosity at 50°C. Calculate for setback (final viscosity minus peak viscosity) and consistency (final viscosity minus breakdown viscosity or trough).

RESULTS AND DISCUSSION

Moisture Content of Rough Rice

NSIC Rc 222 had high (14.70%) moisture content (Table 1), which means that this variety of rice was in improper drying and storage practices that lead to low grain or seed quality. Some problems related to incomplete or untimely drying or storage of paddy with high moisture content were heat buildup in the grain, mold development, insect infestation, discoloration or yellowing, loss of germination and vigor, loss of freshness or odor development and reduced head rice yield (www.knowledgebank.irri.org). Moisture content does not directly affect grain quality but can indirectly affect quality since grain will spoil at moisture contents above that recommended (12-14%) for storage.

Milling Recovery

Both PSB Rc 22 (77.0%) and M-19 (77.0%) of brown rice had good to premium classification of at least 76% and above milling recovery whereas the total milled rice had grade 2 to premium classification of at least 65% and above while Iniput ibon (61.54%) had low milling recovery (Table 1). According to Khush (2005), grain with high milling recovery is the less grain breakage during milling. The maximum milling recovery is 69 to 70% depending on rice variety, but because of grain imperfections and the presence of unfilled grains, commercial millers are happy when they achieve 65% milling recovery (Dhankhar, 2014).

Percent Chalky and Immature Grains

Chalky grains of selected rice varieties within grade 1 to premium classification of less than 5.0% were Laon mahilab (5.0%), Vita rice (3%), Brown rice (3%), M-19 (2.0%), M-20 (1.0%), Matador long grain (1.0%) and Jasmine rice (0.0%) whereas most of immature grains had premium classification of at least less than 2.0%, except for M-1 14 DS (4.5%), NSIC Rc 122 (8.0%), M-20 (3.0%) and Laon mahilab (5.0%) had grade 1 to grade 3 classification of at least 3% and above (Table 1). In every standard grade of rice, there were specific ranges of percent of chalky grain permissible to each class of quality. Chalkiness disappears upon cooking and has no direct effect on cooking and eating quality. But influences consumer preference and affects milling recovery (Ikehashi and Khush, 1979). Therefore, higher the percentage of chalky grain and immature grain was the lesser in the milling recovery. According to Areum et al. (2009), chalky rice decreases the value of rice because of its undesirable

Table 1. Rough rice moisture content, milling recovery, and percent chalky and immature grains of selected rice varieties.

Variety Name	Moisture Content (Rough Rice)	Brown Rice[1] (%)	Milled Rice[2] (%)	Chalky Grains[3] (%)	Immature Grains[4] (%)
Iniput Ibon	13.63	72.25	61.54	18.5	0.0
NSIC Rc23	14.43	75.17	66.97	11.5	1.0
NSIC Rc240	14.33	74.06	66.57	10.0	0.0
M-1 14DS	14.13	72.16	66.28	19.0	4.5
PSB Rc22	12.83	77.00	71.00	6.0	2.0
NSIC Rc122	14.67	75.00	69.00	10.0	8.0
M-19	13.57	77.00	72.00	2.0	2.0
M-20	13.80	75.00	70.00	1.0	3.0
Jasmine Rice[5]	-	-	-	0.0	0.0
Sinandomeng[5]	-	-	-	10.5	1.5
Vita Rice[5]	-	-	-	3.0	2.0
Brown Rice[5]	-	-	91.00	3.0	1.0
Matador Long Grain[5]	-	-	-	1.0	0.0
Laon Mahilab[5]	-	-	-	5.0	5.0

[1]>80% (premium); 76-80% (good); 71-75% (fair); <71% (poor)
[2]>70% (premium); 68-70% (grade 1); 65-67% (grade 2); <65% (grade 3)
[3]<4% (premium); 4-5% (grade 1); 6-7% (grade 2); 8-10% (grade 3); 11-15% (grade 4); >15% (sample grade)
[4]<2.0% (premium); 2.0-5.0% (grade 1); 5.1-10.0% (grade 2); 10.1-15.0% (grade 3)
[5]Purchased as milled rice

appearance and eating quality for consumers. Also, immature thin grain reduces yield and lowers milling quality due to deep creases on the surface, which hinder removal of the bran (Yonemaru and Morita, 2012).

Grain Length and Shape

Most of the selected rice grain varieties of rough rice had extra-long (at least > 7.4 mm) and slender (at least >3.0 mm) classification whereas all of the milled rice and brown rice had long (between 6.4-7.4 mm) and slender classification, except for Iniput ibon, NSIC Rc 23, NSIC Rc 240 (brown rice), M1 14 DS (brown rice) had long and bold (between 2.0-3.0 mm) classification; M1 14 DS (milled rice) had medium (between 5.5-6.3 mm) and bold classification; Jasmine rice (milled rice) had medium and slender classification; and PSB Rc 22 (brown rice) had extra-long and slender classification (Table 2). The shape of the grain influences its volume and weight. In slender varieties of rice occupy more volume than round varieties. Therefore, one ton of a slender variety of rice will need more storage space than the same weight of a round variety of rice (Alaka et al., 2014). In the Philippines, shape and grain size preferences varied across countries and regions (Unnevehr et al., 1992).

Gelatinization Temperature (GT) Type and Apparent Amylose Content (AC)

Selected rice varieties had high GT with ASV (alkali spreading value) of at least 5.4 and below were Iniput ibon, NSIC Rc 23, M1 14 DS, Sinandomeng, PSB Rc 22, NSIC Rc 122, M-19, M-20, Brown rice, and Laon mahilab whereas NSIC Rc 240, Jasmine rice, Vita rice, and Matador long grain had low GT with ASV of at least 5.5 to 7.0 (Table 3). Those with low GT (<70°C) have softer cooked rice and rice products than those with high GT (>74°C) (Merca and Juliano, 1981; Okamoto et al., 2002; Perez et al., 1993; Singh et al., 2012; Villareal et al., 1997; Villareal et al., 1993). Most of low GT rice had high AC, except for Matador long grain had intermediate to high AC whereas high GT rice had intermediate AC (Iniput ibon), low to intermediate AC (NSIC Rc 23, M1 14 DS, PSB Rc 22, NSIC Rc 122, M-19, M-20), high AC (Sinandomeng), and intermediate to high AC (Brown rice , Laon mahilab)

Table 2. Grain length and shape of different rice varieties.

Variety Name		Length[1] (mm)	Classification[1]	Shape[2] (mm)	Classification[2]
Iniput Ibon	Rough rice	8.49	Extra Long	2.98	Bold
	Brown rice	6.81	Long	2.84	Bold
	Milled rice	6.63	Long	2.88	Bold
NSIC Rc23	Rough rice	9.44	Extra Long	3.35	Slender
	Brown rice	6.46	Long	2.63	Bold
	Milled rice	6.47	Long	2.97	Bold
NSIC Rc240	Rough rice	8.81	Extra Long	3.07	Slender
	Brown rice	6.96	Long	2.96	Bold
	Milled rice	6.93	Long	3.27	Slender
M-1 14DS	Rough rice	9.80	Extra Long	3.66	Slender
	Brown rice	6.63	Long	2.62	Bold
	Milled rice	6.23	Medium	2.81	Bold
PSB Rc22	Rough rice	9.00	Extra Long	3.64	Slender
	Brown rice	7.70	Extra Long	3.80	Slender
	Milled rice	7.20	Long	3.60	Slender
NSIC Rc122	Rough rice	9.50	Extra Long	3.85	Slender
	Brown rice	6.90	Long	3.40	Slender
	Milled rice	6.60	Long	3.20	Slender
M-19	Rough rice	9.00	Extra Long	3.60	Slender
	Brown rice	7.10	Long	3.20	Slender
	Milled rice	7.00	Long	3.40	Slender
M-20	Rough rice	9.50	Extra Long	4.00	Slender
	Brown rice	7.00	Long	3.30	Slender
	Milled rice	6.60	Long	3.20	Slender
Jasmine Rice	Milled rice	6.34	Medium	3.13	Slender
Sinandomeng	Milled rice	7.17	Long	3.40	Slender
Vita Rice	Brown rice	6.74	Long	3.20	Slender
	Milled rice	6.95	Long	3.19	Slender
Brown Rice	Brown rice	6.60	Long	3.20	Slender
	Milled rice	6.60	Long	3.10	Slender
Matador Long Grain	Milled rice	6.80	Long	3.10	Slender
Laon Mahilab	Milled rice	6.70	Long	3.30	Slender

[1]>7.4 (extra-long); 6.4-7.4 (long); 5.5-6.3 (medium); <5.5 (short)
[2]>3.0 (slender); 2.0-3.0 (bold); <2.0 (round)

(Table 3). Juliano et al. (1965) found that cooked high-amylose rice is flaky and dry, and low-amylose rice is sticky and moist. Moreover, the lower AC of rice may induce higher glycemic index (GI) (Atkinson et al., 2008; Fitzgerald et al., 2011; Juliano and Goddard, 1986; Juliano et al., 1989; Trinidad et al., 2013). Also, high-AC rice gave AC values below 25% with the ammonium buffer method for AC (Juliano et al., 2012).

Water Uptake Ratio

Most of the selected rice varieties had a value of 1.1 (50%) and 1.2 (50%) water uptake ratios (fresh) whereas majority of staled water uptake ratio had a value of 1.2 (64%) and 1.1 (36%) (Table 4). Milled rice with higher water uptake ratio attributed to higher volume expansion ratio, due to

Table 3. Gelatinization temperature types and apparent amylose content of selected rice varieties.

Variety Name	Moisture Content	Alkali Spreading Value[1]	Apparent Amylose Content[2]	
			NH_4Cl	HAC
Iniput Ibon	12.37	4.70	18.13	19.72
NSIC Rc23	13.00	4.10	15.32	19.28
NSIC Rc240	12.90	6.90	24.08	26.36
M-1 14DS	12.80	5.40	15.79	20.03
Jasmine Rice	10.93	6.90	23.57	24.99
Sinandomeng	11.83	4.80	21.41	23.98
Vita Rice	11.77	5.90	20.19	22.73
PSB Rc22	11.77	5.00	17.00	20.65
NSIC Rc122	13.73	4.60	13.45	17.52
M-19	12.83	4.00	16.40	21.05
M-20	13.27	3.90	16.60	21.23
Brown Rice	11.80	5.20	17.70	23.02
Matador Long Grain	12.40	6.20	19.70	23.60
Laon Mahilab	12.43	5.30	21.20	23.18

[1]1 (grain not affected); 2 (grain swollen); 3 (grain swollen, collar incomplete and narrow); 4 (grain swollen, collar complete and wide); 5 (grain split or segmented collar complete and wide); 6 (grain dispersed merging with collar); 7 (grain completely dispersed and intermingled)
[2]0-2.0% (waxy/glutinous); 2.1-10.0% (very low); 10.1-17.0% (low); 17.1-22.0% (intermediate); >22.1% (high)

Table 4. Water uptake ratio of selected rice varieties.

VARIETY NAME	FRESH	STALED
PSB Rc82	1.10	1.20
NSIC Rc122	1.10	1.20
M-19	1.10	1.20
M-20	1.20	1.20
Brown Rice	1.10	1.20
Matador Long Grain	1.20	1.20
Laon Mahilab	1.10	1.20
Iniput Ibon	1.10	1.20
RC 23	1.20	1.10
RC 240	1.20	1.10
M-1 14DS	1.20	1.10
Jasmine Rice	1.10	1.20
Sinandomeng	1.20	1.10
Vita Rice (milled)	1.20	1.10

absorption of more water compared to the other samples (Mohapatra and Bal, 2006).

Cooked Rice Hardness and RVA Pasting Viscosity

Among the selected rice varieties, NSIC Rc 240 had high Instron hardness for staled (4.44) and fresh (6.99) than M-1 14 DS. PSB Rc 122 had lower RVA setback and consistency than laon mahilab (Table 5). Zhong et al. (2005) reported that the rice with high eating quality had higher breakdown value and lower setback and consistency value. High-amylose rice, laon mahilab, is characterized in their amylogram by solidification of the cooked paste as reflected in high setback and consistency (Juliano 1979).

Table 5. Cooked rice hardness and pasting characteristics of selected rice varieties.

VARIETY NAME	INSTRON HARDNESS STALED	INSTRON HARDNESS FRESH	RVU			
			PEAK	BREAKDOWN	SETBACK	CONSISTENCY
Iniput Ibon	3.90	4.72	-	-	-	-
NSIC Rc23	3.60	3.79	-	-	-	-
NSIC Rc240	4.44	6.99	-	-	-	-
M-1 14DS	2.68	3.28	-	-	-	-
Jasmine Rice	4.65	5.73	-	-	-	-
Sinandomeng	3.26	4.71	-	-	-	-
Vita Rice	3.46	4.61	-	-	-	-
PSB Rc82	2.76	2.45	142.13	40.34	64.92	105.25
NSIC Rc122	2.76	2.70	158.17	45.08	120.50	165.58
M-19	3.52	2.94	100.84	47.13	150.21	197.34
M-20	3.30	2.97	101.63	44.71	150.59	195.29
Brown Rice	3.33	3.44	-	-	-	-
Matador Long Grain	2.90	2.66	-	-	-	-
Laon Mahilab	3.00	3.29	139.50	35.58	163.75	199.39

CONCLUSION

Some problems related to incomplete or untimely drying or storage of paddy with high moisture content however, moisture content does not directly affect grain quality but can indirectly affect quality since grain will spoil at moisture contents above that recommended (12-14%) for storage. High milling recovery is the less grain breakage during milling and the maximum milling recovery is 69 to 70% depending on rice variety. Chalkiness disappears upon cooking and has no direct effect on cooking and eating quality but influences consumer preference and affects milling recovery. The shape of the grain influences its volume and weight however, shape and grain size preferences varied across countries and regions. Those with low GT (<70°C) have softer cooked rice and rice products than those with high GT (>74°C). Cooked high-amylose rice is flaky and dry, and low-amylose rice is sticky and moist moreover, the lower AC of rice may induce higher glycemic index (GI).

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