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CONSUMER DEMAND FOR RICE GRAIN QUALITY IN THAILAND, INDONESIA, AND THE PHILIPPINES

L. J. UNNEVEHR, B. O. JULIANO, C. M. PEREZ, and E. B. MARCIANO

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The International Rice Research Institute
P.O. Box 933, Manila, Philippines

CONSUMER DEMAND FOR RICE GRAIN QUALITY IN THAILAND, INDONESIA, AND THE PHILIPPINES[1]

ABSTRACT

Abundant world rice supply has led to renewed interest in improving the grain quality of modern rice varieties. The implicit values that consumers pay for grain quality characteristics are estimated for Thailand, Indonesia, and the Philippines. Consumers in all three countries significantly prefer better milling quality (fewer brokens and more polish) and aroma. Preferences for shape and chemical attributes vary, but consumers generally prefer intermediate amylose. International rice research should maintain good potential head rice recovery and reduce amylose content of future modern varieties. This study drew samples from urban centers; national programs might wish to study regional variation in preferences.

[1]By L. J. Unnevehr, B. O. Juliano, C. M. Perez, and E. B. Marciano, visiting associate agricultural economist, chemist, assistant scientist (Cereal Chemistry), and research aide (Agricultural Economics), respectively. International Rice Research Institute, P.O. Box 933, Manila, Philippines. Submitted to the IRRI Research Paper Series Committee August 1984.

CONSUMER DEMAND FOR RICE GRAIN QUALITY IN THAILAND, INDONESIA, AND THE PHILIPPINES

Modern rice varieties released by IRRI and national research programs in tropical Asia during the 1960s had a reputation for poor market and cooking quality. Hard cooked-rice texture and white belly endosperm were common to semidwarf parents. Market quality was improved by selection of translucent grain but most IR varieties such as IR36 and IR42 still have hard cooked-rice texture. Sacrificing cooking and eating quality for high yields and pest resistance was incidental to meet the growing demand for food in Asia. Asian rice production grew faster than population from 1965 to 1980 as a result of modern varieties (MVs), irrigation, and fertilizer. The real price of rice has declined in world markets and several Asian countries since 1975 (3), and this has increased demand for quality. Improved cooking and eating quality through intermediate amylose content is one of the main goals of IRRI's breeding program for irrigated environments in the 1980s (11).

Consumer taste panel acceptance and characteristics of rice varieties in ASEAN countries were recently reviewed (8). In this paper, we estimate the implicit values of rice grain quality characteristics in Thailand, Indonesia, and the Philippines, using an economic model of consumer demand for goods characteristics. In contrast to consumer panels, market price data provide information about the average preferences of many consumers who make their quality choices under budget constraints. The estimates of implicit values of quality test how observed consumer preferences correspond to the measures of quality used in screening material in breeding programs. They also reveal whether Southeast Asian consumers have similar preferences for rice grain quality and thus whether national or international breeding programs should undertake quality improvement.

A MODEL OF CONSUMER DEMAND FOR GOODS CHARACTERISTICS

Ladd and Suvannunt (14) developed the following model of consumer demand for goods characteristics. Products are demanded for their utility, a function of product characteristics. Let X_{oj} be the total amount of the jth product characteristic provided by consumption of all products, while X_{ij} is the amount of the jth characteristic provided by one unit of product i. Let q_i represent the quantity consumed of product i. Total consumption of each characteristic is a function of the q_i's and the X_{ij}'s (input-output coefficients of the characteristics):

$$X_{oj} = f(q_1, q_2, \ldots q_n, X_{1j}, \ldots X_{nj}) \quad (1)$$

$$\text{for } j = 1, m$$

The consumer's utility function is expressed as a function of goods characteristics:

$$U = U(X_{o1}, X_{o2}, \ldots X_{om}) \quad (2)$$

Because each X_{oj} is a function of the q_i's and the X_{ij}'s:

$$U = U(q_1, q_2, \ldots q_n, X_{11}, X_{12}, \ldots X_{21}, \ldots X_{nm}) \quad (3)$$

Consumers can only vary the q_i's; the X_{ij}'s are given to the consumer.

The consumer maximizes utility (equation 2) subject to the budget constraint:

$$\sum_{i=1}^{n} p_i q_i = E \quad (4)$$

where p_i is the market price for product i and E is the total income (equal to total expenditures). The consumer selects values of q_i that maximize the Lagrangian:

$$L = U(X_{o1}, X_{o2}, \ldots X_{om}) - \lambda \left(\sum_{i=1}^{n} p_i q_i - E \right) \quad (5)$$

Because the X_{oj}'s are functions of the q_i's, the constrained maximum of U is:

$$\frac{dL}{dq_i} = O = \sum_{j=1}^{m} (dU/dX_{oj})(dX_{oj}/dq_i) - \lambda p_i \quad (6)$$

The marginal utility of income, λ, is equal to dU/dE. With this substitution and solved for p_i, equation 6 becomes:

$$p_i = \sum_{j=1}^{m} (dX_{oj}/dq_i)[(dU/dX_{oj})/(dU/dE)] \quad (7)$$

The marginal yield of the jth product characteristic by the ith product is dX_{oj}/dq_i. The marginal utility of the jth product characteristic is dU/dX_{oj} and dU/dE is the marginal utility of income. Therefore, the ratio in brackets is the marginal rate of substitution between income and the jth product characteristic. Because expenditure is assumed to equal income, the bracketed term is also the marginal implicit price of the jth characteristic. Equation 7 states that the product price paid by the consumer equals the sum of the marginal values of the product's characteristics. Each value is equal to the quantity of the characteristic obtained from a marginal unit of the product multiplied by the marginal implicit price of the characteristic.

Because yield of most product characteristics is constant for each unit of the product, $dX_{oj}/dq_i = X_{ij}$ = constant is assumed. Furthermore, the marginal implicit price is also assumed constant, and represented by P_{ij}. Therefore, equation 7 for a particular product such as rice becomes:

$$P_R = \sum_{j=1}^{m} X_{Rj} P_{Rj} \quad (8)$$

If the characteristics that define grain quality can be measured, then the implicit value of these characteristics can be estimated. An ordinary least squares regression of price on measures of quality will provide such estimates.
The estimation equation is:

$$P_R = \sum_{j=1}^{m} X_{Rj} b_{Rj} + u \quad (9)$$

where

b_{Rj} = parameter estimates, and
u = random error.

The dependent variable, P_R, will vary for different grades of rice. The independent variables, the X_{Rj}'s, should explain variance in the rice price. The parameter estimates (b_{Rj}'s) give the implicit values (P_{Rj}'s) of grain characteristics. The usual assumptions regarding u are made, i.e., mean equal to zero, constant variance, and independence.

DATA

The data were obtained from rice samples collected in some retail markets of Thailand (two in Bangkok), Indonesia (five in Jakarta), and Philippines (Metro Manila, Baguio, Calamba). Samples were taken of each grade of rice offered by randomly chosen retailers, and price and advertised variety name were recorded for each sample. The retail markets were chosen to reflect the full range of preferences displayed by different income classes. To minimize price variance due to factors other than quality, all samples were collected within 1 wk.

The samples were analyzed in the Cereal Chemistry laboratory of the International Rice Research Institute for physical and chemical characteristics. Laboratory measures were used as proxies for actual consumer preferences. Measures of appearance or physical characteristics are close to observations consumers make in the market, but consumers are not directly aware of the chemical characteristics used here to measure eating quality. These chemical measures were developed to provide simple and accurate screening methods for breeding programs. The price estimates will test whether these chemical characteristics directly relate to price and consumer utility.

Physical characteristics include whiteness, broken grains, length, translucency, and chalkiness. Whiteness and presence of brokens indicate milling quality. Whole-grain length and chalky areas in the grain are varietal characteristics. Consumers should prefer white, translucent, long-grain rice with few brokens.

Chemical characteristics such as amylose content, gelatinization temperature, and gel consistency affect cooking and eating quality. Consumers express preferences for these characteristics indirectly, for example, through choice of variety. The relationship between chemical characteristics and quality is complex.

Amylose content is the most important chemical characteristic. Intermediate-amylose rices cook moist and tender and do not harden after cooling. Many traditional rice varieties grown in Southeast Asia are of this type. High-amylose content rices, including most MVs, harden after cooling and are less preferred. Price should inversely relate to amylose content.

Gel consistency is another measure of texture. Intermediate- and low-amylose rices almost always have soft gel consistency. Among high-amylose rices, those with soft gel consistency will be preferred because the cooked rice is more tender (18). Price should positively correlate with gel consistency for high-amylose rices.

Gelatinization temperature determines cooking time and it is estimated by alkali spread (alkali spreading value) (7). Among high-amylose rices, those with intermediate gelatinization temperature (low alkali spread) are preferred over those with low gelatinization temperature (high alkali spread), probably because of a correlation between intermediate gelatinization temperature and soft gel consistency. Most traditional varieties have intermediate gelatinization temperature. The alkali spreading value measure of this characteristic should have a negative implicit price.

Protein content determines the nutritional quality of milled rice. It contributes to grain translucency and hardness but may make the cooked rice more flaky by increasing cooking time (7). Mean crude protein content of milled rice is about 7.3% at 14% moisture (4).

Whiteness was measured with a Kett whiteness meter, an optical instrument. The scale is from 0 to 100, with 100 indicating pure white magnesium oxide powder. Translucency was obtained with the Rice Meter with 0-100% scale. Chalkiness was measured by the Rice Quality Laboratory using a visual rating of the chalky proportion of the grain. The scale is 1-9: 1 = less than 10% chalkiness, 5 = 10-20%, and 9 = more than 20% (12). Percent brokens was determined by grain sizing and weighing broken grains in a 100-g subsample. Length and width in millimeters are measured for 10 whole grains. Percent amylose content was evaluated by the simplified iodine colorimetric procedure (10). Gelatinization temperature is measured by the alkali spreading value (15). This is the extent of disintegration of milled rice soaked in a 1.7% potassium hydroxide solution for 23 h at 30° C. Duplicate six grains were soaked in 10 ml of the solution. A high rating indicates more disintegration and a low gelatinization temperature. Gel consistency was

measured by the length of cold milled rice paste in a test tube in a horizontal position (unreplicated 90 and 100 mg/2 ml 0.2 N KOH) (1). A high number indicates a softer consistency. Mean of 90- and 100-mg rice data is presented.

RESULTS

Thailand

In Thailand, the world's largest rice exporter, world market preferences for long translucent grains and good milling quality strongly influence the domestic market. Thai rice improvement has considered export quality since at least 1909, when greater length was selected from local varieties to gain an export advantage (Puckridge, IRRI, pers. comm.) Because IRRI varieties had grains shorter than 7.0 mm, they were not released directly in Thailand (13). Rather, Thai scientists used them as parents in crosses to develop semidwarf varieties with the physical grain quality demanded by the world market. The MVs subsequently released were planted on only about 10% of cultivated area in the late 1970s (5). Adoption of MVs is limited because most of Thailand's rice area is rainfed, and MVs are best suited to irrigated environments.

Unlike in other Southeast Asian countries, Thai markets sell head rice and brokens separately. Raw (rough rice) paddy only yields milled rice with 80% whole grains under laboratory milling conditions. To sell rice with greater percent head rice, rice is sorted into head rice and brokens in Thai mills. Because many measures of characteristics require tests of whole grains, the 12 samples of pure brokens were not included in this analysis. Two waxy rices were also excluded. Of the 86 head rice samples remaining, 27 were the aromatic variety Khao Hawm Mali, having distinctive shape and chemical characteristics.

Quality characteristics of Thai samples reflect world demand and the dominance of traditional varieties (Table 1). The samples had long grains (>7 mm) and slender shape as indicated by a length-width ratio greater than 3. The samples also had a low percentage of brokens (16%). Surprisingly the Thai rice does not have a particularly low chalkiness score, high translucency value, or high milling polish (whiteness).

Table 1. Characteristics of Thai rice samples (n = 86).

Milled rice characteristic	Mean	Standard deviation	Range
Price (baht per 15 kg)[a]	117.62	16.80	80.0 – 150.0
Whiteness (%)	40.46	2.72	27.1 – 46.5
Chalkiness score	4.12	2.16	1.0 – 9.0
Translucency (%)	67.47	25.74	11.0 – 100.0
Brokens (wt %)	16.26	15.35	0.0 – 70.7
Length (mm)	7.05	0.32	5.7 – 7.4
Length/width ratio	3.48	0.27	2.6 – 4.1
Amylose (% dry basis)	23.57	4.18	16.9 – 30.3
Alkali spreading value	5.14	0.76	3.0 – 6.8
Gel consistency (mm)[b]	56.63	14.58	30.0 – 92.5
Protein (% at 14% moisture)	7.45	0.56	6.3 – 9.1

[a]22.6 baht = US$1. [b]Av of 100-mg and 90-mg samples.

Table 2. Average characteristics of aromatic and ordinary Thai rice.[a]

Milled rice characteristic	Aromatic (n = 27)		Ordinary (n = 59)	
Price (baht per 15 kg)[b]	136.15	(12.13)	109.14	(10.72)
Whiteness (%)	40.57	(1.79)	40.41	(3.06)
Chalkiness score	1.89	(1.69)	5.14	(1.48)
Translucency (%)	76.85	(21.55)	63.17	(26.51)
Brokens (%)	15.58	(16.63)	16.57	(14.87)
Length (mm)	7.17	(0.10)	6.99	(0.37)
Length/width ratio	3.72	(0.25)	3.36	(0.24)
Amylose (% dry basis)	18.41	(1.18)	25.93	(2.63)
Alkali spreading value	5.79	(0.53)	4.84	(0.43)
Gel consistency (mm)[c]	69.52	(10.07)	50.74	(12.38)
Protein (% at 14% moisture)	7.31	(0.50)	7.52	(0.57)

[a]Figures in parentheses are standard deviations. [b]22.6 baht = US$1. [c]Av of 100-mg and 90-mg samples.

The chemical characteristics of the samples vary for the aromatic and nonaromatic varieties (Table 2). Khao Hawm Mali has narrower grain than nonaromatic rices. The aromatic samples have low amylose (18%) and soft gel consistency (70 mm), indicating a soft texture. They also have a relatively low gelatinization temperature. The ordinary varieties have high to intermediate amylose (26%), medium gel consistency (51 mm), and an intermediate gelatinization temperature in agreement with reported data (10, 13). Consumer panel tests have indicated that intermediate-amylose varieties with intermediate gelatinization temperatures are preferred (13). It was not clear whether Khao Hawm Mali's popularity was due to aroma or low amylose (13). Aroma dissipates during storage, and new crop Khao Hawm Mali has consistently higher price than old crop. Aromatic and ordinary milled rices have similar protein content.

Regression results for the entire sample show that whiteness, percentage of brokens, and aroma are highly significant determinants of price (Table 3). Shape and chalkiness have the expected signs but are less significant. The chemical characteristics are highly significant when the aroma dummy is excluded, but become insignificant when aroma is included. The results for chemical variables, shape, and chalkiness reflect the high multicollinearity between aroma and these variables (Table 4).

To more clearly test significance of chemical variables, separate regressions were run for the ordinary rice varieties (Table 3). Whiteness and brokens are again significant and explain 69% of price variation. Chemical variables entered separately are not significant. Because combinations of chemical variables may be more important than individual attributes in determining taste, dummy variables were used to differentiate combinations. The two taste dummies have the expected signs and relative magnitudes. Intermediate amylose content with intermediate gelatinization temperature is most preferred, followed by other intermediate amylose and high amylose with an intermediate gelatinization temperature. These dummies are not very significant, however. The gel consistency variable has the wrong sign and is also not significant. These results may be due to the

Table 3. Thailand: regressions of price on grain characteristics.[a]

	Constant	Whiteness	Brokens	Chalkiness	Length/width ratio	Amylose	Alkali spreading value	Gel consistency	Aroma	R^2	Durbin Watson
Full sample (n=86)											
(1)	62.06	0.98 (3.98)	−0.50 (−10.86)	−0.57 (−0.23)	5.54 (1.70)	–	–	–	22.54 (11.14)	.89	1.82
(2)	31.11	1.62 (4.84)	−0.45 (−8.06)	−0.96 (−1.67)	13.42 (3.19)	−1.37 (−4.07)	1.66 (1.25)	0.16 (2.21)	–	.83	1.75
(3)	54.05	0.99 (3.36)	−0.50 (−10.68)	−0.53 (−1.10)	7.25 (2.01)	−0.05 (−0.15)	−0.11 (−0.09)	0.07 (1.12)	20.44 (6.15)	.89	1.81
Ordinary varieties (n=59)											
(1)	61.15	1.15 (3.99)	−0.44 (−7.44)	−0.51 (−0.82)	3.39 (0.91)	–	–	–	–	.70	1.80
(2)	74.17	1.26 (3.71)	−0.44 (−7.03)	–	–	−0.15 (−0.40)	−0.31 (−0.29)	−0.06 (−0.86)	–	.69	1.78
(n=56)						Taste Dummy1[b]	Taste Dummy2[c]				
(3)	104.03	0.39 (0.75)	−0.48 (−7.34)	–	–	5.41 (1.57)	3.66 (1.24)	−0.12 (1.53)	–	.66	1.71

[a]t-statistics are in parentheses. [b]Intermediate amylose and intermediate gelatinization temperature. [c]Other intermediate amylose and high amylose with intermediate gelatinization temperature.

Table 4. Thai rice samples: correlation coefficients.

	Whiteness	Chalkiness	Brokens	Translucency	Length	Length/width ratio	Amylose	Alkali spreading value	Gel consistency	Protein	Aroma dummy[a]
Price	.33**	−.69**	−.56**	.32**	.37**	.65**	−.57**	.50**	.44**	−.02	.75**
Whiteness	–	−.08	−.32**	.34**	.14	.05	.24*	−.10	.03	−.03	.03
Chalkiness		–	.22*	−.34**	−.50**	−.67**	.63**	−.54**	−.36**	.06	−.70**
Brokens			–	−.21	−.21	−.24*	−.04	−.15	.04	−.19	−.03
Translucency				–	.22	.21*	−.21	.15	.10	−.48**	.25*
Length					–	.79**	−.16	.33**	−.12	.04	.26*
Length/width						–	.47**	.56**	.15	.05	.61**
Amylose							–	−.49**	−.61**	.29**	−.84**
Alkali spread								–	.23*	.04	.58**
Gel consistency									–	.28**	.60**
Protein										–	−.16

[a]Aroma dummy = 1 for aromatic samples, 0 for oth. 27 samples were aromatic. **Significant at the 1% level. *Significant at the 5% level.

fairly uniform high quality of the samples. Only 6 of the 56 ordinary samples had the least favored combination of high amylose and low gel temperature, and few had hard gel consistency.

In summary, the importance of whiteness and brokens reflects the export demand for good milling quality. The insignificant results for chemical variables reflect the fairly uniform high quality of Thai varieties. Aroma is the only taste characteristic that significantly determines price.

Indonesia

Modern rice varieties were grown on 60% of rice area in Indonesia in 1980. Varieties include IRRI varieties such as IR36 (PB36 in Indonesia) and local MVs having IRRI parents. Many locally developed varieties such as Pelita and Cisadane have low to intermediate amylose content, rather than the high amylose content of IRRI varieties.

Indonesia was the world's largest rice importer in 1975-80, accounting for 20% of world import. Most imported rice was from Thailand or the United States. Indonesia usually imports low-quality white head rice (25% brokens) from Thailand, but shifted to high-quality rice (10% brokens or 100% head rice) in 1982 when imports declined substantially. Imported rice is found in the market only during the lean season when the government marketing agency releases stocks to hold prices down (16).

A survey found that Indonesians prefer soft (low amylose) rice, although this preference varies by region (16). Consumers also strongly prefer good milling polish, have some preference for fewer brokens and less chalkiness, but have no clear preference for grain shape (16). Consumers generally prefer the traditional *bulu* varieties (such as Cianjur) which have short grains, low amylose content, and low gelatinization temperature. Local aromatic varieties (such as Rojolele) also command a price premium.

The Indonesian samples were collected in March 1983, just as the new harvest began. Of 151 samples, 18 are Thai imports, 17 are U.S. imports, and 118 are domestic varieties (excluding 4 red rices and 2 waxy rices). The domestic varieties include 14 aromatic rices and 46 other bulu rices.

The imported rice has very uniform characteristics distinct from those of domestic samples (Table 5). The California japonica varieties ("Japan") imported from the United States are short (5 mm), and have low amylose content and little chalkiness. Thai imports ("Siam") are similar to ordinary varieties in Thai markets, except for better milling quality. Because of a combination of several unusual characteristics, all imported rice sell at a lower price than domestic varieties. Therefore the price analysis will consider only domestic varieties.

Table 5. Characteristics of imported rice in Indonesian markets.[a]

Milled rice characteristic	U. S. (n=17)		Thailand (n=16)	
Price (rupiah per kg)[b]	397.4	(28.6)	392.3	(20.3)
Whiteness (%)	34.1	(2.6)	38.0	(1.4)
Chalkiness score	4.8	(1.0)	4.3	(2.2)
Translucency (%)	95.5	(13.0)	80.9	(7.8)
Brokens (wt %)	9.3	(5.6)	8.6	(2.2)
Length (mm)	5.1	(0.2)	7.0	(0.1)
Length/width ratio	1.8	(0.1)	3.3	(0.1)
Amylose (% dry basis)	19.6	(0.8)	25.5	(1.3)
Alkali spreading value	7.0	(0.1)	5.5	(0.5)
Gel consistency (mm)[c]	67.6	(10.6)	53.5	(9.1)
Protein (% at 14% moisture)	7.2	(0.7)	6.9	(0.3)

[a]Figures in parentheses are standard deviations. [b]Rp 1000 = US$1. [c]Av of 90-mg and 100-mg samples.

Table 6. Average characteristics of domestic Indonesian samples (n=118).

Mean rice characteristic	Mean	Standard deviation	Range
Price (rupiah per kg)[a]	435.7	71.2	270.0 – 700.0
Whiteness (%)	39.4	2.5	29.8 – 46.5
Chalkiness score	8.0	1.8	1.0 – 9.0
Translucency (%)	73.1	14.7	33.0 – 100.0
Brokens (wt %)	37.7	11.3	10.3 – 60.5
Length (mm)	6.3	0.3	5.2 – 7.0
Length/width ratio	2.5	0.3	1.9 – 3.3
Amylose (% dry basis)	23.4	2.3	16.8 – 31.4
Alkali spreading value	5.5	0.7	4.4 – 7.0
Gel consistency (mm)[b]	46.8	8.3	31.0 – 68.0
Protein (% at 14% moisture)	8.2	0.7	6.6 – 9.9

[a]Rp 1000 = US$1. [b]Av of 9-mg and 100-mg samples.

The domestic varieties have medium chalky grains with intermediate amylose content and low gelatinization temperature (Table 6). The average percentage of brokens is high, even though some fancy rice is sorted at the mill so that only head rice is sold. The domestic rices have more protein than the imported rices. These characteristics are similar to those of Indonesian bulu and native varieties previously analyzed (6, 9, 10, 18).

The regression results show that whiteness, brokens, and shape are the significant variables when the full model is estimated (Table 7). The differences between bulu and indica varieties in this sample lead to multicollinearity between shape or chalkiness and the chemical characteristics (Table 8). When shape and chalkiness are excluded, the chemical variables become more significant, particularly alkali spread.

The results show that Indonesian consumers prefer white, whole grains. They lean toward the chemical characteristics of bulu varieties, i.e., soft texture and low gelatinization temperature. The insignificant result for amylose reflects the low to intermediate amylose content of most samples (101 of 118). Because bulu varieties also have short, round grains, the negative implicit price for shape probably reflects the preference for the chemical quality of these varieties.

Philippines

Modern varieties are grown in 85% of cultivated area in the Philippines. There were no imports and only minor exports from 1977 to 1982. Therefore the June 1983 samples reflect the characteristics of the two most common MVs, IR36 and IR42. Both have high amylose content, but IR42 have shorter grain, low gelatinization temperature, and harder gel consistency (Table 9). Consumer panel tests indicate that Filipinos prefer low to intermediate amylose and soft gel consistency (2, 17). Grain whiteness and hardness were the major criteria for selecting raw milled rice in a Philippine village (2).

Table 7. Indonesia: regressions of price on grain characteristics.[a]

	Constant	Whiteness	Brokens	Chalkiness	Length/ width ratio	Amylose	Alkali spreading value	Gel consistency	Aroma	R^2	Durbin Watson
(1)	66.03	12.62	-1.79	-3.30	-50.81	-0.55	12.48	0.80	–	.48	
		(5.07)	(-3.82)	(-0.88)	(-2.12)	(-0.18)	(1.25)	(1.20)			
(2)	-124.87	13.64	-1.78	–	–	-3.47	23.14	0.90	–	.46	
		(6.09)	(-3.76)			(-1.46)	(2.66)	(1.36)			
					Translucency	Length					
(3)	189.49	13.90	-1.91	0.50	-43.96	–	–	–	88.15	.63	1.48
		(7.91)	(-4.52)	(1.51)	(-3.10)				(6.87)		
(4)	34.48	12.51	-1.71	0.28	-30.00	-0.29	17.63	0.83	91.94	.65	1.55
		(6.69)	(-3.96)	(0.85)	(1.84)	(-0.14)	(2.17)	(1.47)	(7.18)		
(5)	-162.33	13.10	-1.81	–	–	-1.95	24.74	1.03	92.22	.64	1.44
		(7.08)	(-4.63)			(-0.98)	(3.44)	(1.87)	(7.25)		

[a]t-statistics are in parentheses.

Table 8. Correlation coefficients among characteristics of Indonesian domestic rice (n=118).

	Whiteness	Chalkiness	Brokens	Translucency	Length	Length/ width ratio	Amylose	Alkali spreading value	Gel consistency	Protein	Aroma dummy[a]
Price	.54**	.18	-.32**	.30**	-.33**	-.46**	-.08	.33**	.31**	.02	.39**
Whiteness	–	.38**	.07	.05	-.29**	-.43**	-.04	.16	.39**	-.04	.06
Chalkiness		–	.06	-.08	-.27**	-.47**	-.53**	-.30**	.35**	.07	-.01
Brokens			–	-.46	.09	.13	.04	-.32**	.02	.14	.04
Translucency				–	.15	.01	-.03	.17	.19*	.11	.11
Length					–	.86**	.24	-.32**	-.16	.20*	.03
Length/width ratio						–	.48**	-.20*	-.28**	.14	-.05
Amylose							–	.39**	-.20**	-.14	-.15
Alkali spreading value								–	-.13	-.21*	-.15
Gel consistency									–	.08	.10
Protein										–	.25**

[a]Aroma dummy = 1 for aromatic samples; 0 for others. 14 samples were aromatic. **Significant at the 1% level. *Significant at the 5% level.

Table 9. Grain quality characteristics of IR rice varieties.

Variety	Milling characteristics			Grain size, shape, appearance			Cooking characteristics		
	% hulls	% total milled rice	% head rice	Length	Shape	Chalkiness	Gelatinization temperature	Amylose type	Gel consistency
IR5	22	68	40	Medium	Medium	White belly	Intermediate	High	Soft
IR8	26	71	36	Medium	Medium	White belly	Low	High	Hard
IR20	22	70	62	Medium	Medium	Translucent	Intermediate	High	Medium
IR22	22	71	63	Long	Slender	Translucent	Low	High	Hard
IR24	21	70	57	Long	Slender	Translucent	Low	Low	Soft
IR26	24	69	63	Medium	Medium	Translucent	Low	High	Medium
IR28	22	72	61	Long	Slender	Translucent	Low	High	Hard
IR29	25	71	63	Medium	Slender	Opaque	Low	Waxy	Soft
IR30	23	70	55	Medium	Medium	Translucent	Intermediate	High	Soft
IR32	23	67	64	Long	Slender	Translucent	Intermediate-low	High	Soft
IR34	21	69	50	Long	Slender	Translucent	Low	High	Hard
IR36	21	71	57	Long	Slender	Translucent	Intermediate	High	Medium
IR38	22	71	65	Long	Slender	Translucent	Low	High	Hard
IR40	21	73	63	Medium	Medium	Translucent	Intermediate	High	Medium-hard
IR42	22	71	52	Medium	Medium	Translucent	Low	High	Hard
IR43	26	62	38	Long	Medium	Translucent	Low	Low	Soft
IR44	22	68	46	Long	Slender	Translucent	Intermediate	High	Hard
IR45	27	59	33	Long	Slender	Translucent	Low	High	Medium-hard
IR46	22	67	51	Long	Slender	Translucent	Intermediate	High	Soft
IR48	21	69	48	Long	Slender	Translucent	Low	Intermediate	Medium
IR50	22	64	50	Long	Slender	Translucent	Intermediate	High	Medium
IR52	22	68	46	Long	Slender	Translucent	Low	High	Hard
IR54	22	67	59	Long	Slender	Translucent	Intermediate-low	High	Hard
IR56	22	68	61	Long	Slender	Translucent	Low	High	Hard
IR58	20	71	65	Long	Medium	Translucent	Low	High	Hard
IR60	19	70	56	Long	Slender	Translucent	Low	High	Hard

Source: Plant Breeding Department, IRRI.

Ninety-seven of the 108 samples could be identified as MVs by their high amylose content. Most (6 of 10) traditional rices were Azucena, a traditional low-intermediate amylose (18-23%) aromatic variety (9). On average, the samples had medium grain length, a high percentage of brokens, high amylose content, intermediate gelatinization temperature, and hard to intermediate gel consistency (Table 10).

Aged or old (*laom*) rice tended to have higher price than new crop. Surprisingly market labels of C4 (C4-63G), BE-3, and Intan were not correct because they have high amylose instead of intermediate amylose (10). Only one of four "C4" samples had intermediate amylose content. All 22 "Wagwag" samples had high amylose and mainly intermediate gelatinization temperature, characteristic of Wagwag. But 19 had long grain (more than 6 mm) suggesting IR36, and only 3 had length less than 6 mm, suggesting IR42. All nine "IR36" rices had the expected combination of properties. However, only two of five "IR42" had short grain, suggesting three may be other varieties. "IR36" rice had similar protein content to "IR42" rice. The Philippine milled rice samples had the lowest protein content (Table 10) followed by Thai rice (Table 2) and then Indonesian rice (Table 6).

The regression results show all physical and chemical characteristics, except gel consistency, significantly determine price (Table 11). Consumers will clearly pay more for whiteness, fewer brokens, longer grains, less chalkiness, lower amylose content, and lower gelatinization temperature (Table 12). Amylose content and percentage of brokens account for 53% of price variation.

Table 10. Average characteristics and price for Philippine rice samples (n=108).

Milled rice characteristic	Mean	Standard deviation	Range
Price (peso per kg)[a]	3.10	0.44	2.0 - 6.0
Whiteness (%)	42.39	2.70	29.9 - 47.0
Chalkiness score	3.95	2.02	0.0 - 9.0
Translucency (%)	85.04	13.74	16.0 - 100.0
Brokens (%)	42.81	10.99	5.4 - 71.5
Length (mm)	6.50	0.23	5.7 - 6.8
Length/width ratio	3.15	0.16	2.6 - 3.4
Alkali spreading value	5.66	0.60	4.2 - 7.0
Amylose (% dry basis)	27.75	2.42	18.0 - 29.9
Gel consistency (mm)[b]	41.06	10.23	30.0 - 81.5
Protein (% at 14% moisture)	7.01	0.49	5.6 - 8.3

[a]At the time of the survey, ₱10.00 = US$1. [b]Av of 90-mg and 100-mg samples.

Only the high-amylose samples were used to test whether the significance of amylose was due to aroma of low-amylose samples (Table 12). Amylose remained a significant price determinant, and largely determines cooking quality of IR varieties.

International comparison

The best estimates of implicit prices of grain quality characteristics are converted to US¢/kg for comparability (Table 13). These are the regression parameter estimates from the best regressions in Tables 3, 7, and 12, converted to US¢/kg. These implicit prices are per unit of change in each quality characteristic. Because the units of measurement differ among characteristics, the size of the implicit prices do not represent their relative importance within each country. Rather, statistically significant estimates indicate the important quality characteristics for each country. It is possible to compare implicit price estimates across countries for a particular characteristic.

Preferences for milling quality (whiteness and brokens) are similar and highly significant determinants of price in all three countries. Indonesians show a stronger preference for milling polish than consumers in the other two countries.

Table 11. Philippines: correlation coefficients for price and quality characteristics.

	Price	Whiteness	Brokens	Length	Length/width ratio	Chalkiness	Translucency	Alkali spreading value	Amylose	Gel consistency	Protein
Whiteness	.24*	–									
Brokens	-.41**	.17	–								
Length	.14	.26	-.10	–							
Length/width ratio	-.07	.24*	-.09	.71**	–						
Chalkiness	-.37**	-.07	.13	.09	.03	–					
Translucency	.28**	.37*	.28**	.06	-.01	-.26**	–				
Alkali spreading value	.17	-.23*	-.05	-.46	-.47**	-.08	.13	–			
Amylose	-.72**	-.18	.21*	-.06	.10	.21*	-.17	.05	–		
Gel consistency	.41**	.48**	-.22*	.30	.52**	-.08	.21*	-.22*	-.46**	–	
Protein	-.17	-.04	.09	.03	.04	-.09	-.29**	-.22*	.04	-.13	–
Aroma[a]	.57**	.20*	.21*	.08	-.08	-.26**	.18	-.03	-.79**	.44**	-.07

[a]Equals 1 for aromatic samples; 0 for others. 6 samples were aromatic. **Significant at the 1% level. *Significant at the 5% level.

Table 12. Philippines: regressions of price on quality characteristics.[a]

	Whiteness	Brokens	Length	Chalkiness	Alkali spreading value	Amylose	Gel consistency	Constant	R^2	Durbin Watson
All samples (n=108)										
	0.04 (3.38)	-0.02 (-5.55)	0.10 (0.62)	-0.07 (-3.78)				1.56	.39	1.85
					0.21 (4.03)	-0.10 (-7.10)	0.01 (2.67)	3.62	.50	1.79
	0.04 (3.44)	-0.01 (-5.59)	0.37 (2.91)	-0.04 (-3.55)	0.24 (5.15)	-0.10 (-8.48)	0.00 (0.30)	1.27	.70	1.63
High-amylose subsamples (n=97)										
	0.02 (3.95)	-0.01 (-7.01)	0.08 (1.10)	-0.03 (-3.36)	0.10 (3.14)	-0.06 (-2.52)	-.003 (-1.47)	3.14	.47	2.05

[a]t-statistics are in parentheses.

Table 13. Implicit prices of grain quality characteristics (US ¢/kg per unit of change).

Milled rice characteristic	Thailand	Indonesia	Philippines
Whiteness (%)	0.30*	1.14*	0.34*
Brokens (%)	-0.15*	-0.18*	-0.12*
Chalkiness score	-0.15	0.00	-0.38*
Shape (length/width ratio)	2.47*	-4.68*	2.85*
Amylose (%)	-0.02	0.14	-1.12*
Gel consistency (mm)	0.02	0.05	-0.01
Alkali spreading value	-0.04	1.92*	1.94*
Aroma	5.89*	9.07*	-

*Significant at 10% level or better.

Chalkiness is negatively related to price in two countries and is significant only in the Philippines. Philippine and Thai consumers prefer long slender grains but Indonesians prefer the bold shape of traditional bulu varieties.

Aroma is highly valued in Thailand and Indonesia. The Philippine data did not have enough aromatic samples to accurately measure an implicit price. Preferences for the other chemical characteristics are most pronounced in the Philippines, with a significant value for reduced amylose content and lower gelatinization temperature. Indonesian consumers similarly prefer low gelatinization temperature but not less amylose. This amylose difference may be due to the high amylose content (more than 26%) of most Philippine samples and the low to intermediate amylose content of most Indonesian samples (less than 26%). Cisadane, the intermediate-amylose MV released in 1981, was so widely adopted that the very few high-amylose rices were found in market samples. Because the amylose content of Indonesian samples is already at the preferred level, Indonesian consumers do not place a significant value on further reductions.

Similarly, the insignificant Thai results for chemical variables reflect the good chemical quality of most Thai samples. Although Thai samples have a higher average gelatinization temperature than samples in other countries (lower alkali spread value), Thai consumers do not prefer a lower gelatinization temperature. Only Thai consumers show the expected preference for intermediate gelatinization temperature.

The combinations of amylose content and gelatinization temperature in market samples from Thailand, Indonesia, and Philippines are presented in Appendix Table 1. The detailed analysis of the market samples from these countries is presented in Appendix Tables 2, 3, and 4, for the reference of rice researchers particularly from these countries.

CONCLUSIONS

This paper has demonstrated a simple methodology for testing consumer preferences. Laboratory measures of physical and chemical quality characteristics of rice can be regressed on rice price to explain observed differences in market prices. The regression parameter estimates show the implicit value of characteristics to consumers and the significance of parameter estimates indicates the importance of characteristics. Such estimates are useful to identify the characteristics that plant breeding program should focus on in improving quality.

Breeders can manipulate potential head rice recovery, chalkiness, shape, and the chemical variables. But grain quality is also determined by cultivation environment and postharvest handling. Improvements in handling and milling will depend on consumer's willingness and ability to pay for better quality, and on cost reductions in processing.

Improvements in quality without reductions in yield will generally benefit rice consumers by lowering the cost of better quality rice. If higher quality varieties were widely adopted, producers would not receive a price premium, but would retain better quality rice for home consumption, and have a wider domestic market for their rice. Similarly, rice-exporting countries would benefit from quality improvement that expands their potential export markets.

The market samples used here were drawn only from one main urban center in each country. Analysis of samples from other markets is needed to test regional variation in consumer preferences. Nevertheless, two types of quality improvement in modern rice varieties would benefit consumers throughout Southeast Asia. Improving potential head rice (whole grain) recovery is the first. In 1970, IR20 boosted potential head rice recovery to more than 60% of paddy. Earlier MVs, IR5 and IR8, have head rice recovery of only 36-40% of rough rice. Head rice recovery must be high in future MVs.

Development of intermediate-amylose rices acceptable in different agroclimatic environments would benefit consumers in Southeast Asia. C4, an intermediate-amylose MV released in the 1960s, was abandoned by farmers when it proved highly susceptible to insect pests. Cisadane, the intermediate-amylose MV developed in Indonesia, resists a major insect pest (brown planthopper), but does not resist a common rice disease in the Philippines. Since 1981, IRRI has released some intermediate-amylose lines with multiple insect and disease resistance, including the new IR64.

Because consumer preferences for other characteristics vary, national programs have leeway to tailor varieties to local preferences. International rice research could provide plant materials with diverse grain characteristics to national programs. National programs might further study consumer preferences to identify quality objectives important to most consumers.

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Appendix Table 1. Combinations of amylose content and gelatinization temperature (indexed by alkali spreading value) in market samples for Thailand, Indonesia, and the Philippines.

Amylose class	Thailand					Indonesia					Philippines				
Alkali spreading value	3-4	5	6	7	Total	4	5	6	7	Total	4	5	6	7	Total
Low (<20%)	0	0	21	0	21	0	1	1	0	2	1	0	1	1	3
Intermediate (20-25%)	5	20	5	0	30	2	52	36	9	99	1	3	3	1	8
High (>25%)	5	23	3	2	33	0	5	10	2	17	1	28	57	11	97
Total	10	43	29	2	84	2	58	47	11	118	3	31	61	13	108

Appendix Table 2. Characteristics of Thai rice samples.

Retailer no.	Variety name	Price (baht/15 kg)[a]	Whiteness (%)	Brokens (%)	Grain weight (mg)	Length (mm)	Width (mm)	Length/ width ratio	Chalkiness score	Translucency (%)	Amylose (%)	Alkali spreading value	Mean gel consistency (mm)	Protein (%)
Farmer's organization market														
1	Kao Hawm Mali (new crop)	150	42.5	6.4	1.86	7.3	1.8	4.1	1	66	20.0	5.2	61.5	7.1
1	Hao Hawm Mali (old crop)	145	39.2	13.9	1.85	7.2	1.9	3.8	1	59	17.6	6.0	81.5	7.9
1	Sticky rice (opaque)	140	56.9	0.7	1.76	6.6	2.0	3.3	waxy	–	2.1	6.1	86.0	7.0
1	Sao Hai	120	44.8	1.7	2.01	7.0	2.0	3.5	5	44	29.4	3.0	33.5	8.2
1	Nang Mon	115	40.5	6.1	2.00	7.0	2.0	3.5	5	51	26.4	4.5	40.0	8.2
1	Khao Tah Haeng	110	41.2	4.7	2.08	7.1	2.1	3.4	5	46	27.1	4.6	70.5	7.5
1	Kao Tah Haeng (broken)	80	43.9	–	–	–	–	–	–	34	25.6	–	33.5	8.0
2	Hawm Mali (new crop)	150	46.5	0.2	1.88	7.2	1.9	3.8	1	68	17.0	6.0	92.5	7.0
2	Sao Hai	125	43.2	1.4	2.06	7.4	2.1	3.5	5	48	28.6	5.0	41.5	8.5
2	Kaiset Luang	115	46.4	4.8	2.00	7.2	2.0	3.6	5	72	30.0	5.2	45.0	8.2
2	Metlek	105	40.0	12.7	1.64	5.7	2.2	2.6	9	42	26.4	4.8	68.5	7.8
2	Su Rin	105	39.5	13.2	1.67	5.9	2.1	2.8	9	52	25.8	4.4	77.5	8.0
2	Ton (big broken)	95	43.9	–	–	–	–	–	–	27	29.8	–	55.5	7.6
2	Broken Hong Meli	85	39.8	–	–	–	–	–	–	52	18.2	–	79.5	8.0
3	Kao Hawm Mali	148	39.8	9.7	1.84	7.2	1.9	3.8	5	44	19.0	5.9	63.0	7.7
3	Hawm Mali	140	39.6	2.7	1.84	7.2	1.9	3.8	1	44	18.9	6.0	70.5	7.7
3	Sao Hai	120	40.8	2.1	2.00	7.2	2.1	3.4	5	56	29.7	4.9	69.0	8.2
3	Leuang Surin	105	40.0	18.2	1.66	5.4/6.2	2.4/2.0	2.2/3.1	9	39	27.0	4.3	69.0	7.5
3	Leuang Awn	115	39.8	13.9	2.01	7.2	2.1	3.4	5	52	25.0	5.0	47.0	7.5
3	Khao Tah Haeng	105	40.8	12.1	1.86	6.8	2.0	3.4	5	34	25.2	4.8	38.5	8.5
3	Sao Ho (broken)	80	41.5	–	–	–	–	–	–	38	23.2	–	40.0	8.0
4	Kao Hawm Meli	147	39.6	0.8	1.78	7.2	1.9	3.8	1	37	17.4	6.0	70.0	7.8
4	Kao Hawm Meli (new)	140	42.2	10.4	1.84	7.0	1.8	3.9	1	62	19.2	5.5	59.0	7.3
4	Kao Hawm Meli	140	41.1	6.4	1.83	7.2	1.9	3.8	1	56	17.1	6.0	79.0	7.6
4	Sao Hai	120	40.2	3.0	2.08	7.2	2.2	3.3	5	44	28.8	5.0	45.5	7.7
4	Sticky Rice (opaque)	120	52.0	20.4	2.20	6.9	2.4	2.9	–	10	2.3	6.4	74.5	7.7
4	Kao 3A	120	43.8	0.5	2.04	7.2	2.0	3.6	5	62	29.0	4.6	52.5	8.4
4	Leuang Pra Talin	115	40.4	12.8	1.82	6.4	2.1	3.0	9	38	26.8	4.4	60.5	7.6
4	Sao Ho (broken)	80	30.7	–	–	–	–	–	–	11	30.8	–	45.0	7.0
5	Hawm Meli (new)	145	39.1	3.3	1.84	7.2	1.9	3.8	1	66	18.0	6.3	65.5	7.6
5	Kao Hawm Meli	140	40.0	22.0	1.81	7.1	1.9	3.7	1	63	17.0	6.1	79.0	7.6
5	Kao Hawm Meli (old)	130	39.0	17.9	1.88	7.3	2.0	3.6	1	42	17.8	6.0	69.5	8.4
5	Sao Hai	120	41.5	11.1	2.08	7.2	2.1	3.4	5	40	23.9	4.2	46.5	8.0
5	Leuang Awn	115	43.5	7.5	2.08	7.0	2.2	3.2	5	24	24.2	4.4	50.5	7.6
5	Old rice	100	40.8	36.1	2.08	7.2	2.1	3.4	5	49	23.8	5.1	50.0	7.6
5	Broken	80	40.4	–	–	–	–	–	–	34	23.0	5.3	43.0	7.5
6	Kao Hawm Meli	150	43.0	9.5	1.80	7.0	1.8	3.9	1	46	20.2	–	61.5	7.1
6	Kao Hawm Meli (old)	148	41.9	3.1	1.82	7.2	1.9	3.8	1	68	17.7	5.8	74.5	7.7
6	Jek Chuey	128	41.8	5.0	2.09	7.2	2.0	3.6	5	46	28.3	4.8	49.5	7.9
6	Sao Hai	120	42.4	15.0	2.08	7.2	2.2	3.3	1	68	29.2	4.8	49.0	7.4
6	Khao Tah Haeng	115	40.0	18.2	2.05	7.2	2.2	3.3	5	42	23.6	4.6	67.5	7.4
6	Golden Apple	113	40.2	20.1	2.04	7.2	2.1	3.4	5	36	25.4	4.6	56.5	7.7
6	Puang Tawng	105	42.1	33.8	1.54	5.7	2.2	2.6	5	61	26.2	4.9	57.0	7.4
6	Old rice (broken)	80	42.0	–	–	–	–	–	–	36	22.4	–	41.5	7.8

Appendix Table 2 continued.

Retailer no.	Variety name	Price (baht/15 kg)[a]	Whiteness (%)	Brokens (%)	Grain weight (mg)	Length (mm)	Width (mm)	Length/ width ratio	Chalkiness score	Translucency (%)	Amylose (%)	Alkali spreading value	Mean gel consistency (mm)	Protein (%)
Weekend market														
1	Kao Hawm Mali (new)	140	40.9	14.1	1.90	7.2	1.9	3.8	1	100	19.8	5.9	57.0	6.7
1	Hawm Mali	135	42.0	21.1	1.92	7.0	2.0	3.5	1	100	16.9	6.1	72.5	6.3
1	Sao Hai	120	41.6	10.7	2.16	7.1	2.0	3.6	5	82	30.3	4.6	35.0	7.0
1	Leuang Awn	115	42.1	9.0	2.17	6.9	2.1	3.3	5	100	26.3	4.6	42.0	7.0
1	Ta Ka Set	115	42.5	20.0	2.18	7.1	2.2	3.2	5	100	24.6	4.6	73.5	6.6
1	Kao Ta Haeng	110	39.2	22.4	2.15	7.2	2.1	3.4	5	100	22.4	5.0	58.5	6.8
1	Khao Tah Haeng	105	36.8	21.2	2.18	7.2	2.0	3.6	5	30	28.5	6.8	40.5	8.1
1	Leuang Awn	100	39.4	28.9	2.18	7.0	2.0	3.5	5	38	26.9	5.8	34.5	7.9
1	Kao Tah Haeng (broken)	80	35.1	66.8	1.97	6.8	2.0	3.4	9	12	22.3	4.6	76.0	7.1
1	Hawm Meli (broken)	75	43.0	–	–	–	–	–	–	58	17.0	–	75.0	6.7
2	Haw Meli (old)	135	39.1	4.3	1.88	7.0	1.9	3.7	1	91	17.2	6.0	77.5	7.3
2	Kao Tah Haeng	110	41.5	8.1	2.20	7.1	2.2	3.2	5	94	23.6	4.5	52.0	6.9
2	Kao Tah Haeng	105	40.8	15.1	2.08	6.9	2.1	3.3	5	88	23.6	4.5	46.5	7.4
2	Kao Tah Haeng	90	29.2	18.9	2.10	6.9	2.1	3.3	5	23	21.2	3.0	55.0	7.3
2	Big brokens	80	39.0	–	–	–	–	–	–	34	23.2	–	40.0	6.4
3	Kao Hawm Mali (old)	135	40.6	14.6	1.91	7.2	1.8	4.0	1	100	17.6	6.0	76.0	7.2
3	Jek Chuey (missing)	120	–	–	–	–	–	–	–	–	–	–	–	–
3	Sao Hai	115	38.9	17.8	2.14	7.0	2.0	3.5	5	85	23.0	5.5	40.0	6.9
3	Kao Tah Haeng	110	38.8	21.5	2.03	7.1	2.0	3.6	5	84	25.1	6.0	42.5	7.3
3	Brokens	70	36.5	–	–	–	–	–	–	39	21.4	–	36.5	7.3
4	Kao Hawm Mali	135	40.5	19.4	1.99	7.1	2.0	3.6	1	100	19.4	5.6	62.5	6.9
4	Leuang Awm	115	42.0	7.0	2.10	7.0	2.0	3.5	5	92	21.7	4.8	50.0	6.9
4	Sao Hai	115	42.0	10.0	2.09	7.0	2.1	3.3	5	91	27.4	4.8	47.5	7.4
4	Kao Tah Haeng	110	41.2	5.7	2.04	7.0	2.1	3.3	5	90	29.4	4.6	37.0	7.6
5	Kao Hawm Mali (new)	145	41.2	5.9	2.01	7.2	1.9	3.8	5	100	19.3	6.4	82.0	6.5
5	Kao Hawm Mali (old)	135	40.6	19.1	2.09	7.1	2.0	3.6	1	100	19.1	6.0	61.5	7.4
5	Leuang Awn	115	42.5	8.5	2.06	7.0	2.1	3.3	1	100	21.9	4.8	73.0	6.9
5	Sao Hai	115	39.6	15.8	2.05	7.1	2.0	3.6	5	80	25.7	5.5	42.0	7.1
5	Kao Hawn Mali	108	40.8	67.9	2.08	7.0	2.0	3.5	5	74	20.0	3.6	66.5	6.9
5	Khao Tah Haeng	103	41.5	20.0	2.16	7.0	2.1	3.3	5	68	26.5	4.4	48.5	7.3
5	Kao Klong	85	27.1	29.6	2.07	6.7	2.1	3.2	5	21	19.6	5.8	30.0	7.2
5	Kao Se Tee	80	40.2	54.8	2.09	7.0	2.1	3.3	5	43	27.4	5.2	43.5	7.2
6	Kao Hawn Mali	135	36.8	16.6	1.86	7.3	1.9	3.8	1	73	17.2	6.0	67.5	8.1
6	Sao Hai	115	39.8	17.4	2.09	7.1	2.0	3.6	1	100	26.4	5.1	43.5	9.1
6	Kao Tah Haeng	110	40.8	10.0	2.15	7.0	2.2	3.2	5	88	26.8	4.4	62.0	7.0
6	Kao Tah Haeng	105	40.2	13.4	2.11	7.1	2.2	3.2	5	86	24.8	4.6	61.5	7.2
6	Leuang Awn	100	44.1	38.8	2.22	7.0	2.2	3.2	5	85	29.3	4.6	60.5	6.5
6	Kao Mai	95	42.0	8.8	2.14	7.0	2.1	3.3	5	90	26.2	4.5	63.0	7.0
7	Kao Hawn Mali	135	38.4	15.1	1.96	7.2	1.9	3.8	1	100	17.9	6.0	72.5	7.3
7	Kao Hawn Mali	130	39.0	9.0	2.04	7.2	2.0	3.6	1	100	17.5	5.8	66.5	7.0
7	Sao Hai	120	38.6	7.2	2.22	7.2	2.0	3.6	5	97	22.2	5.0	36.5	8.6
7	Leuang Awn	115	41.5	2.0	2.14	7.2	2.0	3.6	5	91	26.8	4.9	40.5	7.3
7	Sao Hai	115	40.8	7.6	2.25	7.4	2.0	3.7	5	89	29.1	4.6	53.5	7.3
7	Kaset	110	42.0	7.8	2.11	7.0	2.0	3.6	5	90	23.8	4.6	57.0	6.6
7	Golden Apple	105	39.0	6.4	2.12	7.1	2.0	3.6	5	100	21.8	5.5	85.0	6.3
7	Kao Hawn Mali (big broken)	95	41.0	69.3	1.95	7.0	2.1	3.3	5	78	20.4	5.0	57.5	7.3
7	Sao Hai	100	40.5	50.5	2.03	7.2	2.1	3.4	5	58	21.7	4.8	49.0	7.3

Appendix Table 2 continued.

Retailer no.	Variety name	Price (15 kg) (baht/15 kg)	Whiteness (%)	Brokens (%)	Grain weight (mg)	Length (mm)	Width (mm)	Length/ width ratio	Chalkiness score	Translucency (%)	Amylose (%)	Alkali spreading value	Mean gel consistency (mm)	Protein (%)
8	Kao Hawn Mali	135	40.4	13.9	1.93	7.2	2.0	3.6	1	100	18.0	6.0	85.0	6.9
8	Kao Hawn Mali	130	42.5	13.1	1.83	7.3	2.0	3.6	5	87	20.8	5.4	49.0	7.2
8	Kao Hawn Mali	125	41.2	20.4	1.79	7.2	2.0	3.6	5	97	19.3	5.6	57.5	7.3
8	Sao Hai	120	42.0	20.3	2.09	7.2	2.0	3.6	5	83	27.8	4.8	38.0	7.7
8	Jek Chuey	115	41.6	4.9	2.03	7.2	2.2	3.3	5	39	25.0	4.9	47.5	7.6
8	Sao Hai	110	41.4	13.2	1.99	7.2	2.1	3.4	5	77	28.2	4.8	34.0	7.5
8	Leuang Awn	100	42.0	18.9	2.11	7.3	2.0	3.6	5	45	29.0	6.4	36.5	8.2
8	Khao Tah Haeng	100	37.6	14.0	2.11	7.4	2.0	3.7	5	31	28.8	6.8	36.5	8.6
8	Khao Tah Haeng	80	34.8	70.7	–	6.7	2.0	3.4	5	11	25.2	4.2	71.5	7.4
8	Khao Hawn Mali (broken)	78	44.5	–	–	–	–	–	–	56	17.6	–	60.0	6.5
8	Hawn Som Mao	–	32.2	7.6	1.96	6.8	2.0	3.4	5	63	25.1	–	36.5	7.3
8	Hawn Som Mao	–	19.4	–	–	–	–	–	9	9	21.6	–	30.5	7.8

[a]22.6 baht = US$1.

Appendix Table 3. Characteristics of Indonesian rice samples.

Retailer no.	Variety name	Price (rupiah/kg)[a]	Whiteness (%)	Brokens (%)	Grain weight (mg)	Length (mm)	Width (mm)	Length/ width ratio	Chalkiness score	Translucency (%)	Amylose (%)	Alkali spreading value	Mean gel consistency (mm)	Protein (%)
Senen market														
1	Cianjur Kepala	600	43.5	10.3	2.31	6.0	2.6	2.3	9	86	23.8	6.0	60.0	6.9
1	Pandanwangi	500	41.1	43.0	2.05	5.8	2.6	2.2	9	62	26.0	6.2	55.0	7.6
1	Siam super	450	40.5	7.3	2.01	6.8	2.0	3.4	5	81	23.9	5.1	77.0	6.3
1	Padi Bulu	450	41.1	35.1	2.20	6.4	2.4	2.7	9	62	22.2	4.8	48.5	8.1
1	Bandung Saigon	450	40.0	34.0	2.11	6.6	2.4	2.8	5	59	25.6	5.8	48.5	7.4
1	Cisadane	400	39.1	51.4	2.18	6.3	2.5	2.5	9	58	21.4	4.8	52.5	8.1
1	Cianjur Saigon	400	38.4	50.7	1.92	6.4	2.2	2.9	1	58	29.2	5.9	41.5	8.0
1	Japan Slip	400	33.2	10.7	2.19	4.9	2.8	1.8	1	88	20.1	7.0	65.5	7.4
1	Pelita	400	39.2	46.6	2.07	6.4	2.4	2.7	9	66	21.2	4.7	40.5	7.6
1	IR	350	37.0	47.4	1.85	6.6	2.1	3.1	5	71	29.5	5.4	35.0	7.7
2	Cianjur Kepala	500	43.5	42.4	2.24	5.6	2.8	2.0	9	54	22.8	5.8	58.0	8.1
2	Cianjur Slip	450	39.2	33.0	2.27	6.6	2.5	2.6	9	82	22.3	4.6	62.0	7.7
2	Saigon	400	37.1	46.4	1.91	6.6	2.2	3.0	5	70	28.8	5.8	32.5	7.1
2	Cisadane	400	36.5	40.1	1.08	6.3	2.3	2.7	9	59	21.9	4.6	41.0	8.3
2	Japan	400	34.8	10.3	2.11	5.0	2.8	1.8	5	100	19.6	7.0	78.5	6.5
2	Siam super	400	36.5	7.8	2.04	7.2	2.2	3.3	1	92	27.6	6.2	56.0	6.9
2	Sempat	350	37.2	53.8	1.50	6.3	2.0	3.2	5	33	30.1	6.0	37.5	8.9
3	Cianjur slip	300	39.6	38.3	2.24	6.4	2.5	2.6	9	82	23.1	4.9	62.0	8.5
3	Siam	300	36.6	10.9	2.04	7.0	2.1	3.3	5	72	25.5	5.6	48.5	6.9
3	Saigon	275	36.8	53.9	1.87	6.7	2.1	3.2	5	61	28.6	5.9	44.0	8.8
4	Cianjur Kepala	600	40.0	10.5	2.13	5.8	2.7	2.1	9	89	23.9	6.8	53.5	8.3
4	Pandanwangi	500	46.5	60.0	2.23	5.8	2.6	2.2	9	51	25.0	6.1	57.5	7.1
4	Rojolele Solo	500	40.6	34.1	2.09	6.2	2.4	2.6	5	83	23.5	6.0	52.0	8.4

Appendix Table 3 continued.

Retailer no.	Variety name	Price (rupiah/kg)[a]	Whiteness (%)	Brokens (%)	Grain weight (mg)	Length (mm)	Width (mm)	Length/ width ratio	Chaikiness score	Translucency (%)	Amylose (%)	Alkali spreading value	Mean gel consistency (mm)	Protein (%)
4	Saigon Bandung	460	40.1	35.4	2.13	7.0	2.2	3.2	9	72	27.6	6.1	41.5	7.9
4	Cianjur Slip	420	41.4	39.6	2.12	6.4	2.5	2.6	9	85	24.0	5.0	58.5	8.4
4	Saigon Darmaraja	420	41.6	42.8	2.14	6.4	2.5	2.6	9	95	22.9	5.4	68.5	8.1
4	Saigon Sumedang	400	40.0	34.7	2.10	6.6	2.4	2.8	9	75	23.2	5.9	44.0	8.4
4	Cianjur slip	360	40.4	50.8	2.24	6.7	2.4	2.8	9	89	23.6	5.6	58.5	7.9
4	Cisadane	350	40.6	55.5	2.23	6.5	2.5	2.6	9	35	21.1	4.4	39.0	7.0
4	Saigon Tasik	325	35.2	36.7	1.90	6.6	2.1	3.1	5	77	28.0	6.1	33.5	7.9
5	Rojolele Solo	500	38.6	31.7	2.02	6.6	2.4	2.8	5	85	22.4	6.1	34.5	9.4
5	Rojolele Wangipandan	480	43.8	33.1	2.02	6.0	2.7	2.2	9	66	25.9	6.7	48.0	7.6
5	Cianjur Kepala	450	40.4	25.2	2.22	6.5	2.5	2.6	9	86	22.6	4.9	59.0	8.6
5	Cianjur slip super	400	40.0	55.5	2.02	6.5	2.4	2.7	9	46	24.0	5.1	51.0	9.0
5	Saigon Sumedang	400	39.8	48.9	2.06	6.2	2.4	2.6	9	68	23.0	4.8	47.5	8.4
5	Japan	380	39.0	7.4	2.09	5.0	2.9	1.7	5	100	19.8	7.0	81.0	6.5
5	Siam	375	38.0	5.4	1.97	7.0	2.1	3.3	9	89	25.3	5.0	52.0	6.9
5	Cisadane	320	38.9	47.2	2.19	6.4	2.5	2.6	9	46	21.8	4.8	63.5	8.9
5	IR	300	36.2	38.2	1.82	6.0	2.6	2.3	9	37	25.6	4.9	37.5	8.7
6	Cianjur Kepala	550	40.2	30.5	2.23	6.2	2.6	2.4	9	79	23.2	6.2	46.5	8.5
6	Rojolele Solo	550	37.6	19.3	2.10	6.2	2.5	2.5	5	83	24.4	6.0	40.5	8.2
6	Japan	450	33.8	7.4	2.13	5.0	2.8	1.8	5	100	20.4	7.0	72.0	6.8
6	Saigon Sumedang	450	39.2	30.1	2.17	6.5	2.5	2.6	9	100	21.6	6.1	55.0	9.7
6	Cianjur slip	450	40.9	21.3	2.15	6.2	2.6	2.4	9	81	25.0	6.5	52.5	8.5
6	Siam Super	400	37.0	8.4	1.98	7.2	2.2	3.3	1	85	24.0	5.6	49.0	7.2
6	Cisadane I	400	39.0	42.6	2.26	6.6	2.5	2.6	9	94	22.6	5.0	48.5	8.8
6	Cisadane II	350	39.2	45.7	2.17	6.2	2.6	2.4	9	57	21.8	4.8	49.5	7.4
6	Saigon C-4	325	35.8	12.7	1.94	7.0	2.1	3.3	5	64	24.4	5.1	40.5	7.4
7	Ketan	1200	44.0	25.2	1.83	6.8	2.1	3.2	–	24	3.8	6.7	86.0	9.0
7	Cianjur Kepala	500	40.8	24.0	2.20	5.8	2.7	2.1	9	68	22.5	5.8	50.5	7.9
7	Rojolele	500	40.5	46.6	2.16	6.4	2.5	2.6	9	79	22.0	5.2	48.5	9.2
7	Saigon Bandung	475	42.0	38.5	2.06	6.6	2.4	2.8	5	72	25.2	6.1	43.5	9.3
7	Cianjur Slip	450	39.5	43.4	2.13	6.0	2.6	2.3	9	60	22.7	5.1	48.5	8.6
7	Saigon Sumedang	450	39.8	37.9	2.21	6.4	2.5	2.6	9	64	21.8	4.9	50.0	8.5
7	Saigon Keras	400	36.4	33.5	1.84	7.0	2.1	3.3	5	66	26.6	5.2	34.0	8.3
7	Japan	400	35.4	8.6	2.12	5.0	2.8	1.8	5	100	19.6	7.0	74.0	6.9
7	Siam Super	400	37.6	9.6	1.98	7.1	2.1	3.4	5	77	26.6	5.6	65.5	6.6
7	Cisadane	375	41.5	46.0	2.26	6.4	2.6	2.5	9	86	22.6	5.0	51.5	7.9
Djatinegara market														
8	Rojolele	400	39.0	42.2	2.16	6.4	2.5	2.6	9	73	21.4	4.6	59.5	9.4
8	Black Ketan	400	7.2	–	–	–	–	-	–	–	1.6	–	99.0	9.0
8	Saigon Bandung	350	39.0	33.7	2.19	6.4	2.4	2.7	9	78	22.2	4.8	44.0	9.6
8	Cianjur slip	350	41.8	38.5	2.12	6.2	2.5	2.5	9	59	21.6	4.7	59.5	9.9
8	Red rice	350	15.5	30.9	2.42	6.6	2.8	2.4	9	20	21.2	6.0	31.0	9.7
8	Japan	325	39.0	9.2	2.06	5.0	2.8	1.8	5	100	19.8	7.0	73.5	6.8
8	Cisadane	300	38.6	39.9	1.94	6.1	2.5	2.4	9	61	21.8	4.8	40.0	8.8
8	Siam Super	300	38.2	8.2	2.03	7.0	2.1	3.3	5	81	25.3	6.0	54.0	6.9
8	IR	280	35.5	42.2	1.61	6.4	2.0	3.2	5	65	29.1	5.0	34.5	8.1
9	Rojolele	520	39.1	20.5	2.12	6.4	2.6	2.5	5	88	23.6	6.0	32.5	8.8
9	Cianjur Kepala I	480	40.5	25.0	2.05	6.3	2.6	2.4	5	98	23.4	5.9	48.0	7.5
9	Red rice	475	14.6	16.7	1.74	6.6	2.0	3.3	5	60	22.6	6.8	52.0	8.4
9	Cianjur Kepala II	450	40.5	27.9	2.08	5.8	2.7	2.1	9	70	22.8	5.9	46.0	8.3

Appendix Table 3 continued.

Retailer no.	Variety name	Price (rupiah/kg)[a]	Whiteness (%)	Brokens (%)	Grain weight (mg)	Length (mm)	Width (mm)	Length/ width ratio	Chalkiness score	Translucency (%)	Amylose (%)	Alkali spreading value	Mean gel consistency (mm)	Protein (%)
9	Cianjur Slip	420	37.1	21.1	1.96	6.6	2.2	3.0	5	100	25.2	6.8	36.5	9.1
9	Saigon Sumedang	400	36.9	24.5	2.04	6.6	2.2	3.0	9	96	23.2	6.4	36.0	8.4
9	Japan	400	32.2	9.5	2.14	5.0	1.8	1.8	5	100	19.9	7.0	66.0	7.6
9	Cisadane	380	34.6	35.1	2.21	6.4	2.5	2.6	9	84	21.4	5.0	49.5	7.7
9	Saigon Bandung	380	38.6	30.6	2.12	5.2	2.8	1.9	5	90	22.1	6.5	49.5	7.7
10	Rojolele	460	39.9	52.1	2.14	6.3	2.5	2.5	9	77	20.[illegible]	5.0	50.5	9.0
10	Cianjur Kepala	400	40.2	28.6	2.21	6.4	2.6	2.5	9	83	22.0	5.2	44.0	8.2
10	Japan	390	35.2	7.8	2.11	4.9	2.9	1.7	5	100	20.2	7.0	69.0	8.4
10	Siam Super	380	39.7	5.6	1.96	6.9	2.2	3.1	5	81	26.5	5.6	58.0	6.9
10	Saigon Bandung	380	39.9	33.1	1.77	6.4	2.2	2.9	5	82	26.8	5.1	34.0	6.6
10	Cisadane	375	37.5	30.4	2.12	6.4	2.5	2.6	9	56	21.2	4.9	46.0	7.3
10	Cianjur Slip	370	39.5	30.7	2.24	6.6	2.5	2.6	9	84	21.6	5.1	42.5	8.0
10	IR	350	34.4	35.9	2.09	6.4	2.4	2.7	9	66	21.0	4.4	33.5	7.9
10	Amerika	300	29.9	27.9	1.91	5.8	2.5	2.3	5	47	16.9	6.4	33.0	6.5
11	Kepala Pandanwangi	500	42.8	34.6	2.17	6.2	2.6	2.4	9	74	22.2	6.0	47.0	7.8
11	Cianjur slip	430	39.9	29.4	2.10	6.0	2.6	2.3	9	72	23.0	5.9	36.0	8.2
11	Saigon Sumedang	420	39.6	29.2	2.17	6.4	2.4	2.7	9	76	22.2	5.0	51.0	8.3
11	Saigon Bandung	420	37.6	17.4	2.03	6.6	2.4	2.8	5	91	24.3	6.1	43.5	8.3
11	Siam Super	380	36.0	9.4	1.92	6.9	2.0	3.4	5	76	23.4	5.5	48.0	6.9
11	Cisadane	340	39.0	40.1	2.35	6.4	2.5	2.6	9	74	21.5	4.8	50.0	8.1
12	Cianjur Kepala	425	40.1	31.9	2.15	6.3	2.7	2.3	5	78	23.2	6.[illegible]	46.0	8.5
12	Rojolele	400	40.0	48.2	2.19	6.4	2.4	2.7	9	54	21.4	4.6	55.0	9.0
12	Saigon Cempaka	350	38.5	36.0	2.29	6.4	2.5	2.6	9	88	21.8	4.8	47.5	7.6
12	Japan	325	33.0	6.0	2.14	5.0	2.8	1.8	5	100	19.6	7.0	71.0	7.9
12	Siam Super	300	40.2	5.9	2.02	7.2	2.2	3.3	1	85	26.4	5.2	57.0	6.9
13	Cianjur Kepala	440	40.5	28.7	2.21	6.5	2.6	2.5	9	73	25.2	6.0	42.5	8.4
13	Rojolele	440	40.9	51.1	2.18	6.4	2.5	2.6	9	86	21.4	4.6	55.0	8.8
13	Cianjur Super I	420	40.1	32.4	2.18	6.3	2.6	2.4	9	90	23.2	4.8	46.0	8.6
13	Saigon Sumedang	375	41.8	52.8	2.24	6.5	2.6	2.5	9	72	22.8	5.6	43.0	8.4
13	Cianjur Slip II	370	39.1	36.9	2.22	6.5	2.6	2.5	9	85	22.0	4.9	43.5	8.8
13	Siam Super	360	36.0	10.1	2.01	7.2	2.2	3.3	5	98	25.0	5.8	41.0	7.0
13	IR	270	36.8	53.1	1.73	6.6	2.2	3.0	5	51	27.7	5.6	33.0	8.3
14	Japan	325	36.2	6.5	2.08	5.0	2.8	1.8	5	100	19.5	7.0	68.0	6.6
14	Siam Super	325	38.8	8.6	1.89	7.0	2.1	3.3	5	84	23.8	4.4	45.0	7.0
14	Cisadane	300	37.[illegible]	32.7	2.24	6.6	2.5	2.6	9	71	21.4	4.8	43.0	8.3
Tanah Abang market														
15	Rojolele	475	40.4	32.9	2.17	6.4	2.6	2.5	9	83	22.0	4.8	52.5	8.3
15	Pandanwangi	400	37.6	28.0	2.08	5.8	2.7	2.1	9	60	24.4	7.0	41.5	8.3
15	Cianjur Slip	375	43.2	54.6	2.18	6.0	2.7	2.2	9	66	21.6	6.0	42.0	8.5
15	Saigon Sumedang	360	39.0	47.8	1.96	6.6	2.4	2.8	5	85	26.4	5.6	43.0	8.7
15	Red rice	350	14.5	13.5	1.98	6.8	2.0	3.4	5	54	22.4	7.0	31.0	7.9
15	Japan	325	35.8	6.3	2.05	5.0	2.8	1.8	5	100	19.8	7.0	72.5	6.5
15	Super Siam	310	38.5	14.1	1.97	7.0	2.0	3.5	5	77	25.7	4.6	52.5	6.6
15	America/Cisadane	300	34.8	36.0	2.05	6.2	2.7	2.3	9	69	19.8	5.0	34.0	7.8
16	Pandanwangi	425	45.1	60.5	2.05	5.8	2.6	2.2	9	51	24.2	6.8	39.0	7.4
16	Cianjur Kepala	425	41.1	16.5	1.96	5.8	2.7	2.1	9	92	23.4	6.9	41.5	8.2
16	Cianjur Slip	350	40.4	36.9	1.99	6.3	2.4	2.6	9	89	24.8	4.9	44.5	8.3
16	Sumedang	350	40.4	33.5	1.96	6.6	2.3	2.9	9	98	24.4	5.6	51.0	8.6
16	Japan	325	33.2	4.2	2.11	5.0	2.9	1.7	5	100	20.0	7.0	72.5	7.4

Appendix Table 3 continued.

Retailer no.	Variety name	Price (rupiah/kg)[a]	Whiteness (%)	Brokens (%)	Grain weight (mg)	Length (mm)	Width (mm)	Length/ width ratio	Chalkiness score	Translucency (%)	Amylose (%)	Alkali spreading value	Mean gel consistency (mm)	Protein (%)
16	Saigon Bandung	300	33.0	40.8	1.81	6.7	2.2	3.0	5	100	31.4	6.8	65.0	7.4
16	BA	300	38.4	50.5	2.05	6.4	2.6	2.5	9	64	21.2	4.5	40.5	9.0
17	Cianjur Slip	350	41.2	45.6	2.19	6.5	2.6	2.5	9	60	22.2	4.9	40.0	7.9
17	Japan	325	34.6	16.7	2.07	5.0	2.9	1.7	5	90	20.4	7.0	63.0	6.9
17	BGS	325	41.4	49.2	2.07	6.4	2.6	2.5	9	60	20.8	5.6	38.5	8.3
17	Siam	310	39.2	10.2	2.05	7.0	2.2	3.2	5	69	27.2	6.0	50.0	6.8
17	Saigon Bandung	300	41.2	30.8	2.11	6.4	2.6	2.5	9	67	22.2	5.8	40.0	7.9
17	C4	275	35.0	30.2	2.01	5.8	2.6	2.2	9	59	22.7	6.0	35.5	7.4
Pasar Majestik market														
18	Pandanwangi	550	45.2	27.0	2.22	6.0	2.9	2.1	9	75	24.6	6.1	57.0	7.0
18	Cianjur Kepala	500	42.0	24.4	2.19	6.0	2.7	2.2	9	82	25.4	6.4	35.0	8.6
18	Cianjur Slip	475	44.6	28.3	2.05	6.0	2.8	2.1	9	69	24.4	6.4	53.0	7.9
18	Saigon Sumedang	425	39.8	39.7	2.20	6.2	2.6	2.4	5	96	22.4	5.0	54.5	9.3
18	Japan	400	30.0	6.0	2.15	5.0	2.8	1.8	5	100	19.6	7.0	60.5	7.9
18	Super Siam	400	37.1	7.3	2.02	7.0	2.2	3.2	1	70	26.8	5.6	60.0	7.4
18	Cianjur Cisadane	400	38.0	41.2	2.29	6.9	2.6	2.7	5	82	25.2	6.0	44.0	8.4
19	Rojolele	500	39.0	55.3	2.17	6.4	2.6	2.5	9	80	21.6	4.9	51.0	9.2
19	Cianjur Slip	425	39.6	31.0	2.12	6.3	2.6	2.4	9	61	24.6	5.8	45.0	8.0
19	Japan	400	33.1	4.5	2.15	5.2	2.9	1.8	5	99	18.4	7.0	60.0	8.1
19	Cisadane	400	36.8	31.9	2.21	6.2	2.5	2.5	9	46	21.6	5.0	59.5	9.0
20	Rojolele	500	37.5	43.9	2.13	5.8	2.8	2.1	9	73	21.6	4.6	48.0	8.7
20	Cianjur Slip	450	37.2	56.8	2.14	6.4	2.6	2.5	9	54	21.5	4.7	48.5	9.2
20	Cisadane	400	38.8	42.1	2.30	6.4	2.6	2.5	9	84	21.4	4.8	54.0	8.1
20	Cianjur SD	400	38.5	37.1	2.22	5.8	2.8	2.1	9	81	21.6	4.8	51.0	8.1
20	Japan	400	31.6	9.5	2.16	5.2	3.0	1.7	5	99	19.8	7.0	68.5	8.0
20	Beras Kantor	300	29.8	34.6	1.90	6.0	2.6	2.3	5	56	16.8	6.1	33.0	6.6
Tanah Abang market														
21	Rojolele	700	39.4	28.9	2.17	6.6	2.7	2.4	9	86	21.8	4.8	49.5	8.4
21	Beras Kepala	500	38.8	34.9	2.05	5.5	2.8	2.0	9	74	21.4	6.9	47.0	7.8
21	Cianjur Slip I	460	40.5	52.0	2.03	5.8	2.6	2.2	9	62	22.4	6.2	44.5	7.9
21	Cianjur Slip II	450	37.0	32.1	2.07	6.0	2.6	2.3	5	76	21.0	6.5	50.5	8.1
21	Cianjur Slip	425	38.0	48.8	2.00	6.4	2.5	2.6	9	74	22.8	6.0	44.5	8.7
22	Pandanwangi Kepala	600	41.8	12.3	2.02	6.0	2.8	2.1	9	88	23.2	6.1	57.5	7.5
22	Cianjur Kepala	550	43.0	12.5	2.20	5.8	2.8	2.1	9	74	24.1	6.4	58.0	7.4
22	Pandanwangi Slip	500	42.8	46.7	2.28	6.0	2.8	2.1	9	68	24.5	5.4	50.5	7.3
22	Cianjur Slip	450	40.8	52.8	1.95	6.0	2.7	2.2	9	65	22.4	5.2	57.0	8.2
22	Red rice	450	15.5	21.[illegible]	1.80	6.8	2.2	3.1	5	30	22.4	6.6	31.0	7.9
22	Cempaka	450	40.2	36.1	2.22	6.2	2.6	2.4	9	99	22.0	5.0	45.0	8.8
22	Super Siam	400	38.6	8.1	2.08	7.2	2.2	3.3	5	73	25.2	5.4	42.0	6.5
22	Saigon Sumedang RA	400	37.8	47.2	1.99	6.2	2.6	2.4	9	68	25.2	5.2	37.5	8.3

[a]Rp 1000 = US$1.

Appendix Table 4. Characteristics of Philippine rice samples.

Retailer no.	Variety name	Price (₱/kg)[a]	Whiteness (%)	Brokens (%)	Grain weight (mg)	Length (mm)	Width (mm)	Length/ width ratio	Chalkiness score	Translucency (%)	Amylose (%)	Alkali spreading value	Mean gel consistency (mm)	Protein (%)
Nepa Q Mart														
1	C-4 laon	3.20	43.8	28.3	1.84	6.7	2.0	3.4	5	98	28.0	5.4	45.5	6.5
1	Wagwag	3.10	41.6	49.8	1.84	6.6	2.0	3.3	5	89	27.4	5.4	57.5	7.0
1	C-4 new	2.85	40.8	50.9	1.75	6.5	2.1	3.1	5	88	27.6	6.0	35.5	6.5
2	IR 56	3.10	42.6	38.4	1.86	6.6	2.1	3.1	1	100	28.6	5.8	39.0	6.5
2	C-4	2.85	44.5	58.1	1.75	6.6	2.1	3.1	5	84	28.6	5.8	49.0	7.6
3	C-4	3.10	44.2	50.6	1.72	6.7	2.0	3.4	5	88	27.8	5.5	54.5	6.5
3	IR 36	2.85	43.2	56.3	1.72	6.7	2.1	3.2	5	86	28.8	4.8	48.5	6.1
4	Wagwag	3.20	41.8	45.8	1.78	5.8	2.1	2.8	1	93	28.9	7.0	33.5	6.9
4	IR 58 or C-4	3.10	41.5	17.0	1.52	6.8	2.1	3.2	5	100	28.3	5.2	40.0	7.1
4	IR 36	2.85	40.5	42.1	1.79	6.5	2.0	3.2	5	85	28.0	6.1	45.5	6.8
5	IR 42 laon	3.20	40.1	37.4	1.77	5.8	2.1	2.8	1	100	27.8	7.0	32.0	6.9
5	IR 58	3.10	42.2	50.6	1.52	6.6	2.0	3.3	5	96	28.1	5.8	31.0	6.9
5	IR 36 laon	2.85	41.0	54.1	1.78	6.6	2.1	3.1	5	78	27.4	5.9	36.0	6.9
6	IR 42	3.10	42.9	35.1	1.70	6.7	2.1	3.2	5	92	28.6	6.5	41.5	6.8
6	C-4 laon	3.00	43.4	41.6	1.79	6.6	2.1	3.1	5	86	28.6	5.9	56.0	6.8
6	C-4	2.85	43.2	22.3	1.76	6.4	2.1	3.0	9	83	29.8	4.9	65.5	6.1
7	Dinurado	6.00	46.2	29.7	1.65	6.7	2.1	3.2	1	95	19.8	6.8	76.0	5.7
7	C-4 special	4.00	40.6	7.3	1.90	6.7	2.1	3.2	1	100	28.6	5.8	36.0	7.7
7	Wagwag	3.10	43.4	32.2	1.44	5.7	2.2	2.6	5	90	28.6	7.0	32.5	6.2
7	C-4 ordinary	3.10	41.2	34.9	1.73	6.7	2.1	3.2	5	86	28.8	5.7	41.0	6.7
7	C-4 laon	3.00	35.0	38.5	1.84	6.6	2.0	3.3	5	67	27.8	5.8	32.0	7.4
7	BE-3	3.00	41.0	27.4	1.84	6.8	2.1	3.2	5	88	28.8	5.5	44.0	7.0
7	C-4 Pinagagagan	2.85	42.2	35.1	1.86	6.6	2.0	3.3	5	83	28.3	5.6	47.5	6.9
8	Wagwag luma	3.10	41.0	42.9	1.68	6.6	2.0	3.1	5	91	28.8	5.9	38.0	7.1
8	C-4 luma	2.85	42.6	29.2	1.83	6.5	2.1	3.1	5	96	28.8	6.2	45.0	7.0
9	C-4 laon	3.10	39.9	35.1	1.77	6.7	2.1	3.2	1	92	28.9	6.2	37.0	6.4
9	C-4 new	2.85	41.2	44.7	1.79	6.4	2.1	3.0	5	90	29.2	5.8	42.0	6.6
10	C-4 special	3.50	42.8	5.4	1.84	6.6	2.0	3.3	1	100	29.3	5.3	44.5	6.9
10	IR 58	3.10	42.0	37.7	1.79	6.6	2.1	3.1	5	93	28.8	5.8	40.0	6.6
10	IR 58	2.85	43.8	47.5	1.91	6.5	2.0	3.2	5	92	28.8	5.6	38.0	6.4
10	C-4 broken	2.80	42.8	46.6	1.78	6.6	2.0	3.3	1	99	29.0	5.6	37.5	6.5
11	C-4 laon	3.10	42.5	57.5	1.80	6.5	2.1	3.1	5	83	28.1	5.8	39.5	6.8
11	Wagwag	3.00	36.3	38.3	1.61	6.1	2.2	2.8	5	93	27.8	6.6	32.0	7.4
11	C-4	2.85	45.1	52.9	1.71	6.4	2.0	3.2	5	85	28.5	5.6	42.0	7.0
12	C-4 strained	3.50	38.9	37.3	1.57	5.9	2.1	2.8	1	100	28.2	7.0	31.5	6.4
12	C-4	3.10	40.6	43.4	1.86	6.5	2.1	3.1	5	91	28.5	5.8	35.5	7.3
12	IR 42	3.00	43.9	59.7	1.73	6.6	2.0	3.3	5	86	28.8	5.6	35.0	6.7
12	IR 36	2.85	45.1	45.0	1.70	6.5	2.0	3.2	5	89	29.0	5.6	37.0	6.6
12	Intan	2.85	43.4	51.9	1.75	6.6	2.0	3.3	5	85	28.6	5.6	33.0	6.8
13	C-4	3.10	43.2	50.1	1.80	6.6	2.1	3.1	5	95	28.4	5.5	41.0	5.6
13	BE-3	3.00	43.2	48.5	1.79	6.6	2.0	3.3	5	96	29.9	5.8	38.0	5.8
13	Intan	2.85	41.2	44.6	1.81	6.5	2.0	3.2	5	89	28.3	5.6	37.5	6.6
14	IR 58	3.10	41.5	37.6	1.84	6.7	2.1	3.2	5	79	28.6	5.8	34.5	6.8
14	IR 42	3.10	37.6	37.1	1.54	6.0	2.1	2.9	5	93	27.6	7.0	31.0	6.7
14	IR 36	2.85	39.4	37.8	1.62	6.4	2.1	3.0	5	78	28.0	5.8	31.0	6.4
15	C-4 laon	3.10	43.4	38.5	1.79	6.7	2.0	3.4	5	94	29.6	5.8	37.0	6.4
15	C-4 new	2.85	43.8	44.0	1.81	6.6	2.0	3.3	1	94	28.6	5.3	36 5	6.6

Appendix Table 4 continued.

Retailer no.	Variety name	Price (₱/kg)[a]	Whiteness (%)	Brokens (%)	Grain weight (mg)	Length (mm)	Width (mm)	Length/ width ratio	Chalkiness score	Translucency (%)	Amylose (%)	Alkali spreading value	Mean gel consistency (mm)	Protein (%)
Baguio market														
1	Old wagwag (baac)	3.10	43.0	43.6	1.78	6.6	2.1	3.1	1	61	29.0	5.6	38.0	7.6
1	C-4	2.85	38.8	40.8	1.77	6.5	2.0	3.2	5	87	29.0	5.6	38.5	7.2
2	Old wagwag (baac)	3.10	44.0	44.0	1.77	6.6	2.0	3.3	1	84	29.9	5.1	50.5	7.6
2	Old C-4 special	3.10	44.9	43.3	1.78	6.6	2.0	3.3	5	76	29.7	5.7	58.5	7.3
2	Old wagwag	3.00	46.8	39.4	1.78	6.5	1.9	3.4	5	60	29.2	5.0	55.5	7.5
2	C-4 kiskis	2.85	34.8	34.6	1.82	6.5	2.1	3.1	5	78	28.8	6.0	36.5	7.2
3	Old wagwag (baac)	3.10	41.2	44.3	1.80	6.7	2.0	3.4	1	92	28.8	5.8	33.0	7.6
3	Old C-4	2.85	43.5	60.0	1.80	6.6	2.0	3.3	5	76	29.0	6.1	47.5	7.4
3	Old C-4 (baac)	2.85	46.9	51.7	1.83	6.5	2.1	3.1	5	85	29.4	5.0	37.5	7.0
4	Old wagwag	3.10	44.0	49.8	1.66	6.2	2.0	3.1	1	83	29.0	4.8	37.5	7.4
4	Special C-4	2.85	42.0	47.9	1.71	6.4	2.0	3.2	1	91	29.4	4.8	40.0	7.4
5	Wagwag (old)	3.10	42.8	37.0	1.83	6.5	2.5	2.6	1	93	29.4	6.2	44.0	7.6
5	Old C-4	2.85	45.8	40.5	1.79	6.6	2.0	3.3	1	91	29.4	5.6	54.5	7.2
6	Wagwag	3.10	42.2	40.7	1.78	6.5	2.0	3.2	1	80	29.5	5.8	39.5	7.3
6	Luma C-4	3.00	41.5	41.1	1.76	6.4	1.9	3.4	1	87	29.3	5.4	38.0	7.0
6	C-4 special	2.85	41.4	33.1	1.75	6.4	2.0	3.2	5	95	29.1	5.5	38.5	7.0
7	Old C-4	3.10	44.0	36.9	1.70	6.8	2.1	3.2	5	79	29.1	6.1	47.5	7.2
7	Old wagwag	3.10	44.9	40.8	1.74	6.3	2.0	3.2	5	82	28.8	6.2	58.0	7.1
7	Old B-3	3.10	41.2	35.2	1.83	6.3	2.2	2.9	5	89	28.4	6.2	37.5	6.9
7	(New) "Old" Wagwag	2.85	41.1	33.7	1.79	6.4	2.2	2.9	5	85	28.9	5.5	36.5	7.2
7	(New) "Old" C-4	2.75	46.9	51.4	1.73	6.5	2.0	3.2	5	95	29.6	5.5	58.5	6.8
8	Wagwag special (baac)	3.10	43.5	49.1	1.79	6.6	2.0	3.3	5	84	29.8	5.4	44.0	6.7
8	Tabuk (Mt. Prov.)	2.85	44.0	49.9	1.82	6.6	2.0	3.3	1	82	29.7	5.1	46.5	7.4
8	NGA	2.85	43.4	58.4	1.73	6.7	2.0	3.4	1	85	29.2	5.0	36.0	7.6
8	Kiskis baac	2.75	45.5	64.0	1.69	6.6	2.0	3.3	1	87	29.4	5.0	42.0	8.0
8	NGA baac amarillo	2.60	29.9	42.6	1.73	6.0	2.1	2.9	1	16	28.3	6.0	30.5	7.0
Calamba market														
1	Azucena	3.80	47.0	48.6	1.74	6.5	2.1	3.1	0	100	19.4	6.2	69.0	6.3
1	Denorado	3.50	45.6	35.9	1.73	6.7	2.1	3.2	1	99	21.8	4.3	57.5	8.0
1	Wagwag-San Jose	3.20	45.8	51.0	1.47	5.8	2.0	2.9	1	92	27.6	6.8	31.5	7.6
1	Minantika	3.10	44.9	41.7	1.65	6.3	2.1	3.0	5	93	27.4	5.8	34.5	7.3
1	Intan	3.10	42.2	44.0	1.66	6.2	2.1	3.0	5	80	28.2	5.8	31.0	7.1
1	C-4 special	3.00	41.6	60.2	1.60	6.3	2.1	3.0	1	79	27.0	5.4	34.0	6.5
1	Wagwag-Cabuyao	2.90	40.6	52.7	1.69	6.6	2.1	3.1	5	83	27.6	5.4	39.5	7.4
2	Intan	2.95	43.6	53.7	1.71	6.6	2.1	3.1	5	86	26.9	5.1	40.0	7.4
2	Wagwag-laon	2.95	43.4	40.8	1.68	6.7	2.0	3.4	5	86	27.4	5.4	30.5	7.2
3	Azucena	4.00	41.4	25.0	1.67	6.4	2.1	3.1	1	99	23.0	6.4	39.0	6.7
3	Wagwag	3.00	43.1	41.0	1.76	6.7	2.0	3.4	5	83	27.8	5.5	33.0	7.5
3	C-4	3.00	44.1	36.9	1.73	6.7	2.1	3.2	5	83	28.1	4.4	32.5	7.4
4	Azucena	4.00	45.8	27.4	1.74	6.6	2.1	3.1	5	87	18.1	4.2	81.5	6.7
4	Intan	3.10	41.2	23.5	1.55	6.4	2.1	3.1	5	87	27.4	5.0	49.5	7.9
4	C-4 laon	3.00	40.2	45.6	1.50	6.6	2.1	3.1	5	82	27.6	5.8	31.0	7.0
4	C-4	2.90	38.1	51.0	1.57	6.5	2.0	3.3	5	82	27.0	5.0	34.0	7.2
5	Azucena	4.00	45.1	33.6	1.66	6.7	2.2	3.1	1	98	21.4	4.5	54.5	6.7
5	Azucena-mixed	3.50	45.4	43.9	1.59	6.5	2.1	3.1	5	94	22.4	5.6	47.0	7.0
5	C-4 green	3.20	45.5	35.2	1.76	6.7	2.2	3.1	5	96	23.4	4.5	62.5	7.2

Appendix Table 4 continued.

Retailer no.	Variety name	Price (₱/kg)[a]	Whiteness (%)	Brokens (%)	Grain weight (mg)	Length (mm)	Width (mm)	Length/ width ratio	Chalkiness score	Translucency (%)	Amylose (%)	Alkali spreading value	Mean gel consistency (mm)	Protein (%)
5	Wagwag-special	3.10	43.0	51.0	1.34	6.0	2.1	2.9	5	89	28.4	6.5	35.0	7.1
5	Wagwag-Cabuyao	3.00	43.0	55.1	1.64	6.4	2.1	3.1	5	91	28.5	5.8	35.5	7.0
5	R-36	2.90	43.9	57.8	1.69	6.5	2.0	3.3	5	77	28.1	5.6	34.0	6.9
5	C-4	2.80	40.5	52.6	1.68	6.4	2.1	3.1	9	40	26.5	5.4	30.0	7.9
6	Azucena	4.00	42.0	30.1	1.65	6.6	2.1	3.1	1	99	18.0	6.6	60.0	7.6
6	IR 50	3.10	42.0	41.7	1.57	6.5	2.0	3.3	5	78	27.6	5.2	31.0	7.4
6	C-4	3.10	43.4	44.6	1.67	6.7	2.1	3.2	5	72	27.6	5.2	31.0	7.5
6	IR-36	3.00	39.9	39.0	1.49	6.3	2.0	3.2	5	81	28.3	5.5	30.0	7.2
6	IR-36	2.90	39.0	51.2	1.61	6.6	2.1	3.1	5	71	27.1	5.1	41.0	7.7
7	Azucena	5.00	44.4	31.2	1.74	6.7	2.2	3.1	1	81	22.6	5.8	36.5	7.1
7	IR-36	3.10	44.2	42.2	1.66	6.4	2.1	3.1	5	74	28.0	5.5	31.5	6.7
7	IR-42	3.10	46.6	47.1	1.73	6.8	2.1	3.2	5	88	28.2	6.5	39.0	6.7
7	Kala	3.00	36.6	38.3	1.73	6.7	2.1	3.2	5	63	27.9	5.0	32.0	6.7
8	Wagwag	3.00	43.9	62.1	1.63	6.5	2.2	3.0	5	67	28.4	5.8	31.0	8.3
8	C-4	2.90	41.4	55.3	1.67	6.5	2.1	3.1	9	67	28.8	6.6	32.0	7.1

[a]₱10.00 = US$1.

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