CONSUMER DEMAND FOR RICE GRAIN QUALITY

Edited by L.J. Unnevehr, B. Duff, and B.O. Juliano

IRRI
International Rice Research Institute
IDRC
International Development Research Centre

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Terminal Report of IDRC Projects
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and
International Grain Quality Economics (Asia)

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The International Rice Research Institute (IRRI) was established in 1960 by the Ford and Rockefeller Foundations with the help and approval of the Government of the Philippines. Today IRRI is one of the 16 nonprofit international research and training centers supported by the Consultative Group on International Agricultural Research (CGIAR). The CGIAR is sponsored by the Food and Agriculture Organization of the United Nations, the International Bank for Reconstruction and Development (World Bank), and the United Nations Development Programme (UNDP). The CGIAR consists of 50 donor countries, international and regional organizations, and private foundations.

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Contents

Foreword

IRRI and national rice research programs conduct research to raise the yield potential of rice and increase riceland productivity and sustainability to meet the increasing demand. The application of the new knowledge continually generated has enabled rice supplies to keep up with demand in many countries.

Economic development in some of those countries is leading to increasing prosperity of their people. As their incomes increase, rice consumers have opportunities to become concerned with the quality as well as the quantity of the rice they buy. While the properties preferred vary from culture to culture, rices with preferred qualities always command premium prices.

Studying consumer demand for rice grain quality is complex, given the variation in preferences for different properties. While at IRRI in 1983-85, L.J. Unnevehr undertook the first study of the economics of grain quality using a hedonic, or range of preference, model. Further work by national programs in Bangladesh, Indonesia, Malaysia, the Philippines, and Thailand, together with IRRI, was supported by the International Development Research Centre (IDRC) of Canada (IDRC-3-P-87-0001 [National Grain Quality–Asia]). A companion study examined consumer demand in three rice import markets: Hongkong; Bonn, Germany; and Rome, Italy (IDRC-3-P-86-0340 [International Grain Quality Economics–Asia]).

This book assembles the reports of the results of these projects, including those reports published separately elsewhere. It is intended as a reference on use of the hedonic model to measure rice grain quality value at the farm, miller, retailer, and consumer levels. It also will contribute to increased understanding of the variation in grain quality preferences across countries and the role market incentives play in rice improvement. That understanding will help research managers decide the appropriate roles of national and international research in the study of rice grain quality concerns.

Dr. Unnevehr served as overall technical editor, with the assistance of J. B. Duff, B. O. Juliano, and C. C. David. The book was edited by M. Kumar, assisted by T. Rola.

Klaus Lampe
Director General

Executive summary

Asian rice production surpassed population growth in the last two decades as a result of new seed fertilizer technology and investment in irrigation. In rice research, grain quality was initially overshadowed by the need for higher yields and greater pest resistance; food sufficiency for an expanding population was, of necessity, the primary goal. However, as many traditional rice-importing countries achieved self-sufficiency, real rice prices declined in many Asian countries and in the world market over the last two decades (David 1989, 1991). This price decline renewed interest in grain quality in international and national research programs (Juliano and Duff 1991).

Although secondary to the goal of increasing and sustaining yields, grain quality improvement is important because it enhances consumer welfare and expands market potential. To better define research goals with respect to quality, IRRI and national rice research programs in the Philippines, Indonesia, Thailand, Malaysia, and Bangladesh pursued research on the economics of grain quality from 1987 to 1989. This work was supported in part by the International Development Research Centre. The major findings and contributions are as follows:

- Consumers in all countries studied prefer higher head rice content and more translucent rice. Intermediate amylose is also preferred in all countries except Bangladesh. Preferences for grain shape appear to vary between mainland and insular Southeast Asia. Though rice grain quality and quality preferences vary across countries and regions, some quality preferences are widely shared.
- Consumer preferences for parboiled rice in Bangladesh and glutinous rice in Thailand were measured for the first time, providing useful guidelines for national programs.
- Reflecting their ability to pay, high-income consumers pay higher premiums for a larger number of quality characteristics than do low-income consumers. Though preferences do not vary much across income levels, lower income consumers prefer rice that is more filling, and thus may prefer rice with higher amylose content.
- Laboratory analysis shows that Philippine rice given a traditional variety name is usually a modern variety with shape or cooking characteristics similar to

those of traditional varieties. Thus the “traditional” label signals to consumers that these rices have some desirable characteristics.

- Quality incentives appear to be transmitted from wholesale rice prices to rough rice prices in Indonesia and the Philippines. However, this transmission is not perfect; studies in the Philippines show that barriers to entry in milling may influence pricing efficiency.
- In import markets, Hongkong rice consumers prefer the cooking quality of Thai rices, while consumers in Germany prefer the physical characteristids of U.S. rices. Exporters will need new marketing strategies and packaging technology to be competitive in markets where rice is not a traditional staple.

The findings have implications for future rice research:

- There is evident scope for division of labor between international and national research programs. International rice breeding should focus on maintaining and improving potential head rice recovery, intermediate amylose content, and grain translucency. National programs can “fine-tune” quality to local preferences. IRRI can also provide leadership in assessment of quality differences among, for example, rices with similar amylose content. Studies show that there may be substantial returns to reducing amylose content of national releases in the Philippines and Malaysia.
- In addition to plant breeding, efforts to reduce chalkiness and brokens in rice should include studies on the impact of handling at the farm level on quality losses and the links between milled rice and rough rice prices. The Philippine studies demonstrate the value of understanding quality losses and incentives within the framework of market efficiency.
- Information regarding quality is transmitted through proxy indicators, but is still imperfect. Hence, an assessment of whether formal grades and standards could improve market efficiency is needed. The changing nature of varieties planted and marketed presents a continuing challenge to the efficient transfer of information in Asian rice markets.
- The chemical determinants of cooking time and expansion and their role in low-income consumer preferences should be explored to identify varietal traits of importance to these consumers. Whether low-income consumers prefer volume expansion or slower digestibility needs to be clarified. The substitution between quantity and quality as incomes grow needs to be better understood in order to set research priorities.

Overview

Consumer demand for rice grain quality: introduction and major findings

L.J. Unnevehr, B. Duff, and B.O. Juliano[1]

Rice breeding at IRRI has continually sought to improve the quality characteristics of modern varieties (MVs), from increasing potential head rice recovery to reducing amylose content (Khush and Juliano 1985). Previous research at IRRI has examined the chemical determinants of cooking quality (Juliano 1985), the economics of post-harvest losses (Toquero and Duff 1985), and the consumer demand for grain quality in urban markets of Southeast Asia (Unnevehr et al 1985).

However, many important questions that could guide research goals with respect to quality remain unanswered. Three of the most important questions are: How do consumer preferences vary across regions or income levels within countries? How well do price premiums at the mill or farm level reflect consumer preferences? Where in the marketing chain do quality losses occur?

With support from the International Development Research Centre of Canada, IRRI and national research programs in the Philippines, Indonesia, Thailand, Malaysia, and Bangladesh pursued further work on the economics of grain quality from 1987 to 1989. The results of this multidisciplinary effort are reported in this book. Section II contains analysis of consumer panel data in the Philippines and Indonesia and provides insight into how consumers choose and value rice grain quality. The studies in Section III are related but are based on samples of rice sold at the retail level. The retail surveys from four countries provide a comprehensive picture of the variance in rice quality and rice preferences across Asia. How well consumer preferences are translated into incentives at the farm level is the question addressed in Section IV. Studies of rice mills and market efficiency in Indonesia and the Philippines show how well the market transmits quality signals. The final section reports the differing role of quality in traditional and emerging import markets.

The goal of this chapter is to provide an overview of the findings in this book. We begin by reviewing the motivations for including grain quality in research program goals. A comparison of study findings across countries highlights the themes and

[1]Associate professor, University of Illinois; agricultural economist, IRRI; and chemist, IRRI, respectively.

contributions of international significance, followed by a review of major findings by country. Finally, we discuss the implications for future rice grain quality research.

Characteristics of grain quality

Rice grain quality is multidimensional; it includes both physical characteristics that influence appearance and chemical characteristics that influence cooking quality (Table 1). Grain quality is determined by variety; production and harvesting conditions; and postharvest handling, milling, and marketing techniques. Variety directly determines some quality characteristics and interacts with environment and processing to influence other characteristics indirectly. Varietal differences in crack resistance, for example, influence head rice recovery in combination with drying and milling techniques.

In addition to the technical determinants, there are economic dimensions of quality. Consumers express their preferences for rice quality by paying a premium for rice with the desired characteristics. If these retail price premiums are transmitted back to the farmer through the marketing system, then market participants have the incentive to improve quality.

Because grain quality is complex, rice research can improve grain quality in several ways. Chemists can identify varietal characteristics and their links to cooking quality. Economists can measure consumer preferences, costs of processing and handling, and market efficiency. Agronomists and engineers can identify production and processing techniques that improve quality or lower the cost of maintaining quality. Finally, plant breeders can incorporate quality characteristics into new varieties.

Table 1. Rice grain quality characteristics and their determinants.

Characteristic	Influence of[a]		
	Variety	Production environment	Processing
Size and shape	+	+	0
Degree of milling (whiteness)	+	+	+
Head rice	+	+	+
Translucency	+	+	+
Aroma	+	+	+
Foreign matter	0	+	+
Damaged grains	+	+	+
Amylose content[b]	+	+	0
Gelatinization temperature[c]	+	+	0
Gel consistency[d]	+	+	0
Grain elongation	+	+	+

[a]+ = has influence, 0 = no influence. [b]Determines volume expansion and texture. [c]Determines cooking time. [d]Measures cooked rice hardness.

Importance of grain quality

Improvements in grain quality increase national welfare by raising the value of rice to either consumers or producers. If research can lower the costs of producing higher quality varieties, consumer welfare is enhanced by obtaining improved quality at a lower price. In response, consumers may demand more rice, and producers may thus benefit from an expanded market. Or, if research can allow producers in a particular environmental niche to improve quality, then these producers can capture quality premiums and raise the value of rice sales. As most Asian rice farmers consume their own production, the benefits from quality improvement are likely to be shared by consumers and producers.

Improved quality can also increase national welfare by allowing more efficient competition in the world market. Some traditional importers have achieved self-sufficiency and now wish to export periodically. The existence of new and potential importers has caused traditional exporters to reexamine the issue of grain quality to sustain or expand world market shares. Quality improvements may allow rice exporters to capture better prices or to expand exports.

In spite of its importance, quality improvement will always be secondary to the goal of increasing and sustaining rice yields. Demand for rice will continue to grow in the future with the increasing population and rising incomes (Huang et al 1991). However, supply may not grow as fast because the prospects for further raising yields are uncertain and public investment in irrigation has declined (David 1989, 1991). Meeting the growing demand for food in Asia will remain the paramount goal of IRRI and national research programs in the foreseeable future.

The relative importance of quality as a research goal, however, will vary across countries and over time, due to the nature of consumer demand. With respect to income and prices, demand for better quality is likely to be more elastic than demand for quantity. As income grows, demand for rice grows less than proportionately, and Asian consumers shift to better quality rice or other foods. Similarly, as prices decline, consumers do not increase the quantity consumed proportionately, but they shift to better quality rice. Thus, quality improvement becomes a more important research goal as consumer incomes grow and increased supply forces prices down. Quality assumes less importance when supply lags behind demand.

The changing importance of quality is apparent from recent shifts in research emphasis. When real prices of rice declined in the world market and in most Asian countries during the 1980s, national programs became increasingly interested in improving quality. The importance of quality also varies across countries. It is less important as a breeding objective where rice self-sufficiency is the paramount goal (as in Bangladesh), but it is more important where market competition is vital (as in Thailand).

To evaluate research priorities for international and national programs, it is imperative to understand how the value of rice grain quality improvement differs across countries. The first step is to measure consumer preferences for rice grain quality and the variance in these preferences across regions and income levels.

Most of the studies reported in this book used the hedonic price model to estimate consumer preferences for rice grain quality. If consumers derive utility or satisfaction from the characteristics of goods, then it is possible to show that:

$$P_R = \sum_{j=1}^{m} X_{rj} P_{rj}$$

The price of rice, P_R, is equal to the sum of the value of the quality characteristics, P_{rj}, times the amount of each characteristic in a unit of rice, X_{rj} (see Unnevehr 1992 for the full derivation). Observations of rice prices and differences in quality characteristics allow estimation of the implicit prices, P_{rj}, by linear regression. The sign and significance of P_{rj} show how consumers value quality characteristics. If the desirable X_{rj} can be incorporated into MVs, then consumer welfare will be enhanced. A comparison across countries shows which X_{rj} should be the focus of international research.

Findings of international significance

Rice quality and preferences vary across regions and countries

The studies in this book document the extraordinary range of preferences for rice in South and Southeast Asia. For example, in the north and northeast part of Thailand, glutinous (waxy) rice is consumed as a food staple, whereas it is used only for specialty dishes elsewhere. Bangladesh is one of two Asian countries where most rice is parboiled before milling. Although raw, nonglutinous (nonwaxy) rice is the norm in most other Asian countries, the samples collected for this study show that rice grain types vary from the bold, chalky grains of traditional Javanese varieties to the slender aromatic Thai varieties; from the red-pericarped Philippine upland varieties to the more common intermediate- to high-amylose MVs found throughout Southeast Asia.

Modern varieties now dominate areas planted in the Philippines, Indonesia, and Malaysia, accounting for more than a third of production in Bangladesh, and more than one-sixth of that in Thailand (IRRI 1991). Yet, there are persistent differences in grain characteristics across countries (Table 2), reflecting the efforts of national programs to tailor breeding materials to local tastes. A comparison across countries reveals differences in consumer preferences as well as differences in varieties resulting from agroclimatic variation.

Samples in Thailand have longer grains than samples in other countries (Table 2). Milling quality varies across regions, from a high percentage of head rice and whiteness in Thailand to a very low percentage of head rice in the Philippines. The chemical characteristics of rice also vary. Rice in the Philippines, Malaysia, and Bangladesh has intermediate to high amylose content (apparent amylose content) whereas rice in Indonesia and Thailand has low to intermediate amylose content. The alkali spreading value indicates that gelatinization temperature ranges from low in Thailand and Bangladesh to high in Indonesia. Gel consistency is medium/hard in the Philippines and Indonesia but medium/soft in Bangladesh.

It is interesting to compare these 1987-88 sample averages from Indonesia, Thailand, and the Philippines with the 1983-84 samples reported in Unnevehr et al

Table 2. Comparison of average grain characteristics from consumer and retail samples collected in 1987-88.[a]

	Philippines[b]		Indonesia[c]			Malaysia[d]	Thailand[e]		Bangladesh[f]	
	Urban	Rural	Medan	Jakarta	Ujung Pandang	Urban	Glutinous	Now glutinous	Raw	Parboiled
Head rice (%)	67.2	71.3	80.0	78.0	73.8	79.4	84.0	81.5	80.3	87.2
Whiteness (%)	41.2	39.6	37.4	39.2	35.6	35.1	46.0	na[g]	na	na
Length (mm)	5.4	5.0	n.a.	n.a.	n.a.	6.3	7.2	7.0	4.9	5.2
Shape (length/width)	3.1	3.1	2.7	2.6	2.4	3.0	na	na	2.1	2.5
Amylose (%)	26.1	24.6	23.3	20.7	23.3	24.7	22.8	4.0	24.9	27.1
Gelatinization temperature(%)[h]	5.0	4.7	3.8	2.8	5.1	5.5	6.4	6.8	6.8	3.6
Gel consistency	40.5	44.4	42.0	40.7	34.8	31.1	na	na	54.6	85.5

[a]Chalkiness and translucency are not included because these measures are not comparable across countries. [b]From Abansi et al 1992 [c]From Damardjati and Oka 1992. [d]From Wong et al 1992. [e]From Sriswasdilek et al 1992. [f]From Choudhury et al 1992.[g]na not applicable. [h]As measured by alkali spreading value.

Table 3. Average characteristics of rice samples collected in 1983-84 (Unnevehr et al[1985]).

	Manila, Philippines	Jakarta, Indonesia	Bangkok, Thailand
Head rice (%)	57.5	62.3	83.7
Whiteness (%)	42.4	39.4	40.5
Shape (length/width)	3.2	2.5	3.5
Amylose (%)	27.8	23.4	23.6
Gelatinization temperature[a] (°C)	5.7	5.5	5.1
Gel consistency	41.1	46.8	56.6

[a]Indexed by alkali spreading value: low, 6-7; intermediate, 4-5.

(1985) (Table 3). Average characteristics in Thailand did not change much, with the exception of higher alkali spreading value in the later samples. In Indonesia and the Philippines, the average head rice percentage increased and the average amylose content declined. Improved head rice could reflect better milling and handling, and/or increasing ability to pay for this characteristic. The change in amylose content could reflect the release of IR64—the first IR variety with intermediate amylose content and intermediate gelatinization temperature—in 1985 in the Philippines and in 1987 in Indonesia.

In spite of variation, some regional generalizations about quality preferences are possible

Table 4 indicates that although consumer preferences vary across countries, the results of the hedonic price analysis reveal some shared preferences (see Unnevehr I992 for the methodology used to measure consumer preferences). In the Philippines, Indonesia, Thailand, and Malaysia, consumers prefer greater head rice content (fewer brokens). Bangladesh consumers also share this preference, which is revealed implicitly in their preference for parboiled rice, which has much higher head rice recovery

Table 4. Significant determinants of price at the retail level and their relationship to price.[a]

Characteristic	Philippines[b]	Indonesia[c]	Thailand[d]	Malaysia[e]	Bangladesh[f]
Head rice	* (+)	* (+)	* (+)	* (+)	ns
Foreign matter[g]	* (–)	* (–)	* (–)	* (–)	ns
Shape or length	* (–)		* (+)	* (+)	* (+)
Translucency	ns	* (+)	* (+)	* (+)	
Whiteness	ns	* (+)	ns	ns	
Amylose	* (–)	* (+)	* (–)	* (–)	ns
Gelatinization temperature	* (+)	* (+)	ns	ns	
Aroma			* (+)		
Polish		* (–)			* (–)
1000-grain weight					* (–)
Moisture content					* (–)
Cooking time					* (–)
Imbibition ratio					* (+)

[a]A blank means the variable is not included in the regression. ns = not significant. * = significant at the 5% level. [b]From urban consumer regression in Abansi et al 1992. [c]From regression for Jakarta in Damardjati and Oka 1992. [d]From pooled Round 1 regression in Sriswasdilek et al 1992. [e]From regression of all samples in Wong et al 1992. [f]From regression of parboiled rice samples in all cities in Choudhury et al 1992. [g]Foreign matter or damaged grains.

than raw rice. Consumers in most Southeast Asian countries also prefer translucent (not chalky) grains. Modern varieties tend to have more chalkiness than traditional varieties.

Preferences for shape vary across countries stemming in part from differences among traditional varieties in these regions. Although consumers in Thailand, Malaysia, and Bangladesh pay a premium for longer, more slender rice, consumers in the Philippines prefer the short, bold shape of their own traditional upland varieties. Preference for shape was not measured in Indonesia, but Unnevehr et al (1985) report that Indonesians also prefer the short, bold shape of javanica or bulu rices.

Preferences for chemical characteristics also appear to vary. Philippine and Malaysian consumers prefer less amylose. Currently, much of the rice marketed in these countries has high amylose content. Malaysian consumers pay a premium for Thai imports with intermediate amylose; Philippine consumers pay a premium for varieties labeled "traditional" that have intermediate to low amylose. In Thailand, however, consumers prefer even less amylose than the intermediate levels found in most Thai varieties. Thai consumers pay a premium for low to intermediate amylose. Indonesian consumers also seem to prefer intermediate amylose, but regional preferences vary. Jakarta consumers prefer more amylose than the 20% average level found in samples there, but consumers in Ujung Pandang prefer less amylose than the 23% average level in that market. Bangladesh consumers, on the other hand, clearly do not mind a high amylose content.

The studies are the first to document preferences for parboiled and glutinous rice

A major contribution of the Thai and Bangladesh studies (Sriswasdilek et al 1992, Choudhury et al 1992) is documentation of market quality and consumer preferences for parboiled rice in Bangladesh and glutinous rice in Thailand. Parboiled rice samples in Bangladesh have characteristics that reflect the effects of the parboiling process: more flaky cooked rice and higher head rice recovery. Consumers base their judgment of quality on shape, weight, moisture content, cooking time, and imbibition ratio (Table 4).

Thai glutinous rice samples from the north and northeast regions have opaque grains and virtually no amylose content as expected. Other physical and chemical characteristics such as percent head rice or gelatinization temperature can vary, however, as they do for nonglutinous rice. The Thai study reports that glutinous rice consumers pay a premium for fewer broken grains but other characteristics are not significant. Head rice recovery should be considered in breeding programs for glutinous rice.

Patterns of quality preferences provide important information for quality research

To a large extent, quality premiums at the retail level reflect the preferences of high-income consumers with the ability to pay for better quality. If high-income consumers' preferences are the same as those of others in society, then quality improvement based on observed premiums will benefit everyone. However, if lower income consumers have different preferences, then it will not.

Studies of consumer panels in Indonesia and the Philippines (Abansi et al 1992, Damardjati and Oka 1992) provide insights into the relationship between income and quality preferences. Differences between rural and urban samples in the Philippines (Maranan et al 1992), Bangladesh (Choudhury et al 1992), and Malaysia (Wong et al 1992) also give an idea about preferences by income level. In general, urban/high-income consumers tend to pay higher premiums for quality and for a larger number of quality characteristics than rural/low-income consumers. The income elasticity for quality is positive in the Philippines.

This book shows that quality preferences do not vary by income level. Consumers with different incomes in the Philippines cite factors similar to those which influence rice purchases. Rural and urban preferences do not differ significantly in Malaysia and Bangladesh. There is some evidence, however, that lower income consumers prefer rice that is more filling. Amylose content is positively related to volume expansion during cooking with a correlation coefficient of 0.4 (Juliano et al 1965). Nutritional studies also show that parboiled rices or rices with higher amylose content are digested more slowly (Juliano et al 1989). Low-income consumers in the Philippines are willing to pay a premium for higher amylose content, in contrast to high-income consumers who prefer lower amylose. Rural consumers in Bangladesh also pay a premium for higher amylose content. Although it is the lowest income country among those studied, consumers there are willing to pay for more filling rice (rice with higher imbibition ratio).

The studies provide insights into how consumers obtain information about chemical characteristics

The changing characteristics of MVs and the changing mix of varieties planted and marketed present a continuing challenge to the efficient transfer of information in Asian rice markets. Table 5, which shows varieties planted by Central Luzon farmers,

Table 5. Changes in rice varieties planted in Central Luzon survey farms, 1966-90 (Central Luzon Loop Surveys [wet season data]. 1966-90, unpubl.).[a]

Variety	Percentage of sample area						
	1966	1970	1974	1979	1982	1986	1990
Total IR	–	67	61	92	92	89	86
IR5	–	40	2	0	0	0	0
IR20	–	14	35	0	1	0	0
IR36	–	–	–	47	31	6	6
IR42	–	–	–	19	27	11	3
IR50	–	–	–	0	12	1	0
IR54	–	–	–	–	9	0	0
IR64	–	–	–	–	–	43	19
IR66	–	–	–	–	–	2	13
IR70	–	–	–	–	–	–	11
IR72	–	–	–	–	–	–	14
IR74	–	–	–	–	–	–	12
Other IR	–	13	24	26	13	26	9
Other MVs	–	3	6	2	2	10	13
Traditional	100	30	33	6	6	1	1

[a]Dashes indicate variety is not yet released. MVs = modern varieties.

presents evidence of these changes. Since 1966, farmers have rapidly shifted to newer IR releases as resistance to diseases and insects of older varieties has broken down. IR64, with intermediate amylose, was popular in 1986; by 1990, it had been replaced by later releases with high amylose content. These changes in variety planted lead to the question of how market participants differentiate among varieties. Quality characteristics, especially those related to cooking quality, are not always apparent to consumers. If consumers cannot obtain information about quality, then they cannot express their preferences through willingness to pay for certain characteristics.

In the project, actual characteristics of rice were compared with the variety or grade label to assess the information available to consumers. The existence of many rices with traditional variety names in the Philippines, for example, can be misleading because more than 90% of the rice produced there are MVs. Laboratory analysis shows that rices with traditional names are usually MVs with shape or cooking quality characteristics approximating those of traditional varieties (Juliano et al 1992a). The traditional label provides consumers with clues that these rices possess some “traditionally” desirable characteristics.

Comparisons of the quality of Thai rice in the domestic, export, and Hongkong markets (Sriswasdilek et al 1992, Kaosa-ard and Juliano 1992, Juliano et al 1992b) reveal the complex, hidden role of cooking quality in the world market. Analysis of rice exports in Bangkok shows that exported rice tends to have higher gelatinization temperature, slightly higher amylose content, and less whiteness than domestic market rice samples. This indicates that, on the average, exported rice has characteristics that are somewhat less preferred by domestic consumers. However, Thai rice available in the Hongkong market has lower amylose and more fragrance than the average rice exported from Thailand. Thus, the preferences of Hongkong consumers are transmitted informally in the world market so that Thai varieties sold there meet consumer demand for quality.

These results highlight the fact that international standards based exclusively on physical quality do not tell the entire story of quality preferences in the international market. Cooking quality preferences lead to established trade patterns, but since these characteristics are not transparent, new entrants into the international market could be at a disadvantage.

From these studies, it is apparent that consumers are able to differentiate rice sufficiently to express their quality preferences, but market information is far from perfect. It is possible that formal grades and standards could improve market efficiency, but such intervention should be carefully considered. Market participants currently use proxy indicators such as geographic origin or grain shape, and these may be more efficient than formal standards. (Such proxy indicators are also widely used in developed countries.) The difficulty in creating grades and standards for cooking quality is that these characteristics are costly to measure. The value of the information obtained from measuring a characteristic should be greater than the cost of measurement, and this may not be true for chemical characteristics. Maintaining preserved identity of varieties within the marketing system may also be costly.

The studies raise questions about the ability of the marketing system to transmit quality incentives from consumers to farmers

How well quality incentives are transmitted from either world market or domestic consumers to farmers will determine the returns to improving quality, through price signals that influence choice of variety and postharvest handling. Government intervention in Asian rice markets is commonplace, and such intervention can influence pricing efficiency. The feasibility of quality improvement may depend on the efficiency of the marketing system in relaying price signals.

Studies in the Philippines and Indonesia examined the links between milled rice prices and rough rice prices (Oka et al 1992, Bonifacio and Duff 1992, Wedgwood and Duff 1992, Umali and Duff 1992). Samples of rough rice and milled rice were collected at rice mills. In general, rough rice prices were correlated with milled rice grain quality characteristics in the same fashion as milled rice prices (Table 6). Furthermore, there is a strong positive correlation between rough rice prices and milled rice prices. (The lower correlation between rough rice and milled rice prices in Indonesia reflects the influence of moisture content. Indonesian samples were collected during the wet season and Philippine samples were collected during the dry season.) The correlations in Table 6 indicate that incentives are transmitted from the consumer to the producer, although they do not necessarily indicate perfect transmission.

The studies discuss the role of government intervention in distorting quality incentives

Such intervention can influence the transmission of signals from the international market to the domestic market. This is a concern in Indonesia and the Philippines where export surpluses occasionally occur and a government monopoly on rice trade prevents domestic prices from reflecting world market premiums for physical quality.

Government intervention can also distort price signals in the domestic market as it has allegedly done in Malaysia and the Philippines. In Malaysia, government price controls have reduced the incentive to produce high-quality rice domestically. The

Table 6. Simple correlation coefficients of rough rice and milled rice prices with quality characteristics.

	Indonesia[a]		Philippines[b]	
	Rough rice price	Milled rice price	Rough rice price	Milled rice price
Milled rice	0.44	–	0.83	–
Head rice	–0.18	–0.35	–0.10	–0.16
Whiteness	0.28	0.54	0.05	0.00
Yellow grains	–0.14	–0.32	–0.11	–0.07
Shape	na	na	–0.22	–0.21
Chalkiness	–0.37	–0.12	–0.04	–0.05
Amylose	0.43	0.34	–0.57	–0.58

[a]From Oka et al 1992. [b]From Bonifacio and Duff 1992. na = not applicable.

reduction of government intervention in the Philippines increased the pricing system efficiency after 1983, but government licensing procedures reduced competition in the milling sector.

This book reveals the complexity of the transmission of infomation about quality from consumers to producers. It provides new insights, but a lot more could be done to test the information efficiency of the market for grain quality.

Major findings by country

Philippines

Variety names in the retail market do not always correspond to actual variety. The “traditional” name is an indicator of bold shape and better cooking quality.

Market samples in the Philippines have higher amylose content and higher percentage of brokens than samples from other countries. The low percentage of head rice reflects the continuing reliance on Engleberg hullers in the countryside, which have low head rice recovery. This older technology may persist due to barriers to entry into rice milling.

Panel data show that urban consumers pay more for more characteristics. Preferences are similar, with one exception. Amylose content is negatively related to price in urban areas, but positively related in rural areas. Overall, only foreign matter and head rice content are significant determinants of price.

Panel data also show that high-income consumers prefer shorter grains, less foreign matter, more head rice, less amylose, and lower gelatinization temperature. By contrast, low-income consumers prefer higher amylose content.

Retail survey data confirm that Philippine consumers prefer shorter grains, less foreign matter, and less amylose. They also pay a premium for aged rice which has greater volume expansion during cooking.

Milled rice prices at the mill are influenced by shape and chemical characteristics. Rough rice prices follow milled rice prices closely, but there is a large proportion of unexplained variance. Milling recovery is negatively related to cracked grains in rough rice; head rice recovery is negatively related to chalky and cracked grains.

There are negative returns to drying from harvest moisture content (24%) down to semidry (16%), but positive returns from complete drying down to 14%. Most farmers do not dry, however; they sell immediately.

Market efficiency analysis shows poor price integration at the farm to wholesale level, but it improved after 1983. This may reflect lack of competition at the mill level. Government intervention has been ineffective in support of rough rice prices: reduced government intervention after 1983 resulted in greater market integration.

Indonesia

Consumer panel data from three cities on different islands in Indonesia show that Jakarta consumers express a wider, stronger range of preferences. There are significant differences in regional preferences for cooking quality, although most rice is intermediate amylose. The pooled sample showed that Indonesian consumers prefer whiter, more polished rice, with more whole grains, fewer yellow or damaged grains, and more amylose than the current low to intermediate levels found in the market.

Rice samples have much lower amylose and higher head rice percentage than those in the Philippines. Samples are also shorter and bolder than samples in most countries.

Rice millers look at moisture content and empty grains when pricing rough rice; they look at head rice, milling degree, moisture content, and mixed grains when pricing rice. The biggest price premium at the mill level is the difference between local varieties and MVs. Rough rice and milled rice prices are similarly correlated for most quality characteristics, indicating good transmission of quality incentives.

Thailand

Thai rice samples are long, have few brokens, and have intermediate amylose. Glutinous rice (with little or no amylose) is consumed in the north and northeast part of Thailand. Samples of glutinous rice have more brokens and shorter grains than nonglutinous rice.

Broken grains, chalkiness, amylose content (negative sign), and aroma are, most often, significant price determinants for nonglutinous rice. Broken grains are the most important price determinant for glutinous rice.

The cooking quality characteristics of export samples differ slightly from those found in the domestic market.

Malaysia

Government intervention in rice markets may reduce transmission of incentives.

Rice samples have few brokens, are slightly shorter on average than Thai samples, and have intermediate to high amylose.

Consumers prefer more head rice, lower amylose content, and longer shape. The high amylose content of locally produced rice indicates substantial scope for improvement in local quality.

Bangladesh

Most rice is parboiled, but raw rice is consumed in some regions. Rice samples are shorter than those in other countries. Samples have high head rice—reflecting the effects of the parboiling process—and high amylose content.

Urban consumers prefer less grain weight, more slender grains, less moisture, shorter cooking time, and higher imbibition ratio. Rural consumers prefer less grain weight, more slender grains, and more amylose. For raw rice, there is greater variation across regions, but consumers prefer less yellow grain, shorter cooking time, and higher imbibition ratio.

Selected international markets

Hongkong consumers want long grain, high head rice percentage, and flaky but soft texture (samples had low to intermediate amylose). Most Thai rice in this market is aromatic, with low to intermediate amylose content. Thailand has the advantage in supplying this market because of the cooking quality of its rice varieties.

Italian consumers like the characteristics of japonicas traditionally grown there, including chalky grains and harder gel consistency. As a surplus country with unique preferences, Italy will continue to supply its own needs.

Bonn consumers' preferences are mainly for physical quality, and consumers there are not well-informed about eating quality. The U.S. has the advantage in supplying this market since U.S. rice producers have a domestic market focused on physical quality and attractive packaging. For Thailand to compete in the northern European market, Thai exporters would need to develop aggressive marketing strategies to advertise quality and to improve their packaging.

Conclusions and implications for future research

The results reported in this book provide some guidance with respect to quality objectives for international and national rice breeding programs. Moreover, they raise questions that multidisciplinary research must address to understand the potential for grain quality improvement. The following conclusions are reached:

- Potential head rice recovery is an important quality characteristic that should be considered in both international and national breeding programs.
- In view of the fact that consumers in most Southeast Asian countries prefer translucent grains and since translucency can be influenced genetically, international and national breeding programs should focus their attention to this characteristic.
- Notwithstanding regional differences in shape preferences, national programs should consider local preferences for shape in their breeding programs.
- There is potential for returns to reduced amylose content in some countries. Philippine and Malaysian consumers would benefit from reducing the amylose content of locally produced MVs. Although IR64 is now grown in the Philippines, it is not suited to all growing conditions and its grain size may not be preferred. Thus the national program in the Philippines could work to extend the availability of more intermediate-amylose varieties. The very high amylose content of local Malaysian varieties in comparison to Thai imports and the price premium attached ro amylose suggest that very substantial welfare gains are possible from the introduction of intermediate-amylose MVs in Malaysia.

  In other countries, however, it is not clear whether efforts to further reduce amylose content would be rewarded. Intermediate amylose content may be viewed much like high potential head rice recovery—it is a broadly desired characteristic and is becoming a minimum standard for acceptable quality in MVs. Thus it is an important characteristic for international breeding programs to consider. Local differences in preferences, however, may require "fine-tuning" by national programs.

Cooking quality characteristics aside from amylose content show little significance, with one exception. Consumers in the Philippines and Indonesia appear to prefer higher alkali spreading value, indicating lower gelatinization temperature and shorter cooking time. National programs in these countries should note this preference as they evaluate breeding materials.

- Bangladesh rice research should consider grain shape and varietal characteristics that influence cooking time and imbibition ratio.
- Head rice recovery should be considered in breeding programs for glutinous rice.
- The results of the studies in this book support Unnevehr's (1986) conclusion that international rice research should focus on a limited number of quality characteristics, and leave other work on quality to national programs. International rice breeding should focus on maintaining or improving potential head rice movery, intermediate amylose content, and translucency (reducing chalkiness) of MVs. Progress on these aspects has been achieved in the past. Further improvements must include adapting intermediate-amylose MVs to a wider range of environments or reducing the incidence of cracked and chalky grains. International research can also make available to national programs materials with a variety of characteristics to aid in the process of adapting international materials to local preferences. Finally, international research can provide leadership in developing better methods for quality assessment and variety identification.
- Head rice content and translucency are widely shared preferences. These characteristics are not wholly determined by variety, but are also strongly influenced by environment and handling at the farm level. To assess the potential for improving quality, international collaborative research is needed to measure the impact of farm level handling on quality losses and to examine the quality incentives provided by rough rice prices. The studies in this book raise questions about how well quality premiums for rice are reflected in rough rice prices. The studies in the Philippines show the value of addressing this issue within the larger framework of understanding market efficiency and government intervention.
- Information about cooking quality characteristics can be transmitted informally through proxy indicators. However, it is likely that information is imperfect, given the rapid changes in varieties planted. An issue to be explored is whether formal standards or variety identification could improve information efficiency.
- The observation that low-income consumers seem to prefer more filling rice (greater expansion or slower digestibility) and/or shorter cooking time needs to be verified. Chemical research is needed to better understand the influence of variety, chemical characteristics or handling on cooking time, volume expansion, and digestibility. Furthermore, here is a need to examine how consumers substitute quality for quantity as income grows in order to project the importance of grain quality in the future.

As urbanization and income growth continue in Asia, quality will play a more important role in consumer demand for rice. International and national rice research programs will continue to work toward grain quality improvement. The studies in this book provide useful information to guide such research programs.

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Methodologies for measuring consumer preferences and welfare effects of quality improvement[1]

L.J. Unnevehr

Agricultural research has focused primarily on increasing yields, often without incorporating other desirable characteristics in the food crop, such as eating quality. In fact, efforts to improve quality are sometimes criticized for diverting research resources from the more important task of increasing food supplies. However, food quality is important even to the very poorest consumers, and meeting food preferences can be an important part of fostering better nutrition (Shah 1983). Improving quality does not necessarily mean providing everyone with the best quality. Sometimes, very simple changes in food characteristics can greatly increase palatability.

To incorporate quality characteristics into new varieties, agricultural researchers need to have a way of measuring how important these quality characteristics are to consumers. This chapter discusses how estimates of hedonic prices for quality characteristics can be used to evaluate the returns to research for quality. The first three sections of the chapter present models for estimating hedonic prices and discuss the limitations of the underlying assumptions and common estimation problems. The fourth section demsuates how hedonic price estimates can be used to measure welfare gains from improved quality under various assumptions. The chapter concludes with an example of how this methodology has been used to evaluate the returns to quality improvement in modern rice varieties.

Model of demand for characteristics

Several authors have proposed an alternative view of consumer demand in which consumers derive utility or satisfaction from the characteristics that goods possess rather than from the goods themselves (Becker 1965, Griliches 1971, Ladd and

[1]Reprinted with permission from the International Service for National Agricultural Research (ISNAR), The Hague, The Netherlands. This chapter first appeared in *Methods for diagnosing research constraints and assessing the impact of agricultural research* (1990). Proceedings of the ISNAR/Rutgers Agricultural Technology Management Workshop, 6-8 Jul 1988, Vol. II, pages 101-116. R. G. Echeverria, ed. Rutgers University, New Jersey, USA.

Suvannunt 1976, Lancaster 1966, Rosen 1974).[2] For example, it is argued that satisfaction is not obtained from food per se but rather from the nutrients and flavor of the food. This model has been applied to consumer durables in order to estimate a quality-constant price index of inflation (see Griliches 1971 for example).

In the area of food demand, few authors have measured the value of food nutrients to consumers (Ladd and Suvannunt 1976, Morgan et al 1979). Studies of the value of food characteristics have also been conducted at international agricultural research centers (Von Oppen and Jambunathan 1978, Unnevehr et al 1985).

All hedonic price models start by defining the consumer utility function as a function of the quantity of goods consumed and the characteristics embodied in those goods. Different assumptions are made, however, concerning the relationship of the yield of characteristics to the quantity consumed and the separability of consumption decisions regarding quantity and characteristics.

Ladd and Suvannunt (1976) have developed a useful version of the hedonic price model with assumptions appropriate for analyzing foods. In their model, the amount of a characteristic obtained from each good is fixed to the consumer (and variable to the producer) who determines the quantities of goods consumed. This seems reasonable for food because the amount of nutrients or the flavor characteristics embodied in a food product cannot be determined by the consumer. Furthermore, hedonic prices in Ladd and Suvannunt's (1976) model are not required to be non-negative as they are in Lancaster's (1966) earlier model. It seems reasonable to assume in empirical work that some characteristics detract from quality and have negative utility.

The following is a slightly simplified summary of the Ladd and Suvannunt (1976) model. Let X_{oj} be the total amount of the jth product characteristic provided by consumption of all products, and X_{ij} be the amount of the jth characteristic provided by one unit of product i. Let q_i represent the quantity of product i consumed. Total consumption of each characteristic is a function of the q_is and the X_{ij}s (input-output coefficients of the characteristics):

$$X_{oj} = f(q_1, q_2, ..., q_n, X_{ij}, ..., X_{nj}) \tag{1}$$

for j= 1, m.

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

$$U = U(X_{01}, X_{02}, ..., X_{0m}). \tag{2}$$

Because each X_{oj} is a function of q_is and X_{ij}s, then

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

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

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

$$\sum_{i=1}^{n} p_i q_i = E \tag{4}$$

[2]Becker (1965) proposed a more comprehensive model in which goods are inputs into a household production function that produces the characteristics (i.e., a cooked meal with flavor and nutrients) that yield ulility. In practice, it is difficult to apply this model because information on household capital and labor inputs are rarely available.

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

$$L = U(X_{01}, X_{02}, ..., X_{0m}) - \lambda \sum_{i=1}^{n} p_i q_i - E \qquad (5)$$

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

$$\frac{dL}{dq_i} = 0 = \sum_{j=1}^{m} \left(\frac{dU}{dX_{oj}} \right) \left(\frac{dX_{oj}}{dq_i} \right) - \lambda \text{ Pi}. \qquad (6)$$

The marginal utility of income, 1 , is equal to $\frac{dU}{dE}$.

With this substitution and solving for p_i, equation 6 becomes

$$P_i = \sum_{j=1}^{m} \left(\frac{dX_{oj}}{dq_j} \right) \left(\frac{dU/dX_{oj}}{dU/dE} \right) \qquad (7)$$

The marginal yield of the jth product characteristic by the ith product is dX_{oj}/d_{qi}. 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 the parentheses is the marginal rate of substitution between income and the jth product characteristic.

Expenditure is assumed to equal income, hence the term in the parentheses 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 characteristics obtained from a marginal unit of the product multiplied by the marginal implicit price of the characteristic.

Because the yield of most product characteristics is constant for each unit of product, it is assumed that $dX_{oj}/d_{qi} = X_{ij}$ = constant. Furthermore, the marginal implicit price is also assumed to be constant and is represented by P_{ij}. Therefore, equation 7 for a particular product, F, becomes

$$P_F = \sum_{j=1}^{m} X_{Fj} P_{Fj} \qquad (8)$$

The addition of a random error term to equation 8 provides the familiar equation used to estimate hedonic prices, P_{Fj}, from observations of characteristics, X_{Fj}, and market prices, P_F, of different qualities of good F.[3]

[3] Note that this equation is linear. Lucas (1975) observed that the estimation equation derived from Lancaster's (1966) model is also linear, yet researchers frequently estimate hedonic price equations in a log-linear form. The log-linear functional fonn cannot be justified from theory but may be justified empirically by aggregation over consumers with different tastes, incomes, or nonhomothetic indifference maps.

There is also the issue of how to interpret the constant term. In Ladd and Suvannunt's (1976) original model, they define a unique characteristic for each good—one that is only found in that good. The price of this unique characteristic should be found in the constant. Alternatively, the constant can be interpreted as the value of the unspecified characteristics.

Market-level assumptions underlying the model

Any model is based on simplified assumptions; whether such assumptions are reasonably realistic can only be determined at the time of empirical application. For example, the model of consumer demand for goods characteristics assumes perfect competition in the goods markets, which implies that complete information is available to consumers about the quality characteristics of goods. In fact, most food commodity markets tend to approximate the conditions of perfect competition because there are many buyers and sellers.

When food standards are not regulated by a government agency, quality premiums should reflect the consumer's valuation of characteristics. However, consumers may not always be able to perceive quality characteristics when buying a product because certain eating quality characteristics become apparent only after food is cooked. In this case, consumers must either rely on proxy characteristics (such as brand name) or on an established relationship with a retailer to obtain information. For example, rice consumers in Thailand can easily identify the physical characteristics of rice but have no way of knowing the chemical characteristics that determine eating quality. For the latter, they rely on the place of origin of the rice as an indicator. In this way, they are indirectly paying for the characteristics they want, and therefore, price premiums for chemical characteristics should reflect consumer preferences.

Implicit in the assumption of competitive markets is the assumption that quality premiums are transmitted through the marketing chain. The characteristics of the unprocessed commodity that produces preferred characteristics in the processed good must be known and measurable. Otherwise consumer preferences will not be transmitted back through the marketing chain and reflected in price premiums at the farm gate.[4]

Perhaps the most serious restriction of the model of consumer demand for goods characteristics is that it reflects only one side of the market whereas prices observed in a marketplace reflect the forces of both supply and demand. Rosen (1974) has demonstrated that any estimated hedonic price represents both the marginal cost of producing a quality characteristic and the marginal utility of that characteristic to consumers. For example, a fancy variety costs more than ordinary varieties because it tastes better and has higher production costs. Rosen (1974) has suggested that this identification problem disappears when all consumers are identical but producers have different costs of production. In such cases, estimates from equation 8 identify consumer demand for quality.

Whether consumers have identical preferences for quality can be decided from prior information about the consumer papulation. However, it is reasonable to assume that all consumers do not define quality in the same way. It is necessary to determine if all consumers demand more of the same characteristics as incomes rise. If not, it may be desirable to estimate the hedonic price function separately for different segments of the population. This could be accomplished by collecting samples in markets fre-

[4]An alternative, related model for measuring the value of characteristics in a good that is an industrial input is found in Ladd and Martin (1976).

quented by particular income classes, or if resources are available, by household surveys of the purchases of particular income groups.[5]

Common problems in estimating hedonic prices

The first task of a researcher who wishes to estimate equation 8 is to choose X_{Fj} since the obvious starting point would be measures of quality that are already used in agricultural research for evaluating breeding material. However, a more rigorous approach would be to first form consumer taste panels and conduct interviews about taste preferences. Such panels would ensure that all relevant variables are included in the estimation. In this approach, it is necessary to establish some correlation between consumer statements about quality and laboratory measures of quality. For example, if consumers prefer sticky rice, it is necessary to ascertain if they are choosing rice that has low amylose content. If so, amylose content is a good measure of quality in texture (Del Mundo and Juliano 1981).

Not all the variables that determine quality are related to the genetic base of a food crop. Quality is determined by variety, growing environment, postharvest handling, and the interactions among these three factors. Identifying the role of genetics and other factors in food quality is an important step in the definition and interpretation of the measures of quality characteristics. For example, the percent of broken grains in milled rice is an important quality characteristic that would appear to be a function of postharvest processing. However, potential head rice recovery in milling is an inherited trait and thus genetics also has an influence on this quality factor.

Quality Characteristics are frequently highly correlated in a particular sample. Values of different characteristics tend to bunch together because higher (or lower) quality varieties tend to have all the more (or less) desirable quality characteristics at once.[6] The resulting multicollinearity among variables inflates the standard errors of P_{Fj}. Therefore, it is difficult to estimate the individual contribution of each quality characteristic to total value. Although there are econometric techniques that will improve the reliability of the estimates, it is better to eliminate the multicollinearity problem if possible. More data could provide greater variation in combinations of characteristic values. Quality could also be viewed by consumers as a function of groups of characteristics; hence individual characteristics would have no value by themselves. If so, it is more useful to define variables as combinations of characteristics.

The simplification of the above model to obtain equation 8 for estimation includes an assumption of constant marginal utility for each characteristic. This assumption may be unrealistic, particularly when there is wide variation in the observed range of

[5]Sometimes preferences may vary across different regions of a country. A national research program must then allocate scarce research resources to make quality improvements that will be valued by the largest possible portion of the population.

[6]Ironically, this bunching can occur even when there is no relationship among characteristics across different breeding lines. It is technically possible to breed a variety with any combination of characteristics; yet in practice, only a few combinations are common in varieties planted by farmers.

values for a characteristic. In this case, a nonlinear approximation (obtained, for example, by adding the squared value of a variable) may provide better estimates of hedonic prices.

Market prices vary for reasons other than quality. The whole schedule of price variation due to quality can shift up or down with changes in location or time of the year. In collecting market samples of different qualities of a food commodity, care should be taken to ensure that price variations are primarily due to quality. Usually this means limiting sampling to a particular time and location. However, if this is not possible, dummy variables can be added to the estimating equation to account for variation in prices across locations and sampling periods.

Measurement of welfare gains from improved quality

Agricultural research can alter the different characteristics available to consumers in each unit of a food commodity. For example, plant breeders can alter the chemical characteristics of rice varieties and thereby change the cooked texture of milled rice. When research alters the X_{Fj}s in a food commodity, the demand for that commodity shifts because the utility gained from consumption increases. This demand shift increases consumer surplus. Whether the price of the commodity and producer surplus also changes depends on the cost of production of the new higher quality variety. This section outlines the theory behind the measurement of changes in producer and consumer surplus following a change in a good's characteristics.

Ladd and Suvannunt (1976) have shown that the relationship of quantity demanded of good u to changes in characteristics v is

$$\frac{dq_u}{dX_{uv}} = \left[\left(\frac{-1}{dU/dE}\right)\left(\frac{dU}{dX_{uv}}\right)\right]\left(\frac{dq_u}{dP_u}\right)^* \tag{9}$$

where $\left(\frac{dq_u}{dP_u}\right)^*$ is the income-compensated, own-price substitution effect from the Slutsky equation. It is assumed that the change in X_{uv} does not alter any of the other marginal utilities of the characteristics. From equations 7 and 8,

$$\left[\left(\frac{-1}{dU/dE}\right)\left(\frac{dU}{dX_{uv}}\right)\right] = -P_{uv}.$$

As the income-compensated, own-price substitution term is always negative, an increase in a positively valued characteristic will increase the quantity demanded of the good.

The change in quantity demanded is represented by a shift to the right in the demand curve (Fig. 1). This increase in quantity demanded is equivalent to an increase in consumer utility obtained from each unit of the good. From equation 8, this increase is equal to

$$G = (X^*_{uv} - X_{uv})P_{uv} \tag{10}$$

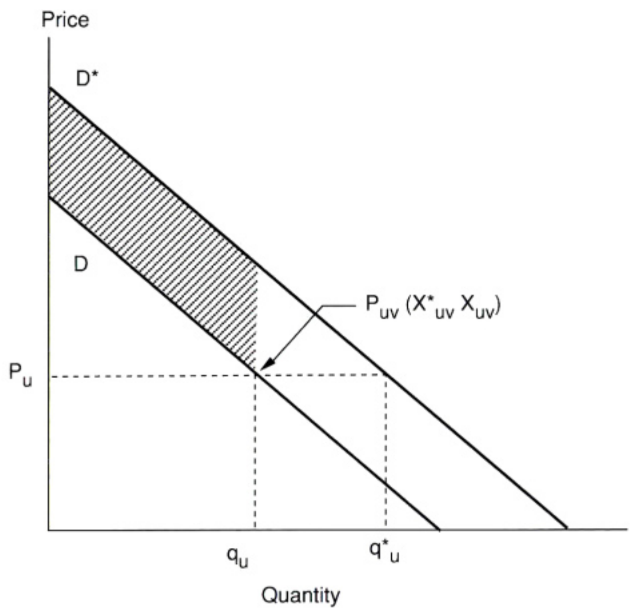
where

G = the consumer surplus gain per unit of good u consumed,
P_{uv} = the hedonic price of characteristic v,
X^*_{uv} = the new value of characteristic v obtained from one unit of u, and
X_{uv} = the old value of characteristic u obtained from v.[7]

It is assumed that P_{uv} does not vary with the change in X_{uv}. The new quantity demanded, q^*_u, is given by the following:[8]

$$q^*_u = q_u \left[1 - \frac{G}{P_u} \varepsilon_d\right] \tag{11}$$

where ε_d is the income-compensated, own-price elasticity of demand. To estimate q^*_u, it is necessary to have some estimate of the income-compensated, own-price elasticity



1. Gains in consumer surplus from improvements in quality with infinitely elastic supply.

[7] If more than one characteristic changes, then G is equal lo the sum of the changes in characteristics times their implicit value.

[8] The demand function can be written as:

$$P_d = P_u\left(1 - \frac{1}{\varepsilon_d}\right) + \left(\frac{P_u}{q_u\,\varepsilon_d}\right) q_d \tag{11a}$$

The new demand function after the quality change is

$$P^*_d = P_u\left(1 - \frac{1}{\varepsilon_d}\right) + G + \left(\frac{P_u}{q_u\,\varepsilon_d}\right) q^*_d \tag{11b}$$

Solving equation 11b for the new equilibrium quantity yields equation 11 in the text.

of demand for the food commodity in question. Fortunately, in most countries existing consumer demand studies can provide such estimates for the major food crops.[9]

The size of the total change in consumer surplus depends on whether the price of good u, P_u, changes following the change in quality. This in turn depends on the cost of production of the new higher quality variety and the elasticity of supply. In the simplest case, the new higher quality variety would have the same cost of production as the more common older varieties, and supply would be infinitely elastic over the range of the increase in quantity demanded. This latter assumption would not be unrealistic for fairly small shifts in quantity demanded. Under these assumptions, P_u remains unchanged, there is no change in producer surplus, and the consumer surplus gain is the shaded area in Figure 1. This area is estimated by the following:

$$CS = q_u G + \frac{1}{2}[(q^*_u - q_u) G]. \tag{12}$$

Even if the new, higher quality variety has the same costs of production as do existing ordinary varieties, the increase in quantity demanded may be so large that increased supply can only be provided at a higher cost. In this case, supply is not infinitely elastic over the range of the increase in quantity demanded, and the price of good u will increase after the quality change. This situation is illustrated in Figure 2. Consumers gain the area *ebfg,* producers gain the area *abcd* (of which *afcd* is a transfer from consumers), and society's net gain is *ebcg*.

To estimate the changes in consumer and producer surplus, it is first necessary to estimate the new equilibrium P^*_u and q^*_u. In this case, some estimate of the elasticity of supply is needed. Then the new equilibrium can be calculated from the following:[10]

$$q^*_u = q_u + \left[\frac{G\left(\frac{q_u}{P_u}\right)}{\frac{1}{\varepsilon_s} - \frac{1}{\varepsilon_d}}\right] \tag{13}$$

$$P^*_u = P_u\left(1 - \frac{1}{\varepsilon_s}\right) + \frac{P_u}{\varepsilon_s} + \left[\frac{\frac{G}{\varepsilon_s}}{\frac{1}{\varepsilon_s} - \frac{1}{\varepsilon_d}}\right] \tag{14}$$

---

[9]The income-compensated, own-price elasticity of demand can be calculated from estimates of own-price elasticity, income elasticity, and budget share, using the Slutsky equation.

[10]The supply functions can be written as:

$$P_s = P_u\left(1 - \frac{1}{\varepsilon_s}\right) + \left(\frac{P_u}{Q_u \varepsilon_s}\right) q_s \tag{13a}$$

The new demand function after the quality change is still equation 11b. Setting equation 11b equal to 13a and solving for the new equilibrium quantity yields equation 13 in the text. Substituting the right side of equation 13 for qs in equation 13a yields equation 14 in the text. See Norton and Davis (1981) for a review of equations used to calculate consumer and producer surplus changes.

where e_s is the elasticity of supply. The net social gain is given by

$$NS = q_u G + 1/2\ [G(q^*_u - q_u)]. \tag{15}$$

Although this contains the same terms as equation 12, the net social gain in this case will be smaller because q^*_u is smaller.

It may be of interest to calculate the gains to consumers and producers separately to see the income distribution effects of the change (Bale 1979). The following equations give the changes in consumer and producer surplus:

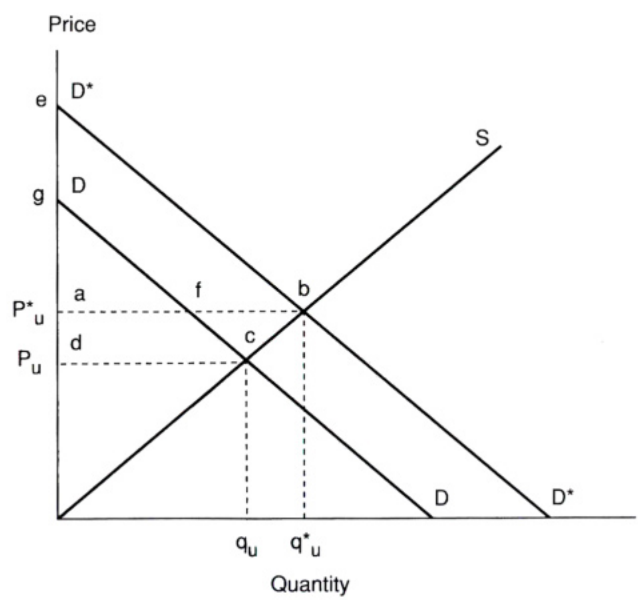
$$CS = q_u G \tag{16}$$

$$PS = q_u\ (P^*_u - P_u) + 1/2\ [(q^*_u - q_u)\ (P^*_u - P_u)] \tag{17}$$

If producers are generally poorer than consumers, the transfer from consumers to producers will improve the distribution of income. If purchasing consumers are poorer than producers, then a quality change that results in a price increase will cause a deterioration in the distribution of income.

The net social gain can be estimated on the basis of production in one year, and presumably, this gain will recur for several years in the future. The present value of the net social gain in future years can be compared with the present value of research costs to develop the new variety in order to estimate the returns to research on quality improvement.

The methodology presented in this section relies on some simplified assumptions. First, supply and demand curves are assumed to be linear over the portions relevant to the demand shift. Hertford and Schmitz (1977) have argued that the difference in



2. Changes in producer and consumer surplus after improvements in quality with less than infinitely elastic supply.

surplus estimates between linear and nonlinear models is small for the percentage changes usually considered in returns to research studies, so this simplification seems reasonable.

Moreover, international trade is not explicitly incorporated into the model of supply and demand. In an open economy, exports or imports adjust so that price will not vary with shift in the demand curve. Domestic consumers then gain from the increase in quality of domestically produced food. Equation 12 provides estimates of the consumer surplus gain from consumption of domestic production. Welfare gains will probably be limited to the domestic market because the value and even the definition of quality frequently differ between domestic and world markets. On the other hand, if the quality improvements are valued on the world market and the commodity is exported, consumers outside the country will benefit. Domestic producers of the commodity will benefit only if the increase in quality allows them to capture a greater share of the world market.

Finally, this discussion does not include the impact of quality improvement in a variety with higher costs of production than current ordinary varieties. This type of improvement would provide benefits only to a limited group of producers who could grow the variety and to consumers who could afford to buy it. Because this would not serve the primary goal of agricultural research, which is to increase food supplies and the welfare of low-income consumers and producers, this case is not considered here.

An example of estimating returns to rice quality improvement

Hedonic prices of rice characteristics were estimated for samples of rice from three Southeast Asian countries at the International Rice Research Institute (IRRI) (Unnevehr et al 1985, Unnevehr 1986). One of the salient findings was the universal and strongly significant preference for better milling quality—i.e., fewer broken grains of rice and better polish. An increase of 1% in the proportion of broken grains in rice reduced the price of rice by 0.12 cents/kg in the Philippines and by 0.18 cents/kg in Indonesia.

Potential head rice recovery in milling is an inherited trait. The earliest modern varieties (MVs), IR5 and IR8, had potential headrice recovery of only 36-40% of rough rice. By 1970, these MVs had been adopted on 50% of the area planted to rice in the Philippines and on 25% of that in Indonesia (Herdt and Capule 1983, Salmon 1984). IR20, a new MV introduced in 1970 with potential head rice recovery of more than 60%, rapidly replaced the earlier MVs in farmers' fields. With the introduction of IR20, the increase of 38% in potential head rice recovery represented a value to consumers of 4.56 cents/kg in the Philippines and 6.84 cents/kg in Indonesia (Table 1). If the own-price elasticity of rice is 1.16 in Indonesia (Timmer and Alderman 1979) and 0.67 in the Philippines (Bouis 1982), this quality improvement should have led to an 8% increase in consumption in the Philippines and a 14% increase in Indonesia. This increase in demand could be supplied by an increase in adoption of higher yielding MVs, which in fact occurred after IR20 was introduced. Therefore, supply was assumed to be infinitely elastic over the range of the projected increase in demand. The total annual gain in consumer surplus was $73 million in the Philippines and $224 million in Indonesia (Table 1).

The cost of developing better head rice recovery is assumed to be 15% of IRRI's budget from 1962 (when the Institute opened) to 1969 (when IR20 was released). IRRI plant breeders estimate that 15% of the program effort was devoted to quality, and as other programs support plant breeding, 15% of the total budget is taken as a conservative estimate of costs. The future value of gain in consumer surplus was compared to the past value of research costs. The improvement in head rice recovery had a benefit-cost ratio of 49 (using a 12% discount rate) and an internal rate of return of 61%.[11] This return is substantial, although not as large as past returns to improvements in rice yields that have been as high as 84-87% (Evenson and Flora 1978, Scobie and Posada 1976). These large returns to quality improvement suggest that there is underinvestment in research to improve the quality of agricultural commodities, in addition to the widespread underinvestment in research to increase yields as suggested by Akino and Hayami (1975).

Conclusions

The methodology outlined here would enable programs to test the importance of quality measures and to estimate the potential returns to improving quality with few additional research resources. The hedonic or implicit prices of quality characteristics are relatively easy to estimate from market samples. If the laboratory equipment is in place to screen breeding lines for quality, it is easy to measure the quality characteristics of market samples. These measures of characteristics can then be regressed on observations of market prices with a microcomputer statistical package.

Interpreting the estimates of hedonic prices requires knowledge of the commodity market and consumer preferences, which must be provided by economists, cereal chemists, and other scientists in the quality program. If the estimates are reasonable and

Table 1. Gains in welfare from the introduction of modern rice varieties with better head rice recovery.

	Philippines	Indonesia
P_{uv} $(X^*_{uv}X_{uv})$ cents/kg[a]	4.56	6.84
q_u (000 t rice)[b]	1532	3059
q^*_u (000 t rice)[c]	1655	3487
CS (million $)[d]	73	224

[a]Head rice recovery assumed to improve 38%. Each 1% reduction in broken grains increases the price by 0.12 cents/kg in the Philippines and by 0.18 cents/kg in Indonesia. [b]Consumption of MVs is 50% of the average 1967-71 rice production in the Philippines and 25% of that in Indonesia. [c]Estimated from equation 11, with own-price elasticity of rice assumed to be 1.16 in Indonesia (Timmer and Alderman 1979) and 0.67 in the Philippines (Bouis 1982). [d]This is estimated from equation 12.

[11]Full adoption of IR20 (or later varieties with equivalent milling quality) was assumed lo be complete 5 yr after introduction. Hence, consumer benefits start 5 yr after the improvement and last for 50 yr.

significant, they provide a measure of the value of different quality characteristics to consumers. These values yield estimates of the returns to research for improving quality and can be used to rank the importance of potential quality improvements in setting research priorities.

More important, the returns to quality improvements can be used to demonstrate the usefulness of further research. Most agricultural research focuses on increasing the food supply to benefit consumers and producers who retain their crop for home consumption. If, in addition to increasing food supply, agricultural research can also provide varieties of better quality that have the same or lower production costs as current varieties, then the welfare of all consumers can be enhanced.

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Consumer demand for rice grain quality

Consumer demand for rice grain quality in selected rural and urban markets in the Philippines[1]

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In the Philippine domestic market, consumer preferences for rice quality have been given little attention. Although some quality attributes appear to be relevant, only one study has estimated the value of these characteristics (Unnevehr et al 1985); generally, studies of consumer preference for rice have utilized laboratory and consumer taste panels (Del Mundo 1979). Therefore, quality determination remains highly dependent on personal observation and induction from qualities, grades, and prices observed in the market.

The hedonic pricing model permits assessment of rice grain characteristics valued by consumers. Knowledge of consumer preferences for characteristics through implicit pricing helps highlight areas for future research, extension, and policy initiatives. In particular, the method enhances understanding of consumer quality requirements and their implications for improvements in breeding, cultivation, and postproduction handling systems.

Using the hedonic pricing model, a study of consumer preferences for rice quality was conducted to evaluate the relationship between price and quality. Consumers were categorized by location (urban vs rural) and by income class (low, medium, or high). The physical and chemical characteristics which were considered important determinants of rice price were whiteness, translucency, grain length, foreign matter content, head rice recovery, amylose content, and alkali spread.

This study was designed to estimate implicit prices for characteristics that define rice grain quality at the consumer level. Specifically, it aimed to

- determine the effects of consumer status and purchasing capacity on the demand for rice quality;

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[1]Reprinted with permission in part from the University of the Philippines at Los Baños Regional Training Programme on Food and Nutrition Planning Monograph Series 13 (1990) and from *Advances in grain postharvest technology generation and utilization,* Proceedings of the 11 th ASEAN Technical Seminar on Grain Postharvest Technology, 23-26 August 1988, Kuala Lumpur. p. 350-376. J.O. Naewbanij, ed. 1991. ASEAN Grain Postharvest Programme, Bangkok. Presented in part at the 12th Annual Scientific Meeting of the National Academy of Science and Technology, 11 July 1990, Manila.

[2]Research assistant (IRRI), agricultural economist (IRRI), professor (UPLB), and cereal chemist (IRRI), respectively.

- determine the variation in demand for rice quality between urban and rural areas, and among income groups; and
- examine the implications for future rice grain quality improvement activities.

Methodology

The model

Consumer goods characteristics model. Lancaster's (1966) model of consumption theory was the first to depart from the traditional approach in which goods were considered the direct objects of utility. Instead, Lancaster used the properties of goods from which utility is derived. Using this concept, Ladd and Suvannunt (1976) developed the consumer goods characteristics model (CGCM) which regarded characteristics as intrinsic and objective properties of consumption activities. The model remains consistent with the basic assumption of demand theory that consumers maximize utility subject to a budget constraint (Unnevehr 1992). For rice, the CGCM can be expressed mathematically as:

$$Pr = \sum_{j=1}^{m} X_{rj} P_{rj} \tag{1}$$

where P_r = price of rice, X_{rj} = quantity of rice grain characteristic j, and P_{rj} = implicit price of characteristic j.

Physical and chemical characteristics, most relevant in determining the price of rice, comprise the collection of characteristics X_{rj} s in the model. If the X_{rj}s can be measured, equation 1 can be used to estimate the demand function for these attributes even in the absence of directly observable prices.

Extended hedonic model. Advocates of the modern consumption theory introduced by Lancaster (1966) describe the price-quality relationships given in equation 1 in terms of a pure hedonic model for rice. The underlying assumption is that differences in prices between rice grades can be fully explained by quality differences. However, it is highly unlikely that the price of a particular rice is exactly determined by its quality mix with each quality being weighted by its estimated implicit or shadow price. It is more likely that the relationship between price and quality has a significant amount of residual variation. This is to be expected in markets where consumers have different preferences or different incomes and nonhomothetic indifference maps (Cowling and Rayner 1970, Lucas 1975). Therefore, the observed marginal price and quality characteristics reveal little about underlying supply and demand conditions.

Rosen (1974) provided a theoretical framework in which the price of rice is not only a linear summation of the implicit values of its attributes but also a merging of the effects of varying consumer tastes. Mathematically, the model can be expressed as:

$$P_r = f(X_{rj}, \alpha) \tag{2}$$

where a = vector of consumer traits.

The first partial derivative of price P_r with respect to any characteristic, dP_r/dX_{rj} = b_{rj}, reveals the consumers' implicit bid for the underlying attribute, X_{rj}. These implicit/shadow prices provide a method for weighing the different quality attributes of rice in the consumer valuation system.

In principle, Rosen's modeling strategy is applicable to rice. Data on income and taste variables such as age, education, and nature of employment are available and can be used to allow parametrization of tastes across different consuming groups. The vector of consumer traits, a, would therefore represent exogenous shift variables. Figure 1 illustrates this framework, hereafter referred to as the extended hedonic model.

Hedonic model estimation. In practice, the model developed by Ladd and Suvannunt (1976) follows a strictly linear specification, which reflects the basic premise of the Lancastrian framework. In fact, Lucas (1975) expounded that if the analysis revolves around inherent physical properties which are typically measurable on a cardinal scale, the consumption technology is additive and homogeneous of degree one. If the working model is confined to a CGCM type of analysis, additivity is deemed appropriate because the physical and chemical characteristics of rice are assumed fixed by producers and could be measured by laboratory analysis.

However, because the present empirical exercise is also concerned with interpersonal variances in tastes, a vector of consumer traits which would pinpoint the nature of preferences among different groups of consumers is also incorporated in the operational model. Lucas (1975) cautioned that once consumers with different tastes or different incomes and nonhomothetic indifference maps are considered, a linear specification becomes restrictive and the resultant nonlinear price quality locus provides a more acceptable solution.

Different functional forms including the linear, logarithmic, and semilogarithmic models were therefore fitted in the extended hedonic equation. Choice of the model that best estimates and explains variations in prices of rice and demand for quality consisted of deciding whether the estimates of the parameters were theoretically meaningful or statistically satisfactory. Ordinary least squares (OLS) was used to estimate the relationships for each location and income group. The Chow test (Chow 1960, Fisher 1970) was applied to determine if the estimated price and quality relationships differed significantly between rural and urban consumers. A similar analysis combining all data sets and using dummy variables was also conducted with urban and rural data.

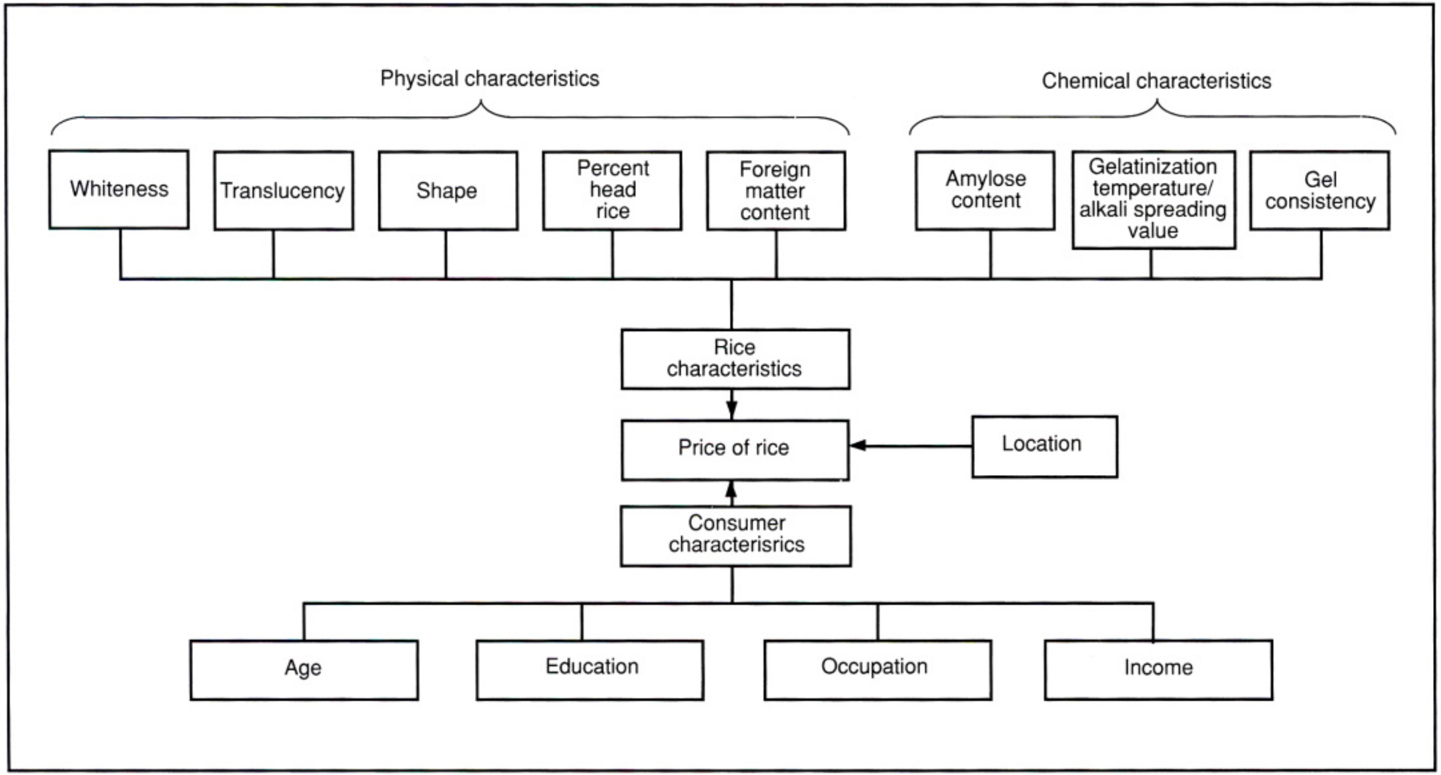
Study areas

Variations in consumer preferences between urban and rural areas were captured by selecting four markets each in Nueva Ecija Province and in Manila, representing contrasting rural and urban areas, respectively (Fig. 2).

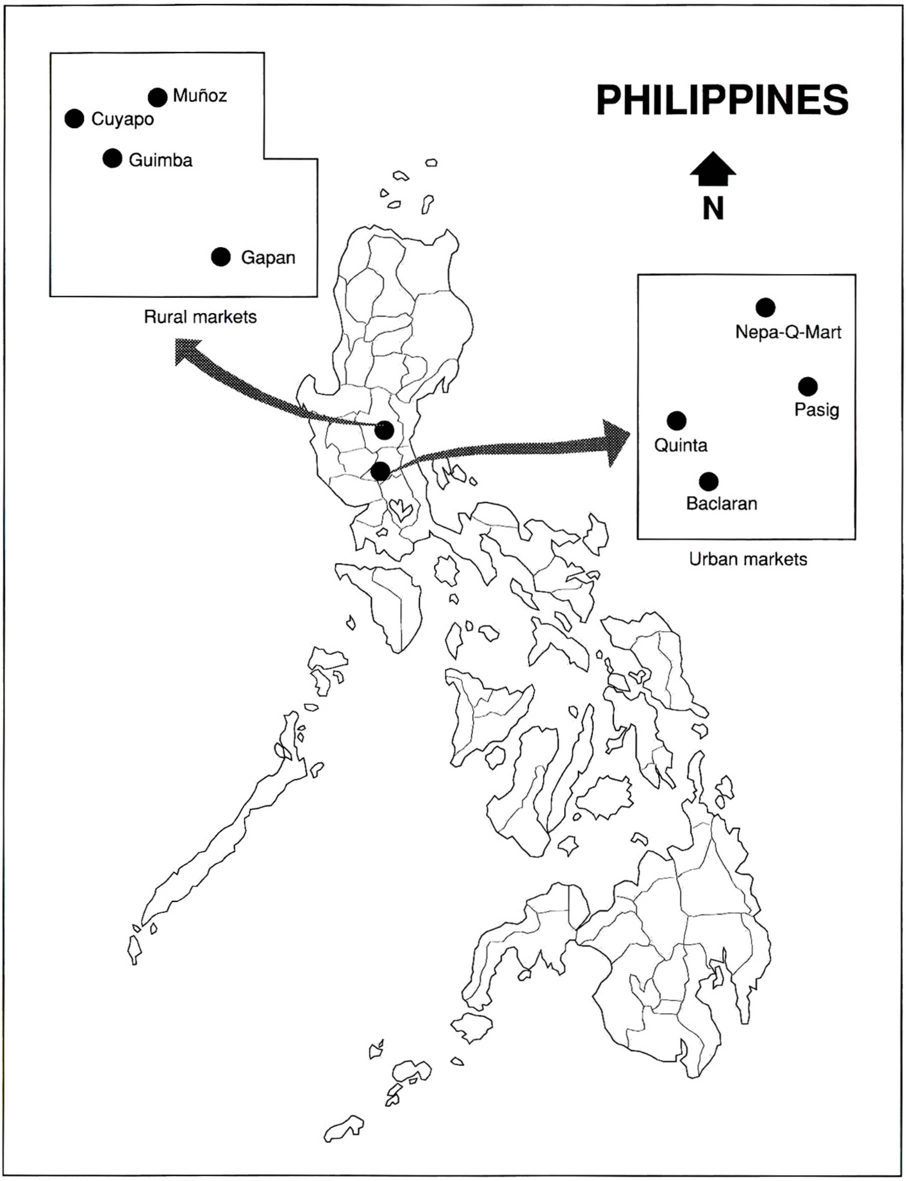
The rural area. In 1985, the per capita production and consumption of Nueva Ecija were estimated at 820 and 99 kg, respectively. The major markets in the towns of Gapan, Cuyapo, Muñoz, and Guimba were large and developed. Table 1 provides a summary profile of the four towns.

The urban site. Metro Manila, a major rice-consuming area, has a 5-yr annual deficit of 660,464 t. The larger markets selected for this study were Pasig in the east, Nepa-Q-Mart in the west, Quinta in the north, and Baclaran in the south.

The rice markets. The major markets in the study area have a substantial number of retailers, indicating that these are major trading centers. The rice section in all market centers was relatively developed with an average of 14 retailers in urban areas and 12



1. Schematic diagram of embodied rice characteristics and consumer traits affecting the price of rice (extended hedonic model).



2. Location of rural and urban consumer markets, 1987, Philippines.

Table 1. Profile of 4 selected towns in Nueva Ecija, Philippines, 1987.

Item	Gapan	Muñoz	Guimba	Cuyapo
Total population (no.)	60,014	43,211	58,847	39,654
Rural inhabitants (no.)	48,427	34,602	48,904	32,362
Urban inhabitants (no.)	11,587	8,609	9,943	7,292
Percent rural	80	80	83	81
Distance to city (km)[a]	25	31	35	57
Production condition[b]	F	F	LF	LF

[a]Reference is Cabanatuan City. [b]Rice production in terms of presence or absence of irrigation and distance to city: F = favorable, LF = less favorable.

Table 2. Characteristics of selected rice markets in Manila and Nueva Ecija, Philippines, 1987.

	Retailers (no.)	Available varieties (no.)		Price (₱/kg)	
		Range	Av	Range	Av
Urban					
Pasig	13	6-10	8	5.50 - 10.00	7.75
Quinta	19	3-9	6	5.50 - 11.00	8.25
Baclaran	11	6-9	8	6.00 - 9.00	7.50
Nepa-Q-Mart	14	5-9	7	6.00 - 10.00	8.00
All urban (av)	14	3-10	7	5.50 - 11.00	7.88
Rural					
Cuyapo	9	3-7	5	4.80 - 7.00	5.90
Guimba	12	3-7	5	5.50 - 7.00	5.90
Muñoz	14	3-6	5	5.50 - 7.50	6.50
Gapan	14	3-7	5	5.20 - 8.00	6.60
All rural (av)	12	3-7	5	5.20 - 8.00	6.31
All markets (av)	13	3-10	6	5.20 - 11.00	7.09

retailers in rural locations. Retailers occupied adjacent stalls which formed rows or rectangles. Likewise, consumers were given a wide range of choices—urban retailers offered 3-10 varieties or grades; rural retailers sold 3-7 selections. On the average, about seven varieties or grades were available in urban markets as opposed to five varieties in rural markets. The price range was widest in the urban market, with the lowest grade being sold at ₱5.50/kg and the highest at ₱11.00/kg. A much narrower range of retail prices was observed in rural markets—from ₱5.20 to ₱8.00/kg. The average price was ₱7.90/kg in urban markets and ₱6.30/kg in rural markets (Table 2).

The respondents

A sampling frame comprising regular consumers and with reference to their per capita incomes was developed to identify the respondents. After 2 wk of directly observing and interviewing retailers, the total number of regular consumers who bought rice in each selected market was determined. The consumers were divided into three income groups—low, medium, and high—based on the food consumption survey conducted by the Food and Nutrition Research Institute (FNRI 1983). Respondents earning less than ₱400/mo were considered low-income consumers, those earning ₱400-₱800/mo comprised the medium-income group, and those earning more than ₱800/mo were regarded high-income earners. A random sample representing 10% of the population was drawn from each stratum generating a total of 296 respondents. Of these, 99 were low-income consumers; 89, medium-income; and 108, high-income. There were 150 urban and 146 rural respondents.

Consumer respondents were personally interviewed to obtain their socioeconomic characteristics and preferences for rice quality. The information gathered included age, educational attainment, occupation, household size, income, quantity of rice consumed, and rice-related and other household expenditures. Interviews were conducted while consumers were purchasing rice in the market to ensure simultaneous collection of rice samples to generate data on rice characteristics.

Rice samples were analyzed for physical and chemical characteristics at the Cereal Chemistry Laboratory of the International Rice Research Institute (IRRI). The different measures of quality and the procedures in their analysis are discussed in Appendix 2a.

Results and discussion

Socioeconomic characteristics of rice consumers

Urban und rural consumers. Differences in average age between the two consumer groups—37 yr for rural residents and 40 yr for urban residents—were significant but

Table 3. Characteristics of consumers. by location, Manila and Nueva Ecija, Philippines, 1987. [a]

Characteristic	Location				Difference	Both	
	Urban		Rural				
Number reporting	150		146			296	
Av age (yr)	37		40		3*	38.50	
Education (yr in school)							
<6	32	(21)	58	(40)		90	(30)
>6-10	35	(23)	63	(43)		98	(32)
11-14	76	(51)	21	(14)		97	(33)
>14	7	(5)	4	(3)		11	(4)
Av	11		9		2**	10	
Occupation							
White-collar job	45	(30)	36	(25)		81	(27)
Blue-collar job	52	(35)	54	(37)		106	(36)
Unemployed	53	(35)	56	(38)		109	(37)
Av household size	5		6		1*	5	
Total monthly income (₱)	5258		2736		2522**	4014	
Per capita income (₱/mo)							
<400	25	(17)	73	(50)		98	(33)
400-800	52	(34)	41	(28)		93	(31)
>800	73	(49)	32	(22)		105	(36)
Av	1136		595		541**	869	

[a] Figures in parentheses are percentages of respondents reporting. **, * = significant at the 1 and 5% level, respectively.

small. Majority of the urban homemakers had reached college; 51% spent 11-14 yr in school. On the other hand, elementary (40%) and high school (43%) graduates dominated the rural respondents.

The distribution of respondents by occupation was more or less the same for the two groups. Respondents engaged in white-collar jobs (27%) were teachers, lawyers, doctors, engineers, and businessmen; blue-collar workers (36%) were dressmakers, factory workers, vendors, street cleaners, farm laborers, and craftsmen; 37% of the respondents were housewives.

The total monthly income of urban households was significantly higher than that of rural households (P5258 vs P2736). Because the average household size of urban consumers was significantly smaller than that of rural consumers, variation in average per capita income between the two groups was expectedly large. The per capita income of urban consumers averaged ₱ 1136/mo, whereas rural consumers had ₱ 595/mo. Table 3 shows that about 50% of the urban households had a per capita income exceeding ₱ 800/mo while the same percentage of rural households earned less than ₱ 400/mo.

Consumers by income group. Rural consumers (75%) dominated the low-income group while urban households constituted the majority (70%) in the high-income group, In the medium-income group, 45% were from rural areas and 55% were from urban locations (Table 4).

Table 4. Characteristlcs of consumers. by income group, Manila and Nueva Ecija, Philippines, 1987.[a]

Characteristic	Income group					
	Low		Medium		High	
Number reporting	99		89		108	
Av age	37a		39a		40a	
Education (yr in school)						
<6	58	(59)	22	(25)	11	(10)
>6-10	35	(35)	36	(40)	26	(24)
11-14	6	(6)	30	(34)	61	(56)
>14	0	(0)	1	(1)	10	(10)
Av	8	c	10	b	12a	
Occupation						
White-collar job	1	(1)	14	(16)	49	(45)
Bluecollar job	33	(33)	41	(46)	32	(30)
Unemployed	65	(65)	34	(38)	27	(25)
Av household size	6a		5a		4	b
Av monthly income (₱)	1483	c	3015	b	7158a	
Av per capita income (₱/mo)	250	c	576	b	1679a	
Location						
Rural	74	(75)	40	(45)	32	(30)
Urban	25	(25)	49	(55)	76	(70)

[a]Figures in parentheses are percentages of respondents reporting. In a column, means followed by the same letter are not significantly different from each other at the 5% level by DMRT.

Age did not vary significantly among the three consumer groups. However, the average number of years in school significantly increased as the income level went up. Similarly, white-collar earners (45%) dominated the high-income group while blue-collar workers (46%) comprised the majority in the medium-income category. The low-income group was composed mainly of unemployed homemakers (65%). Household size decreased as income increased. As expected, mean total income and average per capita income differed significantly among the three groups.

Characteristics of rice samples

Urban and rural samples. Table 5 presents selected sample characteristics while Table 6 compares the two sets of characteristics. Whiteness averaged 40% in both urban and rural markets and was comparable to the whiteness (45%) of IR rices milled under laboratory conditions. The samples had a high proportion of brokens—29% in rural and 33% in urban markets, indicating low quality by world standards. Percentage of brokens was as low as 20% under laboratory conditions and 25-30% in actual mills (IRRI 1978).

Short-grained rice (av length 5.21 mm) constituted 89% of the purchases of consumers in both markets. Chemical analysis indicated that samples had intermediate to high amylose content, intermediate gelatinization temperature, and hard to intermediate gel consistency,

Among the physical/sensory characteristics, only shape did not reflect a significant difference between the urban and rural samples (Table 6). Rice in urban markets was more translucent than that sold in rural markets. Likewise, there was significant

Table 5. Percent distribution of rice characterlstics, by location, Manila and Nueva Ecija, Philippines, 1987.[a]

Characteristic	Location		
	Urban	Rural	Both
Length (mm)			
Long (6.61-7.50)	9 (6)	0 (0)	9 (3)
Medium (5.51-6.60)	23 (15)	2 (1)	25 (8)
Short (<5.50)	118 (79)	144 (99)	262 (89)
Amylose (%)			
Low (10-20)	1 (1)	0 (0)	1 (0.5)
Intermediate (20-25)	38 (25)	97 (66)	135 (46)
High (25-35)	111 (74)	49 (34)	160 (54)
Alkali spreading value			
Low gelatinization temperature (6-7)	28 (19)	26 (18)	54 (18)
Intermediate gelatinization temperature (4-5)	82 (55)	86 (59)	168 (56)
High gelatinization temperature (2-3)	40 (26)	34 (23)	74 (25)
Gel consistency (mm)			
Soft (61-100)	4 (3)	21 (14)	25 (8)
Intermediate (41-60)	59 (39)	58 (40)	117 (40)
Hard (27-40)	87 (58)	67 (46)	154 (52)

[a]Figures in parentheses are percentages of rice samples.

Table 6. Average characteristics of rice samples, by location, Manila and Nueva Ecija, Philippines, 1987.

Characteristic	Location			
	Urban	Rural	Difference[a]	Both
Physical/sensory				
Foreign matter (%)	2.72	5.46	2.74**	4.07
Head rice (%)	67.20	71.28	4.08**	69.21
Translucency (%)	70.99	66.62	4.37*	68.83
Whiteness (%)	41.19	39.59	1.60**	40.40
Length (mm)	5.39	5.04	0.35**	5.21
Width (mm)	1.75	1.64	0.11**	1.70
Shape (ratio)	3.08	3.09	0.01	3.08
Chemical				
Amylose (%)	26.07	24.60	1.47**	25.35
Alkali spreading value	4.99	4.69	0.30**	4.84
Gel consistency (mm)	40.46	44.41	3.95**	42.41
Economic				
Price (P/kg)	7.05	6.00	1.05**	6.54

[a]**, * = significant at the 1 and 5% level, respectively.

difference in foreign matter, head rice, whiteness, length, and width among rice samples from the two markets. As for chemical characteristics, the percent amylose, alkali spreading value, and gel consistency of the urban samples were all significantly different from those of the rural samples. Average price was considerably higher (P1.05/kg) in urban than in rural markets.

Rice samples by consumer income group. The profile of rice characteristics by income group is outlined in Table 7. Foreign matter decreased and translucency increased as income increased. High-income households consumed whiter rices than either low- or medium-income households. The percentages of brokens were similar in all three groups.

There was little variation in mean gel consistency although amylose content of rices bought by low- and medium-income consumers showed a significant difference. The alkali spreading value was significantly higher in rices bought by high-income consumers (Table 8).

Hedonic relationships and implicit prices

In the working model, care was taken to use the minimum number of characteristics to ensure sufficient explanatory power. Several model specifications and variable combinations were explored. On the basis of a priori expectations regarding consumer perceptions of quality and the anticipated problems of multicollinearity among variables, these characteristics were hypothesized to cause variations in rice price: whiteness, translucency, length, foreign matter, head rice recovery, amylose content, and alkali spreading value. Gel consistency was not included because it was highly correlated with amylose content among consumer groups. Between the two characteristics, amylose content was considered the superior predictor variable. Abansi et al

Table 7. Percent distribution of rice characteristics, by consumer income group, Manila and Nueva Ecija, Philippines, 1987. [a]

Characteristic	Income group		
	Low	Medium	High
Length (mm)			
Long (6.61-7.50)	2 (2)	4 (5)	3 (3)
Medium (5.51-6.60)	3 (3)	9 (10)	13 (12)
Short (<5.50)	94 (95)	76 (85)	92 (85)
Amylose (%)			
Low (10-20)	0 (0)	0 (0)	1 (1)
Intermediate (20-25)	53 (54)	36 (40)	36 (33)
High (25-35)	46 (46)	53 (60)	71 (66)
Alkali spreading value			
Low gelatinization temperature (6-7)	15 (15)	18 (20)	44 (41)
Intermediate gelatinization temperature (4-5)	69 (70)	60 (67)	59 (54)
High gelatinization temperature (2-3)	15 (15)	11 (12)	5 (5)
Gel consistency (mm)			
soft (61-100)	9 (9)	9 (10)	7 (6)
Intermediate (41-60)	42 (42)	36 (40)	45 (42)
Hard (27-40)	48 (49)	44 (49)	56 (52)

[a] Figures in parentheses are percentages of rice samples.

Table 8. Average characteristics of rice samples, by consumer income group, Manila and Nueva Ecija, Philippines, 1987. [a]

Characteristic	Income group		
	Low	Medium	High
Physical/sensory			
Foreign matter (%)	6.34 a	3.97 b	2.09 b
Head rice (%)	69.72 a	69.81 a	68.26 a
Translucency (%)	62.81 b	70.57 a	72.92 a
Whiteness (%)	39.50 b	40.10 b	41.46 a
Length (mm)	5.12 b	5.26 a	5.26 a
Width (mm)	1.66 b	1.71 ab	1.72 a
Shape (mm)	3.10 a	3.09 a	3.05 a
Chemical			
Amylose (%)	24.72 b	25.65 a	25.67 a
Alkali spreading value	4.53 b	4.72 b	5.23 a
Gel consistency (mm)	42.96 a	42.87 a	41.53 a
Economic			
Price (₱/kg)	6.00 c	6.30 b	7.25 a

[a] In a column, means followed by the same letter are not significantly different at the 5% level by DMRT.

(1990) present the correlation matrices for the different consumer groups. From the information describing interpersonal variations in taste, occupation was dropped because this shift variable exhibited a high degree of linear relationship with income. The vector of consumer traits which distinguishes preferences between different groups of consumers included age, educational attainment, income, and location.

The extended hedonic model was best specified in logarithmic form. The linear and semilogarithmic forms were perceptibly inferior and for operational expediency, these forms were rejected in favor of the logarithmic form. Separate estimations were made for each rural and urban location and for each consumer income group. A combined analysis was also made incorporating location and income as explanatory variables.

From the estimated hedonic model, the implicit price of each characteristic was computed to determine its economic importance to consumers. The regression coefficients from the logarithmic model[3] were used to determine the implicit prices. Mean implicit prices were calculated at the mean values of the relevant characteristics.

Urban and rural consumers

Characteristics affecting rice prices in urban and rural areas are given in Table 9 and the calculated implicit prices for these characteristics are shown in Table 10.

Urban consumers. Grain length, foreign matter content, head rice recovery, amylose content, and alkali spreading value were important determinants of price. However, contrary to expectation, length was a negative determinant; a 1% increase in grain length decreased price by 0.25% and consumers were willing to pay ₱0.33/mm as grain length became shorter. This may have resulted from the purchase of higher priced, shorter grained traditional varieties and the presence of short-grained IR42 which enjoys a premium in the market because it resembles traditional varieties.

A negative relationship was observed between price of rice and foreign matter content. Price decreased by 0.04% as foreign matter increased by 1%. Urban consumers considered foreign matter an undesirable characteristic and they were willing to pay ₱0.10 for every percent of foreign matter removed from rice.

Head rice recovery was an important positive factor affecting the price of rice. Consumers pay a lower price for rice with broken grains. Price increased by 0.13% for every percent increase in head rice recovery. The calculated implicit price implies that, on the average, this characteristic costs ₱0.01 per unit.

Because of its impact on taste and cooking qualities, amylose is a significant determinant of rice price. Chemists have demonstrated that amylose content is inversely related to tenderness and moistness after cooking and is directly related to volume expansion and stickiness. Generally, Filipinos prefer rice with low to intermediate amylose content and price is expected to be negatively related to this characteristic. Among urban consumers, price decreased by 0.31% for every percent increase in amylose content. Since urban consumers did not want rice that is hard and sticky when cooked, they were willing to pay ₱0.08 for every percent decrease in amylose.

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[3]For the multiplicative (constant elasticity) form, the marginal prices, $P_j[X_j]$s, were scaled by X_{rj} such that $P_j[X_j]= b_j P_r/X_{rj}$, where b_j = regression coefficient from the hedonic model.

Table 9. Estimated implicit price function, by location, Manila and Nueva Ecija, Philippines, 1987.[a]

Item	Location		
	Urban	Rural	Both
Rice characteristic			
Whiteness	0.11	0.17*	0.07
	(0.08)	(2.32)	(1.00)
Translucency	0.02	–0.02	0.01
	(1.05)	(–0.60)	(0.59)
Length	–0.25**	–0.02	–0.13
	(–2.90)	(–0.20)	(–1.82)
Foreign matter content	–0.04**	–0.02**	–0.03**
	(–3.14)	(–3.53)	(–4.20)
Head rice	0.13*	0.09*	0.15*
	(2.19)	(2.37)	(3.92)
Amylose content	–0.31**	0.31**	–0.06
	(3.24)	(4.94)	(–0.88)
Alkali spreading value	0.18	0.09**	0.14
	(4.39)	(3.25)	(4.97)
Consumer trait			
Age	0.05	0.04*	0.03
	(1.81)	(2.22)	(1.80)
Education	0.02	0.04*	0.02
	(0.65)	(2.21)	(0.92)
Income	0.08**	0.002	0.05**
	(6.48)	(0.27)	(6.20)
Location			0.05**
			(9.20)
Summary statistics			
R^2	0.65	0.48	0.63
F	25.85**	12.24**	44.69**
SEE	0.04	0.02	0.04
n	150	146	296

[a]Figures in parentheses are t-values. **,* = significant at the 1 and 5% levels, respectively.

Table 10. Mean implicit prices (₱/unit) of characteristics paid by urban and rural consumers, Manila and Nueva Ecija, Philippines, 1987.

Characteristic	Location		
	Urban	Rural	Both
Whiteness	–0.02	0.03	0.02
Translucency	0.002	0.002	0.002
Length	–0.33	0.02	–0.16
Foreign matter content	–0.10	–0.02	–0.06
Head rice	0.01	0.01	0.02
Amylose content	–0.08	0.08	0.16
Alkali spreading value	0.25	0.12	0.38

Alkali spreading value measures the temperature and the time required for cooking. A 1% rise in alkali spreading value increased price by 0.18% among urban consumers. Since urban homemakers have busy schedules, they prefer rice that disintegrates faster and that requires lower cooking temperature and less cooking time. Likewise, because urban consumers pay more for rice with lower amylose content, this rice is likely to have less expansion and shorter cooking time. For urban consumers, alkali spreading value was valued at ₱0.25 per unit.

Per capita income was observed to be one of the most significant factors affecting rice prices. As income increased by 1%, price increased by 0.08%. This suggests that the desire for better quality rice is translated into effective demand with increases in purchasing power.

Other characteristics with less significant effects were whiteness and translucency. The age and educational attainment of the homemaker were positive but insignificant determinants of urban rice prices.

Rural consumers. Rice characteristics that cause significant variations in rural rice prices were whiteness, foreign matter content, head rice recovery, amylose content, and alkali spreading value. Rural consumers attached an implicit value of ₱0.03 to whiteness, ₱0.02 for every percent of foreign matter removed, and ₱0.01 for every percent increase in head rice.

Whiteness was a positive determinant of price, causing price to increase by 0.17% for every percent increase in whiteness. Rural consumers also gave considerable weight to the purity of rice; price increased by 0.02% for every percent decrease in the foreign matter content of rice. A direct relationship was observed between rural rice price and head rice recovery. The effect on price of a 1% increase in head rice was 0.09%.

Contrary to expectations, price and amylose content were positively correlated in the rural areas. This may be explained by the fact that higher amylose rice has greater expansion during cooking. Rural consumers were willing to sacrifice moistness and softness for more expansion to feed an entire family with less rice. Price increased by 0.31% for every percent increase in amylose content. However, 66% of the rice samples had intermediate amylose content ranging from 20 to 25%.

Cooking quality was an important criterion in the rural consumers' decision on what price to pay for rice. A 1% increase in alkali spreading value increased price by 0.09%. To rural consumers, alkali spreading value costs ₱0.12 per unit.

Among consumer traits that affect rice prices, age and educational attainment were found to have positive and significant effects. Older and highly educated homemakers purchased higher priced varieties. The influence of income on price of rural rice was small and insignificant. More than 70% of rural consumers had low per capita income. Likewise, 93% of the samples purchased were low-value rice varieties with prices ranging from ₱ 5.50 to ₱ 6.50/kg. Variations in the observed values of these two variables were too small to produce a definite and significant relationship. Compared with urban markets, the number of varieties available for sale in rural markets was relatively small with a notable absence of highly priced traditional varieties. Translucency and grain length were the other rice characteristics considered to be price determinants but their effects were weak and insignificant.

Comparison of rural and urban hedonic relationships. The extended hedonic model explained 65% of the variations in the price paid by urban consumers. For rural consumers, the R^2 value dropped to 48%. The high F values of 25.85 and 12.24 for the urban and rural regressions, respectively, indicated that the regression coefficients were significantly different from zero. The independent variables were important in explaining the price variations. The sizable and significant t-statistics calculated for each individual regression coefficient reinforced the conclusions generated by the F ratio.

The applicability of the hedonic model to both urban and rural data sets was determined by conducting a test of equality of coefficients for urban and rural regressions. The Chow test was used to determine significant differences in the estimated price and quality relationships between urban and rural consumers. The results showed that the computed F value was greater than the tabular value at the 1% level of significance. This suggests that the two estimated relationships were significantly different and that it was incorrect to assume equal coefficients. The effects of quality characteristics on the price of rice were not the same across urban and rural locations. Aragon (1972) had shown that rice varieties or grades varied not only by income but also by location.

Consumers by income group

The extended hedonic model was used to determine if the economic significance attached to rice characteristics varied for low-, medium-, and high-income consumers (Table 11,12).

Low-income consumers. The decision of low-income consumers to buy a specific rice grade was significantly affected by amylose and foreign matter content. Price increased by 0.31% for every percent increase in amylose content and rural consumers were willing to pay P0.08 for each percent increase in amylose. Contrary to expectations, consumers paid more for rice with high amylose content because it guarantees greater volume expansion and thus allows them to feed more people with relatively less rice.

A significant negative relationship was shown between price and foreign matter content—price increased by 0.03% for every percent decrease in foreign matter content. Other characteristics such as whiteness, translucency, head rice recovery, and alkali spreading value exhibited a positive but insignificant effect on the price paid by low-income consumers.

Among consumer traits hypothesized to affect price, only location was insignificant. The coefficient of the location dummy shows that the intercept of the regression for urban consumers was higher than that of the regression for rural consumers. This implies that low-income consumers paid different prices for rice depending on the source (rural or urban markets).

Medium-income consumers. The rice Characteristics causing significant variations in price paid by medium-income consumers were grain length, foreign matter content, and alkali spreading value. Grain length was a negative determinant of price, causing a 0.19% decline in price for every percent increase in grain length. Medium-income consumers paid P0.23 for each millimeter reduction in grain length. The inverse relationship between price and grain length was inconsistent with a priori expectations. The presence of short-grained IR42, which commanded a higher price in the market, may help explain this relationship.

An inverse relationship was also noted between price and foreign matter content — a 1% increase in foreign matter decreased price by 0.02%. Medium-income consumers

Table 11. Implicit price function, by income group, Manila and Nueva Ecija, Philippines, 1987. [a]

Item	Income group		
	Low	Medium	High
Rice characteristic			
Whiteness	0.09	0.09	–0.16
	(1.10)	(0.81)	(–0.91)
Translucency	0.001	0.008	0.02
	(0.05)	(0.30)	(0.77)
Length	0.14	–0.19	–0.32**
	(1.30)	(–1.63)	(–2.93)
Foreign matter content	–0.03**	–0.16	–0.04**
	(–3.65)	(–1.63)	(–2.95)
Head rice	0.10	0.09	0.20**
	(1.85)	(1.53)	(3.19)
Amylose content	0.31**	0.09	–0.61**
	(3.72)	(0.84)	(–5.72)
Alkali spreading value	0.05	0.11**	0.28**
	(1.50)	(2.72)	(5.76)
Consumer traits			
Age	0.04	0.04	0.06
	(1.36)	(1.76)	(1.90)
Education	0.02	0.04	0.04
	(0.65)	(1.76)	(1.48)
Location	0.02**	0.04**	0.10**
	(2.64)	(4.25)	(10.13)
Summary statistics			
R^2	0.45	0.48	0.70
F	7.26**	7.13**	23.10**
SEE	0.03	0.03	0.04
n	99	89	108

[a] Figures in parentheses are *t*-values. **, * = significant at the 1 and 5% level, respectively.

Table 12. Mean implicit prices (₱/unit) of characteristics paid by different income groups, Manila and Nusva Ecija, Philippines 1987.

Characteristic	Income group		
	Low	Medium	High
Whiteness	–0.01	0.01	0.03
Translucency	0.001	0.001	0.002
Length	–0.16	0.23	–0.14
Foreign matter content	–0.03	–0.03	–0.02
Head rice	0.01	0.01	0.17
Amylose content	–0.08	0.02	0.39
Alkali spreading value	0.07	0.15	0.38

paid ₱0.03 for every percent decrease in foreign matter. Alkali spreading value was a very strong factor causing variations in prices paid by medium-income consumers. A 1% increase in alkali spreading value increased price by 0.11% and a one-unit increase in alkali spreading value cost the medium-income group ₱0.15. This group preferred rice with shorter cooking time.

The effect of location on price paid by medium-income consumers was strong and highly significant. A differential intercept coefficient of 0.04 indicated that medium-income consumers who bought rice in urban markets paid higher prices than those who did so in rural markets.

High-income consumers. The price paid by high-income consumers depended heavily on quality characteristics such as grain length, foreign matter content, head rice recovery, amylose content, and alkali spreading value.

Grain length exhibited a significant negative relationship with price. A 1% increase in length reduced price by 0.32%. High-income consumers paid ₱0.44 for each millimeter reduction in length. The inconsistent negative effect was due to the purchase of highly priced traditional varieties which were relatively shorter than ordinary varieties.

Foreign matter was negatively related to price. The 0.04% decline in price for every percent increase in foreign matter was significant. Among the three consumer groups, the high-income class paid the highest implicit price (₱0.14) for each percent reduction in foreign matter. This emphasized the more discriminating taste of this group of consumers.

This category of consumers also expressed preference for higher head rice recovery. A 1% increase in this characteristic caused a significant 0.20% increase in price. The cost of an additional percentage of head rice was ₱0.02.

The effect of amylose content on price was strongest for high-income consumers. A 1% increase in amylose content significantly decreased price by 0.61%. The inverse relationship was due to the presence of highly priced traditional varieties with intermediate amylose content. An implicit price of ₱0.17 was paid for each percent decrease in amylose content.

The high-income consumers attached the highest value to alkali spreading value; they were willing to incur a 0.28% increase in price for each percent increase in alkali spreading value. On the average, they paid ₱0.39 for each additional unit of alkali spreading value in their rice. This preference for fast-cooking rice could be attributed to the busy schedule of this group which is composed mostly of urban residents with white-collar jobs. Location had a significant influence on the price paid by high-income consumers. A differential intercept coefficient of 0.10 suggests that high-income consumers buying in urban markets paid higher prices than did consumers in rural markets.

Whiteness and translucency were positive but insignificant determinants of price for all income groups. Likewise, age and educational attainment of homemakers positively influenced price, but the magnitude of the coefficients was small and insignificant.

Comparison of hedonic relationships by income group. Table 11 suggests that as income rises, consumers become more discriminating. The willingness to pay for quality characteristics was greatest among high-income consumers. The calculated R^2 statistics support this finding. The value increased as income level rose. Among low-income consumers, the embodied attributes and shifter variables explained only 45% of the variation in price. The explanatory power of the same variables increased to 48% for the medium-income group and to 70% for the high-income consumers. The F ratios were significant and increased with income level, implying an improvement of fit of the regression model with increasing income. This suggests that the variables included in the model explained a large share of the variation in price.

The data in Table 11 also indicate that the effect of each quality attribute on price of rice was strongest for the high-income group. This suggests that this group attached the highest economic value to each quality characteristic. The sizable and significant t-statistics calculated for each individual coefficient in the high-income regression confirmed this observation.

These results support Efferson's (1985) claim that the higher the level of income, the wider is the range of prices consumers will pay for different rice qualities. These consumers will pay well for the highest quality possible but will not buy lower quality rice at any price.

Consumer perceptions of rice quality characteristics. In addition to laboratory analysis, preferences of specific consumers were identified through personal interviews which were designed to complement the laboratory results and to demonstrate the usefulness of this instrument method as a potential substitute for subjective evaluation.

Reasons for preferring a specific rice grade

Table 13 enumerates the reasons given by urban and rural consumers for buying a specific grade of rice; they can be categorized into appearance, cooking and eating

Table 13. Reasons for preferring a specific rice grade as cited by urban and rural consumers, Manila and Nueva Ecija, 1987.[a]

Characteristic	Income group		
	Low	Medium	High
Clean/pure	52 (34)	15 (10)	67 (22)
White/translucent	77 (50)	56 (36)	130 (43)
More whole grains	6 (3)	4 (2)	10 (3)
Long/round grains	2 (1)	0 (0)	2 (0.5)
Easy to cook	20 (13)	42 (28)	62 (20)
Aromatic	25 (16)	4 (2)	29 (9)
Old, brittle, expands more	85 (56)	63 (43)	148 (49)
Tastes good/soft	61 (40)	42 (28)	103 (34)
Consumer feels full for a longer period	7 (4)	7 (4)	14 (4)
Reasonably priced/cheap	57 (37)	77 (52)	134 (45)

[a]Figures in parentheses are percentages.

qualities, and price. Among urban consumers, the most commonly cited reason was volume expansion (56%) and whiteness/translucency (50%). Softness and good taste were cited by 40% while lower price was quoted by 37%. Purity and cleanliness were considered important by 34% of this group.

Among rural consumers, the most important factor was the relative cost of rice (52%); volume expansion was second (43%); and whiteness and translucency, third (36%).

In a pooled sample, the most important quality factor cited was volume expansion during cooking (49%), low price (45%) was second, followed by whiteness and translucency (43%). In the market, consumers generally made buying decisions based on physical appearance and price. Cooking and eating qualities were not explicit and consumers selected these characteristics indirectly through induction from physical and sensory assessment. For example, some consumers determined volume expansion by biting the rice kernel; a hard, nutty kernel indicated more volume expansion and a better cooked rice.

Summary and conclusions

As the study indicates, the price paid by urban consumers is affected significantly by grain length, head rice recovery, presence of foreign matter, amylose content, and alkali spreading value. Monthly per capita income is the only consumer characteristic which affects the purchasing decision of this group of consumers.

Rural consumers base their purchasing decisions on a slightly different set of characteristics: whiteness, head rice recovery, foreign matter content, amylose content, and alkali spreading value. The age and educational attainment of the homemaker also influence the price paid for a particular rice lot.

With the exception of whiteness, the magnitude of the regression coefficients indicates that all characteristics exert stronger influence on rice prices in urban than in rural markets. Urban consumers attach higher implicit prices to these characteristics than do rural consumers. The results of the Chow test further confirm the significant difference in the estimated price and quality relationships between urban and rural consumers.

As income levels rise, consumers become more discriminating; this is evident from the observation that high-income consumers purchase rice based on quality characteristics and attach higher implicit prices to these attributes than do low- and medium-income consumers. Among the shift variables, only location is found to significantly affect price for the three income groups, implying that within income groups, prices paid by consumers vary depending on whether purchases are made in urban or rural markets.

Laboratory analysis and personal interviews are used to identify the preferences of specific consumers. For all consumers, the most commonly cited reason for buying a specific rice is volume expansion of the cooked rice. Other major selection criteria, in descending order of importance, are reasonable prices, whiteness and translucency, softness, and good taste.

These findings confirm that consumers attach economic importance to rice quality. The study also confirms that preferences for rice quality vary somewhat among distinct consumer groups. Any program to improve quality must consider these differences.

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Notes

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Evaluation of urban consumer preferences for rice quality characteristics in Indonesia[1]

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Over the past 15 yr, modern rice technology has had a significant impact on rice production in Indonesia. Indonesia has increased rice production remarkably within the last 2 decades, from 12.3 million t in 1970 to 27.5 million t in 1987. From being one of the world's largest rice importers, Indonesia achieved rice self-sufficiency in 1984. As consumers become more concerned about and more discriminating with respect to appearance and eating quality of rice, the country must confront the second-generation problems of maintaining self-sufficiency and improving the quality of rice produced in an effort to increase sales in the domestic and world markets.

A study to assess consumer preferences for rice grain quality was conducted in three major urban centers—Jakarta, Medan, and Ujung Pandang—from March to September 1987. Data on household consumption patterns, tastes, preferences, and expenditures were gathered from rice consumers in these markets. Rice samples were also collected to analyze physical, chemical, and organoleptical characteristics.

This research also compared the pattern of consumer demand for characteristics based on location. Several physical and chemical characteristics—whiteness, chalkiness, milling degree, head rice percentage, yellow grains, amylose content, alkali spreading value, and stickiness—were expected to affect consumers' decision in determining the price of rice.

The objectives of the study are to identify economically important rice quality characteristics, to assess the market value of different quality Characteristics at different market levels and different regions, and to identify factors that determine consumer choice at different income levels.

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[1]Reprinted with permission in part from *Grain postharvest research and development: priorities for the nineties.* Proceedings of the 12th ASEAN Seminar on Grain Postharvest Technology, 29-31 August 1989, Surabaya, Indonesia. J.O. Naewbanij, ed. (1991) ASEAN Grain Postharvest Programme. Bangkok. p. 268-292.

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Literature review

While previous studies in Indonesia have reported on certain aspects such as rice quality characteristics (Damardjati 1978, Damardjati et al 1986) or consumer preferences (BULOG 1978, Unnevehr et al 1985), studies of their relationship to marketing and socioeconomic aspects are limited.

Previous studies of rice quality characteristics had revealed that Javanese consumers prefer rice with moderate amylase content and smooth texture ("pulen"), whereas West and North Sumateran consumers prefer a more easily separating, high-amylose, hard-textured rice ("pera") (Damardjati et al 1987). The results of the 1978 BULOG survey showed that laborers performing heavy work paid less attention to taste but more to expansion potential of the rice because the latter gave an enhanced feeling of satiation. Javanese consumers preferred highly polished rice and attached little value to rice shape or to amount of brokens in the rice (BULOG 1978). Consumers in Jakarta preferred highly polished rice with few brokens (Unnevehr 1986).

A recent consumer survey conducted by the Directorate of Food Crops Economics (1988) in Java showed that consumers overwhelmingly preferred the taste of traditional rice varieties (TVs) and would buy such rice if they could afford to do so. Nearly 95% of total rice produced are modern varieties (MVs), and although some of the more recently released MVs have desirable taste characteristics (such as Cisadane and IR64), the price premium paid for TVs (or mixes) sharply exceed the price of the better tasting MVs. With growth in income, more consumers demand, and are able to afford, rice with desirable taste characteristics.

An important dimension of quality relates to physical (rather than chemical) characteristics and is influenced primarily by postharvest handling and processing rather than by variety characteristics. Physical quality includes moisture content, immature or chalky grains, discolored and damaged grain, or excess brewers and broken grains (Damardjati and Barrett 1986). The oxidation and spoilage resulting from long-term storage induces a rancid odor in the older vintage public stock. This rice is distributed to civil servants who typically resell it in the private market (Falcon 1986).

The relationship between demand and quality is influenced by a number of factors that are both exogenous and endogenous to the institutional organization of the market. A few of the more important institutional factors which influence rice quality include the buying and selling practices of traders, the technical capacity of mills to alter quality, and the changing nature of rice harvesting operations. Wholesalers and retailers have been found to add moisture to increase rice weight and to blend traditional and local varieties of rice, which are then sold as traditional rice brands (Directorate of Food Crops Economics 1988).

There is no standard system of grading in Indonesia, except for rice procured for the government stockpile by the National Logistics Agency. Different wholesalers and retailers use locally recognized brand names and easily observable physical quality characteristics to differentiate rice in the private market (Damardjati et al 1987). The quality standards or specifications for milled rice and rough rice have been established by BULOG in a domestic procurement proposal. Only some physical characteristics affecting grain storability—eg., moisture content (not exceeding 14%), chalky grain, broken kernel, and degree of milling—are taken into account (Damardjati and Barrett 1986). These criteria appear to be more of a storage standard than a reflection of consumer preference. In the market, consumers always consider taste, cooking quality, and aroma as well as physical components in assessing quality. The greatest price differentials occur in rice varieties with different eating qualities, even if physical qualities are the same.

Research methodology

Field surveys

Surveys were conducted in three large cities within the main urban area in Indonesia—Jakarta (Java Island), Ujung Pandang (South Sulawesi), and Medan (North Sumatera)—from March to September 1987 (Fig. 1). The total number of respondents (with corresponding rice samples) were 469: 280 from Jakarta, 97 from Ujung Pandang, and 92 from Medan. Samples were taken from three categories of markets—large, medium, or small (or traditional).

Interviewers waited for consumers to buy rice from retailers. A prepared questionnaire was given each respondent to determine socioeconomic characteristics such as family size, rice consumption, other expenses, and additional information. Respondents were also asked about the rice bought, its price, and the reasons for buying it. The interviewer then bought exactly the same rice as that purchased by the respondent for laboratory analysis.

Rice quality analysis

Samples were analyzed for physical, chemical, and organoleptic characteristics in the Chemistry Laboratory of the Sukamandi Research Institute for Food Crops (SURIF)

1. Survey sites in Indonesia to assess grain quality.

in Sukamandi. Physical characteristics included moisture content, shape, size, whiteness, translucency, chalkiness, head rice, broken rice, brewers, green kernels, and yellow kernels. The analysis of physicochemical characteristics of cooked rice included amylose content (Juliano 1971), protein content (AOAC 1975), gel consistency (Cagampang et al 1473), alkali test (Little et al 1958), volume of expansion of cooked rice, water absorption, and cooking time. The organoleptic test of cooked rice included color, aroma, hardness, stickiness, and consistency ("pulen").

Statistical analysis

The determination of the major factors of rice characteristics was attempted on 19 variables of physical, chemical, and organoleptic properties which were screened stepwise by principal component analysis (PCA) to determine the main constituent, relationship between variables, and order in the system. The procedure reported by Damardjati et al (1986) was used in the analysis.

Consumer demand follows the consumer goods characteristics model developed by Ladd and Suvannunt (1976). It is assumed that consumer demand is based on the characteristics of the product. For rice, the model can be expressed mathematically as

$$P_r = f\,(P_j X_{rj}) \tag{1}$$

where P_r = market price,

X_{rj} = total of characteristic j in a unit of rice, and

P_j = implicit price of characteristic j.

This function shows the average price paid by the consumer for different grades of rice with attribute X_{rj} (Unnevehr 1992).

To quantify the relative expense share for rice to total food expenses, a model described by Tabor (1988) was used:

$$W = \ln\,(Mn) + \ln\,(P) + Fam + e \tag{2}$$

where w = share (expense for rice/total expense for food),

Mr = consumer's total expenses, and

P = price of rice.

Identification of variables

Some physical and chemical characteristics of rice are expected to affect, directly or indirectly, the price of rice paid by consumers; for example, degree of whiteness, level of polishing, and head rice percentage have a positive correlation with price. On the other hand, physical characteristics such as chalkiness and yellow grain negatively affect price. Chemical characteristics such as amylose content and scores from alkali test indirectly affect price. Amylose content is highly correlated with stickiness of cooked rice and its effect might be positive or negative, depending on the region of origin of the consumers. Scores from the chalkiness test, on the other hand, are related to cooking time: the higher the score, the shorter the time to cook; this characteristic is therefore expected to affect price positively. The only dominant physical characteristic of cooked rice is stickiness but consumer tastes and preferences in Indonesia vary widely (i.e., most people in Sumatera and Sulawesi prefer nonsticky and hard-cooked rice). People in Java, on the other hand, prefer sticky and soft-cooked rice such as Cianjur, Rojolele, and the Pandanwangi variety. Because of this variation, the effects of stickiness on price cannot be predicted yet.

The least-square method of regression is used to estimate equations (1) and (2), based on location.

Results and discussion

Consumer characteristics

Consumer characteristics in three selected cities (Medan, Jakarta, and Ujung Pandang) are summarized in Table 1.

Income distribution. The average per capita income of consumers on a monthly basis in the three cities was about Rp 35,120, with Jakarta registering the highest (Rp 37,928) and Ujung Pandang, the lowest (Rp 29,765). The average monthly expenditure on food per capita was about Rp 22,557, with the largest food expenditure gap found in Medan and the smallest in Ujung Pandang. The average food expense in Jakarta (Rp 23,706) was the highest among the three cities (Table 1).

Rice consumption and family size. The average per capita rice consumption was 7.7 kg/mo. The lowest consumption (7 kg) was recorded in Jakarta and the highest (8.7 and 8.5 kg) were observed in Medan and Ujung Pandang, respectively. For all cities, the average family size was about 6 persons, indicating that each couple had 3-4 children (assuming no other people were under their responsibility). With this family size, 15% were less than 5 yr old and were wholly dependent on their parents. The

Table 1. Socioeconomic characteristics of consumers in three selected cities, Indonesia, 1987.

Characteristic	Medan	Jakarta	Ujung Pandang
Income per capita[a] (Rp/mo)	32,223 ± 19,089 (11,156 – 156,850)	37,928 ± 25,592 (9,063 – 157,344)	29,765 ± 17,390 (10,167 – 90,286)
Food expenditure (Rp/mo)	22,984 ± 16,165 (7,750 – 52,850)	23,706 ± 14,073 (5,538 – 89,444)	18,835 ± 8,259) (6,250 – 44,500)
Rice consumption (kg/capita per mo)	8.52 ± 2.85 (3.06 – 16.25)	7.08 ± 2.61 (2.50 – 15.88)	8.74 ± 2.88 (2.96 – 16.40)
Price (Rp/kg)	507.71 ± 66.10 (408.20 – 714.29)	471.48 ± 69.50 (325.00 – 762.00)	492.82 ± 77.93 (386.18 – 777.03)
Rice brand (score)[b]	4.8± 1.5 (1.0 – 7.0)	3.6 ± 1.3 (1.0 – 7.0)	3.6 ± 1.8 (1.0 – 7.0)
Market level (score)[c]	2.5 ± 0.8 (1 – 3)	1.95 ± 0.7 (1 – 3)	2.0 ± 0.8 (1 – 3)
Family size (no. of persons)	5.9 ± 2.5 (2 – 14)	5.8 ± 2.7 (1 – 15)	5.9 ± 2.7 (1 – 14)
Dependency ratio[d]	0.22 ± 0.26 (0 – 2)	0.14 ± 0.16 (0 – 1)	0.15 ± 0.17 (0 – 1)
Purchasing scale (kg)[e]	8.83 ± 10.60 (0.48 – 39.20)	9.17 ± 21.54 (0.69 – 50.00)	12.40 ± 13.81 (0.70 – 57.50)

[a]Income per capita is defined as total expenditure on food, clothes, energy, house rent, and health. Numbers in parentheses indicate range. [b]Rice brand is determined by price level, from the cheapest to the most expensive. [c]Market level: 1 = high, 2 = medium, 3 = low. [d]Dependency ratio is defined as the number of children below 6 years old. [e]Purchasing scale is defined as the volume of rice purchased at a certain time.

dependency ratio was highest in Medan where 22% of family members were under 5 yr of age. The lowest dependency ratio was in Jakarta (14%).

The average amount of rice bought by consumers in one transaction was 9.8 kg; if this figure were related to the average consumption of 8 kg per capita/mo or 48 kg/mo for 6 family members, it is evident that they bought enough rice for 4-5 d. The average amount of each transaction was highest in Ujung Pandang (12.5 kg), compared with those in Medan (8.8 kg) and Jakarta (9.2 kg).

Consumer choice. The tendency of consumers to consume foods other than rice, especially those made of wheat such as bread and noodles, was higher in Medan (63%) than in Jakarta and Ujung Pandang (only 40%).

The consumers' basis for choosing rice was generally the brand. Various types of rice sold in the market can be classified into 3 main groups—group I, improved varieties with hard-cooked rice; group II, improved varieties with sticky cooked rice; and group III, local varieties with different names, depending on where they were produced (Table 2).

Although the ability to express preferences was limited by income, a consistent trend between brand preference and actual purchase by consumers was found in Medan and Jakarta. In Medan, 96.4% of the consumers preferred group III rices (local brand),

Table 2. Consumer preferences and purchasing patterns, by rice brand group, Indonesia, 1987.

City	Choice	Brand group[a] (%)		
		I	II	III
Medan	Preferred	3.60	0	96.40
	Purchased	36.96	5.43	57.61
Jakarta	Preferred	4.65	72.10	23.20
	Purchased	5.36	65.36	29.29
Ujung Pandang	Preferred	9.00	19.20	71.90
	Purchased	57.61	21.65	20.62

[a] Brand group is categorized as follows: Group I = modern variety with hard-cooked rice, Group II = modem variety with sticky cooked rice, and Group III = local variety with aromatic taste.

Table 3. Consumers' reasons for choosing a particular rice brand group in three selected cities, Indonesia, 1987.

Reason	Medan				Jakarta				Ujung Pandang			
	Brand group				Brand group				Brand group			
	I	II	III	Total	I	II	III	Total	I	II	III	Total
Eating quality	10.8	1.1	44.5	56.4	1.8	38.6	23.5	63.9	20.5	17.5	17.5	55.5
Physical appearance	0	0	0	0	0	3.2	0.4	3.6	0	0	1.0	1.0
Cooking property	3.3	0	0	3.3	1.1	1.1	0.4	2.6	21.6	1.0	0	22.6
Socioeconomic factors	22.9	4.4	13.1	40.4	2.5	22.5	5.0	30.0	14.4	3.1	2.0	19.5

but only 57.6% actually purchased them. In Jakarta, group II rices (MVs) were preferred and actually purchased by majority of the consumers. In Ujung Pandang, 71.9% of the consumers preferred brands from group III but only 20.6% bought them.

Consumers generally have several reasons for selecting a particular type of rice. These can be classified as eating quality, physical appearance, cooking characteristics, and socioeconomic factors (Table 3). Consumers often face a trade-off between price and quality.[3] For example, 22.9% of consumers in Medan chose group I rices because of the lower price while 56.4% of the consumers chose local varieties because of better eating quality. In Jakarta, 38.6% of consumers chose soft MVs (group II) because of eating quality while 22.5% of consumers did so for economic reasons; at the same time, 23.5% of consumers chose group III (local varieties) also because of eating quality. Consumers in Ujung Pandang preferred group I rices for their eating quality (20.5%), cooking properties (21.6%), and economic attributes (14.4%).

Price distribution. Table 4 shows the price distribution of seven groups of rice based on brand name and price. The price distribution in Jakarta was not as consistent

Table 4. Distribution of rice varietal group based on brand name and price in three selected cities in Indonesia, 1987.

Varietal group	Frequency (%)	Price (Rp/kg)	Brand name
Medan			
1	3.3	417.70	1: Beras lama, Aceh, Simanggar
2	2.2	433.70	2: Simotong
3	18.5	442.00	3: Sawah halus, Si Pisang, IR/C4
4	20.6	461.60	4: Si Lumat, Jongkong, GL and Cinta
5	6.5	503.00	5: Munthe
6	42.4	552.30	6: Ramos, Cantik manis
7	6.5	624.10	7: Kukubalam, Arias
Jakarta			
1	3.6	451.70	1: IR
2	1.8	411.70	2: Stock, Ex BULOG
3	58.2	443.20	3: Cisadane
4	19.3	484.00	4: Cianjur
5	7.5	542.60	5: Saigon
6	2.9	534.90	6: Rojolele
7	6.8	599.80	7: Pandanwangi
Ujung Pandang			
1	1.0	427.50	1: Banda
2	40.2	446.20	2: IR, Ex DOLOG
3	17.5	460.10	3: Bogor, Cisadane + IR
4	15.5	484.50	4: Cisadane
5	6.2	514.60	5: Citarum, C4
6	4.1	543.40	6: Lapang
7	15.5	640.00	7: Mandi Super

[3]Regressions of quality characteristics on price were run separarely for the three different income classes. The results show that even low-income consumers were willing to pay significantly higher prices for more head rice, fewer yellow and damaged grains, and less sticky rice.

as those in Medan and Ujung Pandang. This situation reflected a relatively higher consumer heterogeneity in Jakarta. Therefore, the willingness of consumers to pay for a particular quality of rice varied, depending on their preferences.

The average price paid by consumers per kilogram of rice was Rp 483. In the three selected cities, the highest price was paid by consumers in Medan (Rp 507/kg), while the lowest was in Jakarta (Rp 471/kg). The wide range of prices observed in Medan, Jakarta, or Ujung Pandang was certainly due to differences in rice quality offered by retailers.

Among seven brand groups of rice in Medan, Kukubalam and Arias were the most expensive varieties (Rp 624.10/kg); in Jakarta and Ujung Pandang, the prices of Pandanwangi (Rp 600.00) and Mandi Super (Rp 640.00) were highest. In Jakarta, the Saigon rice type was more expensive than the local popular variety Rojolele, costing Rp 542.60 and Rp 534.90/kg, respectively. In addition, rice released by DOLOG/ BULOG was cheaper in Jakarta (Rp 411.70) than in Ujung Pandang (Rp 466.20). This type of rice was reserved for government employees and army personnel.

Rice quality

The quality of rice sold in the market at the retail level in Medan, Jakarta, and Ujung Pandang was affected, in varying degrees, by physical, chemical, and organoleptical characteristics (Table 5, 6).

Table 5. Physical characteristics of rice at the consumer level in three selected cities in Indonesia, 1987.

Characteristic	Medan	Jakarta	Ujung Pandang
Moisture content (%)	12.03 ± 0.47	12.94 ± 0.70	14.63 ± 0.96
	(11.0 – 12.9)	(11.0 – 15.9)	(10.0 – 16.6)
Shape (L/W)	2.73 ± 0.28	2.61 ± 0.21	2.39 ± 0.20
	(2.11 – 3.43)	(1.83 – 3.50)	(2.00 – 3.00)
Whiteness (%)	37.38 ± 4.08	39.24 ± 2.09	35.55 ± 2.68
	(21.20 – 44.70)	(33.40 – 47.30)	(29.70 – 41.90)
Chalkiness (score)	3.35 ± 0.45	1.97 ± 0.59	3.66 ± 0.84
	(2.2 – 4.4)	(0.10 – 3.50)	(1.4 – 5.0)
Translucency (score)	3.14 ± 0.45	2.79 ± 0.62	3.33 ± 0.52
	(1.3 – 4.4)	(0.70 – 4.70)	(1.7 – 5.0)
Milling degree (%)	88.10 ± 4.22	85.79 1– 5.80	81.80 ± 3.53
	(80.8 – 95.0)	(70.0 – 100.0)	(70.0 – 95.0)
Head rice (%)	79.88 ± 6.57	77.97 ± 6.37	73.81 ± 9.60
	(58.30 – 93.10)	(48.20 – 91.30)	(49.20 – 95.70)
Broken rice (%)	18.20 ± 5.72	21.32 ± 6.58	24.4 ± 7.78
	(6.50 – 34.50)	(8.60 – 61.10)	(2.0 – 47.30)
Brewer (%)	2.02 ± 1.27	0.89 ± 0.64	2.05 ± 1.76
	(0.40 – 7.20)	(0.10 – 8.00)	(0.10 – 11.00)
Bulk density (g/liter)	809.5 ± 23.6	797.0 ± 11.2	822.1 ± 9.8
	(646.0 – 897.0)	(759.6 – 834.1)	(795.3 – 846.5)
Green kernel (%)	0.79 ± 0.59	0.79 ± 0.94	1.45 ± 1.07
	(0.0 – 3.4)	(0.0 – 8.9)	(0.1 – 6.7)
Yellow rice (%)	1.61 ± 1.34	1.26 ± 1.10	2.6 ± 1.94
	(0.2 – 6.3)	(0.0 – 7.8)	(0.3 – 9.3)

Shape and appearance. The shape (expressed as length-width ratio) and size of kernels depend on variety. Rice marketed in selected cities was usually medium shaped (2.1-3.0).

Rice whiteness, as measured with a Kett Whiteness meter, averaged 38.11% in Medan (range 21.20-47.30%). Rice from Jakarta had the highest degree of whiteness (39.24%) while Ujung Pandang rice had the lowest (35.55%). Whiteness affected rice gloss.

There was wide variation in chalkiness, the scores for chalkiness in Medan, Jakarta, and Ujung Pandang being 3.35 (medium), 1.97 (low), and 3.66 (medium), respectively (Table 5).

Another physical characteristic of rice, translucency, affects the color of rice and can be measured by scoring. Rice marketed in the rural areas had a mean translucency score of 2.97 (range 0.70-5.00). The highest score was recorded in Ujung Pandang (3.33).

Milling quality. There was positive correlation between whiteness and milling degree which is generally a measure of the degree of polishing of the outer layer. The average milling degree of rice marketed in the three cities was 85.42%, the range was from 70 to 100%. The milling degree in Ujung Pandang was lowest (81.80%) compared with Medan's 88.10% and Jakarta's 85.79%.

Table 6. Chemical and organoleptic characteristics of rice in three selected cities in Indonesia, 1987.

Characteristic	Medan	Jakarta	Ujung Pandang
Amylose (%)	23.30 ± 1.54 (20.30 – 27.00)	20.67 ± 1.67 (17.20 – 27.30)	23.32 ± 1.55 (19.50 – 27.00)
Protein (%)	7.95 ± 0.68 (6.20 – 9.90)	9.17 ± 0.67 (7.30 – 11.90)	7.85 ± 0.65 (6.40 – 9.50)
Gel consistency (mm)	41.98 ± 12.35 (24.50 – 77.50)	40.69 ± 10.27 (20.90 – 84.00)	34.82 ± 8.26 (20.00 – 70.00)
Alkali spreading value (score)	3.82 ± 1.74 (1.00 – 7.00)	2.80 ± 1.25 (1.80 – 7.00)	5.06 ± 2.10 (1.00 – 7.00)
Water absorbance index (g/g)	2.47 ± 0.41 (1.76 – 3.89)	2.50 ± 0.38 (1.76 – 3.95)	2.69 ± 0.38 (1.56 – 3.54)
Volume expansion (g/g)	4.12 ± 0.38 (3.13 – 5.23)	4.101 ± 0.51 (0.77 – 5.87)	4.4 ± 0.55 (3.13 – 6.00)
Cooking time (min)	24.88 ± 3.25 (18.00 – 34.00)	23.46 ± 2.41 (18.00 – 40.00)	24.87 ± 4.48 (17.00 – 37.00)
Color (score) [a]	3.39 ± 1.02 (2.00 – 7.00)	3.31 ± 0.81 (1.80 – 7.00)	3.65 ± 0.89 (2.10 – 6.60)
Glossiness (score) [b]	3.55 ± 0.76 (2.00 – 6.10)	3.49 ± 0.70 (2.00 – 6.50)	3.85 ± 0.77 (2.20 – 6.00)
Aroma (dummy) [c]	0.18 ± 0.32 (0.00 – 1.00)	0.11 ± 0.31 (0.00 – 1.00)	0.05 ± 0.20 (0.00 – 1.00)
Hardness [d]	5.30 ± 0.95 (2.80 – 8.00)	5.04 ± 0.80 (2.70 – 7.40)	4.73 ± 1.17 (1.80 – 8.00)
Stickiness [e]	3.22 ± 0.69 (1.30 – 5.70)	3.03 ± 0.60 (1.30 – 5.00)	3.43 ± 0.67 (1.20 – 4.80)

[a]Whiteness was given a higher score (range, 1-9). [b]Lower score given to glossy cooked rice (range, 1-9). [c]Aroma: 1 = yes; 0 = no. [d]Lower scare given to harder cooked rice (range, 1-9). [e]Lower score given to more sticky rice (range, 1-9).

Both milling degree and moisture content affect the percentage of head rice, the former, significantly. Rice with high moisture content will discolor easily and rice with low moisture content will be more brittle. Rice marketed in Medan had the highest percentage of head rice (79.88%) while that in Ujung Pandang had the lowest (73.81%).

Improper grain. Green and chalky grains result from immature grain or from abnormal growth or genetic factors, while yellow or damaged grains are caused by fermentation, deterioration, or fungal growth because of improper drying (Damardjati 1987). An average of 0.93% chalky grains and 1.61% yellow and damaged grains were recorded in marketed rice in the three cities. Rice marketed in Ujung Pandang had the highest percentage of green and chalky grains and yellow and damaged grains—1.45 and 2.60%, respectively.

Chemical properties. Chemical characteristics of rice indirectly affect the choice consumers make even though such characteristics are not directly observable. Physicochemical and organoleptical characteristics of rice are presented in Table 6. The average amylose content of rice was 21.73%, with a wide range of 17.30-27.30%. There was no significant difference in the average amylose content of rices found in the three cities.

It was also observed that protein content was negatively correlated with milling degree. The increased milling degree obtains a high gloss which reduces the protein content. The average protein content in rice samples was 8.66% (range 6.20-11.90%). A slightly higher protein content was recorded in Ujung Pandang (9.19%).

There was a relatively wide variation in gel consistency, with a mean of 39.73 mm and a range of 14.50-84.00 mm. At intermediate amylose content, a high gel consistency value indicates that the cooked rice would have a sticky texture. Rice with low to intermediate amylose content has soft gel consistency. Rice with high amylose content with soft gel consistency (more than 61 mm) is preferred because it gives softer cooked rice (Perez and Juliano 1979). The average alkali spreading value was 3.47 and the lowest value was recorded in Jakarta.

Cooking properties. Water absorption index is a measure of the quantity of water ahsorbed during cooking of rice. Greater water absorption index makes cooked rice more expandable and heavier. Volume expansion measures the ratio of volume of cooked rice to that of raw rice. The averages of water absorption index and volume increase index were 2.54 and 4.17, respectively. The two chemical characteristics were not significantly different among rice marketed in the three cities surveyed.

Cooking time depends on the chemical composition, rice variety, and the length of storage before rice is cooked. The average cooking time was 24 min, with a range of 17-40 min. The average cooking times recorded in Medan, Jakarta, and Ujung Pandang did not differ significantly. The longest cooking time (in Medan) was only 34 min; this is shorter than the cooking time in Jakarta and Ujung Pandang—40 and 37 min, respectively.

Principal component analysis of milled rice characteristics

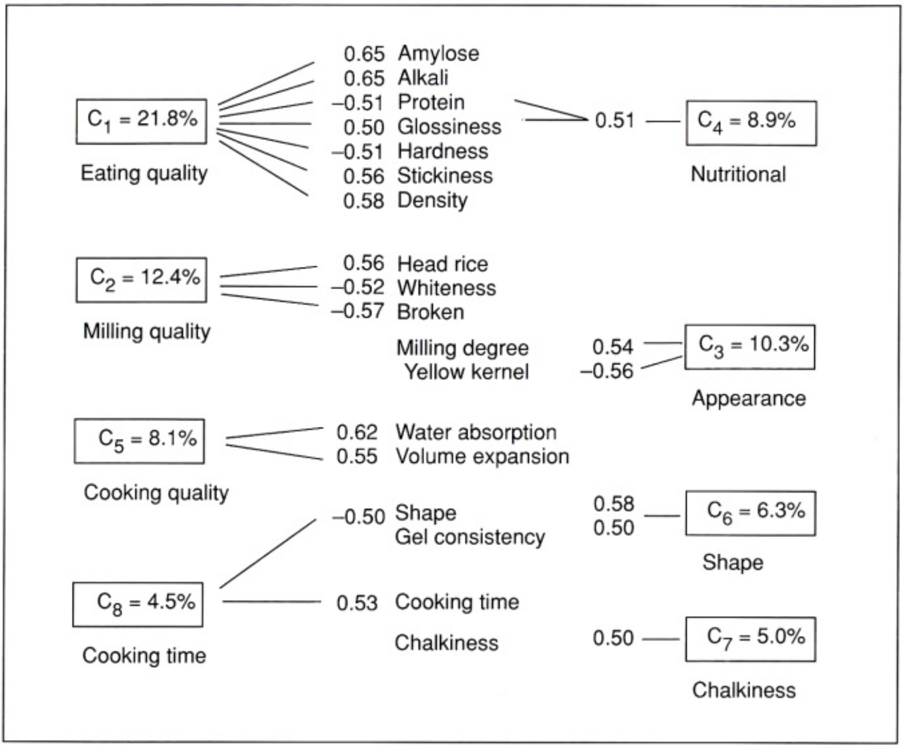
From 25 variables of physical, chemical, and organoleptic characteristics, 19 were selected for PCA.

Table 7. Principal component matrix with variable loading of physical, chemical, and organoleptic characteristics of milled rice, Indonesia, 1987 (n = 469).

Variable	Component							
	C1	C2	C3	C4	C5	C6	C7	C8
Shape	–0.32	0.28	0.06	0.19	0.14	0.58	–0.03	–0.49
Whiteness	–0.37	–0.52	0.27	0.14	0.27	–0.05	0.38	–0.04
Milling degree	–0.39	0.16	0.54	0.30	0.21	0.10	–0.29	0.15
Head rice	–0.56	0.56	–0.20	0.41	–0.15	–0.21	0.26	–0.04
Brokens	–0.49	0.57	0.19	–0.46	0.17	0.23	–0.26	0.03
Density	0.58	–0.37	0.00	0.36	–0.26	–0.09	–0.01	0.00
Chalkiness	0.40	–0.45	0.12	–0.05	–0.17	–0.09	0.50	–0.38
Yellow	0.47	–0.05	–0.56	–0.06	–0.20	0.20	–0.11	–0.23
Amylose content	0.65	0.17	0.44	0.36	–0.10	0.01	–0.07	0.00
Protein	–0.51	0.08	0.00	–0.54	0.31	–0.04	0.21	0.11
Gel consistency	–0.21	–0.34	0.01	0.38	0.34	0.50	0.09	0.00
Alkali spreading value	0.65	0.24	0.47	0.14	0.01	–0.19	–0.03	–0.11
Water absorption	0.33	–0.16	–0.41	0.31	0.62	–0.22	–0.08	0.01
Volume expansion	0.44	0.04	–0.44	0.27	0.55	–0.17	0.01	0.03
Cooking time	0.10	–0.26	–0.25	0.30	–0.36	0.39	0.23	0.53
Glossiness	0.49	0.47	–0.35	–0.25	0.05	0.26	0.11	0.03
Hardness	–0.51	–0.34	–0.31	0.17	0.31	–0.08	–0.35	–0.15
Stickiness	0.56	0.49	–0.20	–0.07	0.11	0.21	0.19	0.13
Latent root	3.92	2.23	1.85	1.61	1.47	1.14	0.90	0.80
Total variance (%)	21.79	12.37	10.29	8.93	8.15	6.31	5.00	4.47
Cumulative variance (%)	21.79	34.15	44.44	53.37	61.52	67.83	72.83	77.30

Based on the magnitude of the variable loading associated with each principal component, the variables of milled rice characteristics can be grouped into eight components, accounting for 77.3% of total variability (Table 7). Generally, loading below 0.50 was disregarded for purposes of interpretation. The interrelationships among variables within components are presented in Figure 2.

- C1, accounting for 21.8% of total variability, was called eating quality dimension because this component had high correlation with eating quality factors such as stickiness and hardness of cooked rice, amylose content, and alkali spreading value. This indicated that amylose content was the major factor in determining eating quality. Similar results have been reported previously (Reycs et al 1965, Juliano 1973, Damardjati 1978, Damardjati et al 1986).
- C2, accounting for 12.4% of total variability, can be thought of as milling quality because variables such as head rice and broken rice recovery and whiteness of milled rice dominated correlation with this component. Broken rice percentage was negatively correlated with head rice yield and positively correlated with whiteness value.
- C3, named physical appearance dimension, explained 10.3% of total variability and showed a negative correlation between milling degree and percentage of yellow rice.
- C4, called nutritional dimension, explained 8.9% of total variability as a single variable. There was no other variable that correlated with protein content as the major nutritional factor in milled rice.



2. Scheme illustrating the effect of principal components on variables. Numbers at the end of lines represent the principal component loadings of variables (n=469).

- C5, named cooking properties dimension, accounted for 6.3% of total variability and showed positive correlation with volume expansion and water absorption ratio during cooking.
- C6, termed grain shape dimension, accounted for 6.3% of total variability and had positive correlation with grain shape, size, and gel consistency.
- C7, called chalky grain dimension, explained 5% of total variability and had positive correlation with percentage of chalky or immature grain.
- C8, named cooking time dimension, explained 4.5% of total variability and showed a negative relationship between cooking time and shape of grain.

Based on this evaluation and the PCA of milled rice characteristics (including physical, chemical, and organoleptic properties), we may determine which physicochemical properties of milled rice were involved in the physical, cooking, and eating quality assessment and their relative importance to Indonesian rice varieties. In the hedonic price analysis, this finding was used as the basis for selecting variables.

The pattern of consumer demand for quality factors

Demand for quality characteristics. The model for hedonic price analysis has been used to obtain information on the pattern of consumer demand for rice quality

Table 8. Regression of price on selected physicochemical characteristics of rice in urban areas, Indonesia, 1987.[a]

Variable[b]	Medan		Ujung Pandang		Jakarta		All cities	
	Coefficient	*t*-statistics[c]	Coefficient	*t*-statistics	Coefficient	*t*-statistics	Coefficient	*t*-statistics
LWHI	–6.796	–0.156	21.193	0.294	457.240	6.001*	67.494	1.912*
LCKY	–29.966	–1.002	9.456	0.470	–18.106	–2.499*	–1.677	–0.308
LMID	270.560	2.618*	–41.373	–0.310	–171.380	–3.355*	–142.610	–3.179*
LHEA	20.036	0.299	88.965	2.049*	116.530	2.982*	100.600	3.654*
LTYLL	–10.483	–0.509	–4.863	–0.250	–58.924	–3.766*	–31.634	–2.802*
LAMY	–8.154	–0.087	–193.870	–1.934*	135.120	2.259*	196.670	4.986*
LALK	1.415	0.148*	13.894	1.135	34.856	2.716*	19.637	2.722
LTPUL	–95.137	–1.480*	–77.636	–1.440	–61.892	–1.414	–133.160	–3.991*
DBRA	81.168	7.145*	118.780	7.528*	34.538	4.581*	70.611	11.518*
Constant	–675.950	–1.011	836.470	1.180	–1333.100	–3.143*	–102.720	–0.359
R^2	0.6282		0.6522		0.4786		0.4134	
R-adj.	0.5874		0.6162		0.4612		0.4019	

[a]Regression equation is in semilog form and the price of rice was used as the independent variable.[b] = significant at the 5% level. [c]LWHI = whiteness, LCKY = chalkiness, LMID = milling degree, LHEA = head rice, LTYLL = yellow and damaged grains, LAMY = amylose content. LALK = alkali spreading value, LTPUL = softness, DBRA = brand name dummy (0 = modern varieties. 1 = traditional varieties).

characteristics in Indonesia. Econometric models were estimated to quantify the effects and the amount of consumers' expenditure for food (Tabor 1988).

Results of the estimation of parameters of each independent variable are presented in Table 8. Generally, most rice characteristics significantly affected price except chalkiness which had a negative but insignificant effect. Varieties had the most dominant effect among all independent variables, and the price of rice in Jakarta was significantly affected by most characteristics except stickiness.

Econometric models of the hedonic price function used in this study explained about 41% of the price variation at the national level. This figure represented a lower coefficient of determination compared with that at the city level. However, the model used in Jakarta was able to explain 48% of the variation which was the lowest compared with figures obtained in Medan (63%) and Ujung Pandang (65%).

Some coefficients had values which were different from the expected—i.e., the milling degree in Jakarta had a negative effect in spite of the expected positive value. Fewer characteristics affected the price of rice in Medan and Ujung Pandang than in Jakarta. In Medan, the analysis of hedonic price showed that only variety, milling degree, alkali spreading value, and stickiness significantly affected price. On the other hand, even fewer Characteristics affected the price of rice in Ujung Pandang—head rice percentage, amylose content, and variety (brand name) had significant effects.

Conclusions

The findings indicate that there are some variations in the consumers' demand for quality. Consumers in Jakarta are relatively more concerned with rice characteristics than are consumers in Medan and Ujung Pandang. Consumers in Jakarta prefer more sticky rice, unlike those in Ujung Pandang who prefer hard-cooked rice. Meanwhile, Medan consumers show preference for intermediate texture.

The pooled sample showed that Indonesian consumers prefer whiter, more polished rice, with more whole grains, fewer yellow or damaged grains, and more amylose. With the exception of amylose content, these characteristics are generally determined by postharvest handling and processing. These results indicate that the Indonesian breeding program has succeeded in developing and adapting MVs to national tastes. Since regional tastes seem to vary with respect to cooking texture, some adjustments in varieties to suit regional tastes must be made to enhance consumer welfare. In general, however, further improvements in quality are more likely to come from reduction of marketing costs than from varietal improvements.

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Rice quality at the retail level

Grain quality characteristics of rice in Philippine retail markets[1]

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Very limited studies have been made on the physicochemical properties of milled rices in the Philippine retail markets. Unnevehr et al (1985a,b) limited their studies to retail markets in Metro Manila, Baguio City, and Calamba, a town 54 km south of Manila. Earlier studies had involved authentic variety samples from various experiment stations (Juliano et al 1964, Merca et al 1979). Market samples of "Wagwag" ana1yzed earlier showed a wide range of properties (Juliano 1972). In 1987-88, milled rice samples with known market label and price were collected from 10 retail markets in the Philippines, so chosen to ensure regional, urban, and rural variation in price. These, together with rice purchased by 150 urban consumers in Manila and 146 rural consumers in Nueva Ecija in the 1987 wet season (WS), were analyzed in detail for physicochemical properties. The physicochemical data of the retail market samples with the same variety name were analyzed and compared with those of authentic variety samples available at the International Rice Research Institute (IRRI) and in the literature (Escureet al 1958, Juliano et al 1964, Merca et al 1979, Juliano and Pascual 1980) (Table 1).

Research methodology

Milled rice samples were obtained from 10 retail markets in the Philippines in the 1987 dry season (DS) (6 Apr-1 May 1987) and 1988 (WS) (25 Jan-28 Feb 1988) in major rice-surplus and -deficit provinces in Luzon, Visayas, and Mindanao (Maranan et al 1989). These 10 markets were chosen to ensure regional, urban, and rural variation in

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Table 1. Milled rice properties important for variety identification.

Property and classification	Value
Amylose content (%)	
Waxy	0 - 5.0
Very low	5.1 - 10.0
Low	10.1 - 20.0
Intermediate	20.1 - 25.0
High	>25.0
Gelatinization temperature[a]	
Low	5.5 - 7.0
Intermediate	3.5 - 5.5
High-intermediate	2.5 - <3.5
Grain length (mm)[b]	
Long	≥ 6.00
Medium	5.00 - 5.99
Short	< 5.00
Length-width ratio[b]	
Slender	> 3.00
Bold	2.00 - 3.00
Round	< 2.00

[a]Classified by alkali spreading value. [b]Classified according to the National Grains Authority Standard Specification for milled rice SQCD-TRSD No. 2:1976 (Philippine Standard).

price and a wide spread of consumer preferences. Three urban centers (Manila, Cebu City, and Davao City) were selected from the rice-deficit provinces. The major rural markets were Cuyapo and Muñoz in Nueva Ecija (Luzon), Passi and Pototan in Iloilo (Visayas), and Kabacan and Midsayap in Cotabato (Mindanao). Milled samples from the 1987 WS survey of 150 urban consumers in Manila and 146 rural consumers in Nueva Ecija (Abansi 1988) were also included.

The rice varieties were analyzed as follows: to determine length-width ratio of 10 grains, a photoenlarger with 10X magnification was used; head rice was analyzed with a Satake testing rice grader TRG 05A with a suitable indented cylinder to remove brokens (<3/4 of whole-grain length) from a 50-g sample; translucency was measured with a Riken-Sanno rice meter (brown rice model); and whiteness was estimated with a Kett Model C-3 whiteness meter and a Minolta Chroma meter model CR-110 on L*a*b* mode with granular material attachment. Grains with >50% chalky area and damaged grains (defined as distinctly discolored or damaged by water, insects, heat, or other means) and impurities were handpicked from a 50-g sample.

Brown rice samples (5 g) were milled in a Kett Pearlest small-scale polisher for 0.5-1 min to obtain milled rice for analysis. Milled rices were analyzed for alkali spreading value (Little et al 1958). Milled rice (5 g) was ground in a Udy cyclone mill with 60-mesh sieve and analyzed for colorimetric apparent amylose content (AC) (Juliano et al 1981) and gel consistency (GC) of 100, 90, and 80 mg flour/2 ml 0.2 N KOH (Cagampang et al 1973). Size and shape of milled rice were classified according to the National Grains Authority Standard Specification for milled rice SQCD-TRSD No. 2: 1976 (PCARRD 1977): long (≥ 6.00 mm), medium (5.00-5.99 mm), and short

(<5.00 mm). Length-width ratio was classified by shape into slender (>3.00), bold (2.00-3.00), and round (<2.00).

Gelatinization temperature (GT) was classified by alkali spreading value into low (5.5-7.0), intermediate (3.5-<5.5), high-intermediate (2.5-<3.5), and high (<2.5) (Little et al 1958). Apparent amylose content (AC) was classified into waxy (0-5.0%), very low (5.1-10.0%), low (10.1-20.0%), intermediate (20.1-25.0%), and high (>25.0%) (Juliano 1985).

Results and discussion

For identification of varieties, grain properties considered important were AC; starch GT; and grain dimensions like length, width, and length-width ratio. A heterogeneous alkali test value for 12 individual grains normally used in the test also indicated mixing of varieties.

The variety labeled C4-63G or simply C4 in Philippine retail markets had high AC and medium GC in both DS and WS; it had low GT in the DS and intermediate GT in the WS (Table 2). An authentic C4-63G variety had intermediate AC (22%), high-intermediate GT, and soft GC. Only a few of the C4 samples exhibited starch properties (AC, GT, and GC) similar to those of an authentic C4-63G. However, a large majority of the samples had long, slender grains identifiable with the grain dimensions of the real C4.

Table 2. Physicochemical properties of C4-636 milled rice samples from selected Philippine retail markets in 1987. IRRI, 1987-88.

Property	Authentic sample[a]	C4-63G[b]	
		DS	WS
Samples (no.)		65	94
Amylose content			
Low		0	0
Intermediate	[22]	13	34
High		52	60
Gelatinization temperature			
Low		50	23
Intermediate		15	66
High-intermediate	[3.1]	0	5
Gel consistency			
Soft	[75]	8	8
Medium		44	49
Hard		13	37
Length			
Long	[6.5]	49	92
Medium		15	2
Short		0	0
Length-width ratio			
Slender	[3.1]	47	72
Bold		18	22

[a]Numbers in brackets are actual values. [b]Numbers represent actual count of market samples possessing the property.

Traditional varieties (TVs) available in the market were Dinorado, Intan, Wagwag, and B-E-3. Dinorado is a prized upland variety with intermediate AC (21%) and intermediate GT but the Dinorado market samples were characterized by a predominance of intermediate AC, low GT, and hard GC (Table 3). The red-pericarped samples had no modern variety (MV) counterpart and the low GT exhibited by the samples may have been the effect of the lower temperature during ripening under upland conditions, since GT and ripening temperature were positively related (Resurreccion et al 1977). Most of the Dinorado samples had the expected medium-length bold grains.

The majority of the Intan market samples had high AC and low GT in the DS (Table 3). However, in the WS, majority had intermediate GT with a corresponding increase in the proportion of intermediate AC relative to high-amylose samples. Samples fitting the grain dimensions of Intan, which were long and slender (Escuro et a1 1958), predominated.

Wagwag is another premium TV with medium-length hold grains (Juliano 1972). Most of the Wagwag market samples had the typically high AC of the true Wagwag variety (Table 3). Most samples also had low GT, particularly in the DS, atypical of the true variety whose GT was intermediate. The market samples were predominantly long-grained and slender, whereas the authentic variety had medium length and bold grains.

The seven B-E-3 samples in the WS had, in general, the expected grain properties of B-E-3 (Escuro et al 1958 Juliano et al 1964), although 5 samples were somewhat longer.

In the market, the IR varieties—IR36, IR42, IR60, and IR64—were more commonly found than the TVs (Table 4,5). Majority showed the expected mean

Table 3. Physicochemical properties of milled rice of traditional Philippine varieties from selected retail markets in 1987. IRRI. 1987-88.[a]

Property	Dinorado		Intan		Wagwag		B-E-3
	DS	WS	DS	WS	DS	WS	WS
Samples (no.)	10	19	12	24	35	84	7
Amylose content							
Low	1	2	0	0	0	0	1
Intermediate	9 (21)	15	3 (22)	11	6	17	5 (21)
High	0	2	9	13	29 (27)	67	1
Gelatinization temperature							
Low	10	12	9	7	29	42	0
Intermediate	0 (4.8)	7	3 (4.6)	15	6 (5.2)	41	7 (5.2)
High-intermediate	0	0	0	2	0	1	0
Length							
Long	1	9	8 (6.4)	24	23	63	5
Medium	7 (5.7)	10	4	0	11 (5.4)	21 (5.9)	2 (5.9)
Short	2	0	0	0	1	0	0
Length-width							
Slender	0	8.0	7 (3.1)	22	28	46.0	2
Bold	10 (2.2)	11.0	5	2	7 (2.6)	38.0	5 (2.6)

[a]Numbers in parentheses are actual values for the property of authentic samples; those not in parentheses represent count of market samples having the property.

properties. IR36 had high AC, intermediate GT, and medium GC while the grains were long and slender (Table 4). IR42 had high AC, low GT (hard GC), and medium-length grains. IR60 also had high AC, low GT, medium GC, and long, slender grains (Table 5). IR64 had intermediate AC, intermediate GT, and long, slender grains. Its GC was divided mainly between medium and hard.

Because MVs predominated in the regions surveyed, it was very likely that they were used to substitute for TVs. A large number of rices sold as C4 in the market were probably IR36, based on their high AC and intermediate GT (Table 2,3). The high-amylose, low-GT samples could be IR60 (Table 5), while the ones with intermediate AC and intermediate GT were probably IR64 or the real C4. Based on grain dimensions, high AC, and low GT, majority of the Intan market samples in the DS were probably IR60 (Table 3,5). In the WS, the intermediate-amylose, intermediate-GT lntan samples were IR64 in all likelihood.

Wagwag and IR42 were considered premium varieties in Luzon because of their medium-length grains. The predominance of long, slender-grained, Wagwag-designated samples was indicative of the possible substitutions of the true Wagwag variety with IR60, IR36, and IR64. This would explain the occurrence of Wagwag market samples with intermediate AC and intermediate GT. Juliano (1972) previously reported variations in grain dimensions and alkali spreading values among Wagwag samples from different markets.

Table 4. Physicochemical properties of IR36 and IR42 milled rice samples from selected Philippine retail markets in 1987. IRRI, 1987-88.[a]

Property	IR36		IR42	
	DS	WS	DS	WS
Samples (no.)	37	59	18	53
Amylose content				
Low	0	0	0	1
Intermediate	5	27	1	5
High	32 (25)	32	17 (26)	47
Gelatinization temperature				
Low	18	13	16 (7)	45
Intermediate	18 (4.4)	46	2	7
High-intermediate	1	0	0	1
Gel consistency				
Soft	3	2	0	3
Medium	11	18	6	3
Hard	23 (34)	39	12 (28)	47
Length				
Long	31 (6.3)	55	4	18
Medium	6	4	14 (5.7)	35
Short	0	0	0	0
Length-width ratio				
Slender	33 (3.2)	45	4	11
Bold	4	14	14 (2.8)	42

[a] Numbers in parentheses are actual values for the property of authentic samples; those not in parentheses represent count of market samples having the property.

Table 5. Physicochemical properties of IR60 and IR64 milled rice samples from selected Philippine retail markets in 1987. IRRI, 1987-88.[a]

Property	IR60		IR64	
	DS	WS	DS	WS
Samples (no.)	22	31	75	163
Amylose content				
Low	0	1	0	2
Intermediate	1	8	57 (22)	146
High	21 (27)	22	18	15
Gelatinization temperature				
Low	22 (7.0)	19	9	9
Intermediate	0	12	60 (4.1)	136
High-intermediate	0	0	6	18
Gel consistency				
Soft	7	3	15 (66)	36
Medium	9 (47)	15	29	64
Hard	6	13	31	63
Length				
Long	14 (6.1)	28	69 (6.6)	162
Medium	8	3	6	1
Short	0	0	0	0
Length-width ratio				
Slender	17 (3.1)	21	70 (3.3)	154
Bold	5	10	5	9

[a]Numbers in parentheses are actual values for the property of authentic samples; those not in parentheses represent count of market samples having the property.

Properties of nonwaxy rices

All the sampled varieties showed similarly wide ranges in headrice yield, translucency, whiteness, and percentage of damaged grains plus foreign matter. Head rice varied from 33 to 98% of milled rice. Damaged grains plus foreign matter was 0-0.66% in all but one sample, with damaged grains contributing more to the value.

Water-damaged rices, locally known as "bahay" in the Visayas, were also sampled from the Iloilo market. A total of 10 water-damaged IR64 sampled in two seasons gave low whiteness values of 27-38%, low translucency values of 41-59%, and as much as 14.2-44% damaged grains. Similarly, water-damaged IR36 and Wagwag showed low whiteness and translucency values.

Dinorado, particularly the red-pericqed selection which obviously cannot be adulterated with nonpigmented rices, had the highest retail price (Table 6). Degree of milling affected price because of its effect on whiteness values. Aged ("laon") rices commanded a higher price than freshly harvested grain although they were darker (more yellow) (Yap et al 1990). Using either a Kett whiteness meter or a Chroma meter (L* values), red Dinorado recorded lower translucency and whiteness values. But it had higher Chroma meter a* values, reflecting traces of the bran's red color. Majority of the market samples tended to have harder GC than laboratory-milled samples of authentic varieties (Table 2,4,5). Gel consistency values of 80- and 90-mg flour samples (rather than of 90- and 100-mg flour samples as normally required) were used

Table 6. Retail price (₱/kg) of nonwaxy rices from selected Philippine markets. IRRI, 1987.88.

Variety	1987 season	Range	Mean
C4	DS	5.30 - 8.50	6.50
	WS	5.50 - 8.50	6.70
Dinorado	DS	7.00 - 11.00	8.90
	WS	7.00 - 12.00	9.90
Intan	DS	5.50 - 7.50	6.30
	WS	5.80 - 7.50	7.10
Wagwag	DS	5.30 - 8.00	6.80
	WS	6.00 - 11.00	7.50
B-E-3	WS	6.00 - 7.20	6.80
IR36	DS	4.60 - 6.50	5.50
	WS	5.50 - 7.50	6.10
IR42	DS	5.50 - 8.00	6.30
	WS	5.80 - 8.50	6.70
IR60	DS	5.80 - 7.50	6.50
	WS	5.80 - 8.00	6.40
IR64	DS	4.00 - 7.50	5.70
	WS	5.50 - 8.00	6.40

in the 1987 DS samples to correct differences in behavior. Factors that contributed to the harder GC of the market samples included undermilling and the age of milled rices (Juliano et al 1980). Those expected to be soft showed medium values; TR36, normally with a medium rating, showed hard values (Table 4).

Among 829 nonwaxy samples, whiteness as measured by a Kett meter and L* value (whiteness) as measured by a Chroma meter were significantly and positively correlated (r = 0.94**); thus, either instrument may be used to measure the whiteness index. The Chroma meter has the added advantage that it can also measure yellowness and redness of samples. Translucency correlated positively with AC (r = 0.74**) and negatively with grain width (r = -0.50**). Chalky portions tend to occur with coarse grains. The positive correlation between translucency and AC may be due in part to traditional pigmented varieties having lower AC and coarse grains (with chalky portions), since translucency correlated positively with Kett whiteness (r = 0.22**) and Chroma meter L* (r = 0.31**).

Major quality factors of waxy rices

Nonpigmented waxy (glutinous) rices are called “Malagkit” in Luzon and Mindanao and “Pilit” in Visayas and Mindanao. Authentic “Malagkit Sungsong” samples with typical short, round grains numbered not more than 1 or 2 (Table 7); they were priced at a high P12-Pl3kg. Waxy rices had mainly low GT. Most of the waxy rices had contaminant translucent grains so that only one sample was classified as true waxy. Thus, the range of AC for waxy rices had to be arbitrarily extended to 0-5% to accommodate more samples. Some samples showed intermediate or high GT and one sample even had a high AC. The long-grained waxy rices were probably modern waxy rices such as IR29, IR65, and UPLRi-1.

The “Tapol” or purple waxy rices were mainly marketed in Davao, Cotabato, and Cebu as brown rice or undermilled rice. Although most samples were also mixed with nonwaxy grains, majority had long, bold grains and high-intermediate GT which was characteristic of Tapol (Table 7).

Other properties of waxy rices

The price of Malagkit, Pilit, and Tapol brown rices varied widely (Table 8). Tapol commanded a higher retail price than Malagkit. Head rice varied from 33 to 95% of

Table 7. Physicochernlcal properties of waxy rices from selected Philippine retail markets in 1987. IRRI, 1987-88.[a]

Property	Malagkit sungsong (authentic)	Malagkit/Pilit		Tapol	
		DS	WS	DS	WS
Samples (no.)		65	45	9	10
Amylose content					
Waxy	2.0	36	18	2 (3)	2
Very low		25	24	6	6
Low		3	3	0	2
Intermediate		0	0	1	0
High		1	0	0	0
Gelatinization temperature					
Low	6.6	62	37	0	0
Intermediate		3	7	2	4
High-intermediate		0	1	7 (3)	6
Gel consistency					
Soft	78	61	41	8 (94)	8
Medium		3	4	0	1
Hard		1	0	1	1
Length					
Long		27	35	6 (6.6)	9
Medium		36	10	3	1
Short	4.6	2	0	0	0
Length-width ratio					
Slender		11	2	0	2
Bold		53	40	9 (3)	8
Round	1.7	1	3	0	0

[a]Numbers in parentheses are actual values for the property of authentic samples; those not in parentheses represent count of market samples having the property.

Table 8. Retail price (₱/kg) of waxy rices from selected Philippine markets. IRRI, 1987-88.

Variety	1987 season	Range	Mean
Malagkit/Pilit	DS	5.00 - 14.00	8.90
	WS	6.00 - 15.00	9.70
Tapol			
Brown rice	DS	5.00 - 26.00	16.90
	WS	9.00 - 28.00	16.60
Milled rice	WS	14.00 - 16.00	14.80

milled rice. Translucency was lower in waxy rices, except for one mislabeled sample. Whiteness values were also relatively higher in waxy rices, except for two undermilled samples in the WS. Percentage of damaged grains also varied. The GC of waxy rice was mainly soft. Tapol samples had lower translucency and whiteness index values than Malagkit or Pilit due to their opaque purple pericarps. As with nonwaxy samples, Kett whiteness values correlated positively with Chroma meter L* values (r = 0.98**, n = 113) among waxy rices.

Gel consistency and AC were negatively correlated (r = -0.52**). Alkali spreading value correlated with Chroma meter L* value (r = 0.55**) and Kett whiteness (r = 0.39**) because of the association of lower alkali values with Tapol samples.

Summary and conclusion

The quality characteristics of 829 nonglutinous and 129 glutinous rice market samples collected in the 1987 DS and WS are determined and the data are analyzed in detail. The study clearly demonstrates the heterogeneity in grain dimensions and starch properties of retail rices with the same market label. Those labeled as TVs are mostly modern rices whose grain properties, especially dimensions are similar to those of the authentic TVs. However, Malagkit Sungsong, a short, round glutinous rice and the red-pericarped Dinorado could not be substituted for MVs.

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Quality preferences for modern and traditional rice at the retail level: the Philippine case[1]

C.L. Maranan, B. Duff, and B.O. Juliana[2]

If preferences of consumers were known, plant breeders, postharvest technologists, social scientists, and policymakers could more effectively set their research and development priorities. Hence, this study of Philippine retail markets was designed to identify quality preferences at the retail level and to estimate the implicit prices for these characteristics using market price as a measure of average consumer preferences subject to budget constraints. This report addresses the following specific issues:

1) For which characteristics of modern (MVs) and traditional milled rice varieties (TVs) would consumers pay more (or less)?
2) How much would they pay for these characteristics?

Research methodology

The model

To estimate implicit prices for rice quality, the consumer goods characteristics model (CGCM), conceptualized by Lancaster in 1966 and developed by Ladd and Suvannunt in 1976, was used. Product demand is a measure of the utility provided by the goods which is a function of the characteristics of the product (see Unnevehr 1992). If the characteristics that define grain quality can be measured, the implicit value of these characteristics can be estimated. An ordinary least-square regression of price or measures of quality provides such estimates. The estimating equation is:

$$P_r = X_{rj} b_{rj} + u$$

where P_r is the price of rice, X_{rj} is the quantity of characteristics j, b_{rj} are parameter estimates, and u is an error term.

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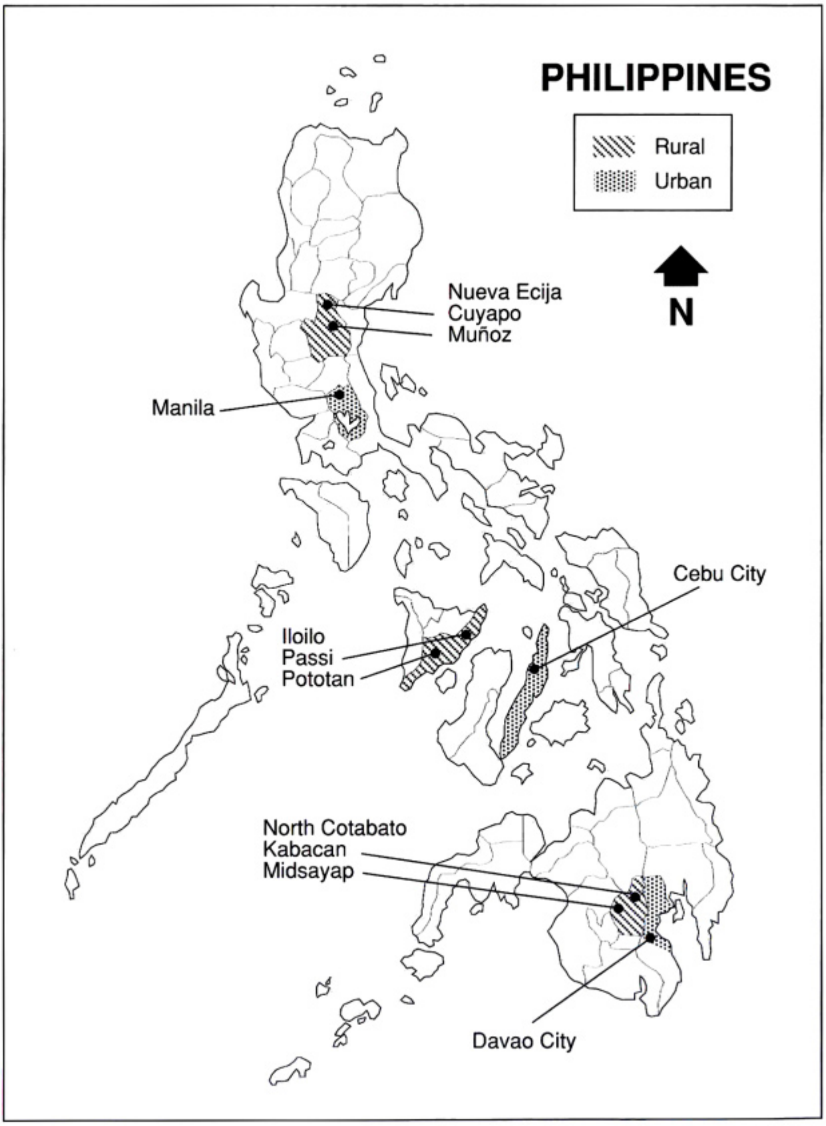
The dependent variable, P_r, will vary for different grades of rice. The independent variables, X_{rj}s, should explain the variance in the price of rice. The parameter estimates, b_{rj}s, give the implicit or hedonic prices of the characteristics.

Study areas

The study was conducted in selected major rice-surplus and -deficit provinces located in three regions (Fig. 1). These were identified using the 5-yr average surplus-deficit



1. Survey sites of the retail-level rice grain quality study.

data of the Bureau of Agricultural Economics and were chosen to ensure regional, urban, and rural variation in prices. A wide spread of consumer preferences was captured in the sample.

The three urban centers selected from the deficit provinces were Manila, Cebu City, and Davao City; two retail markets in Manila were included due to the area's large number of major markets and high population. Rural markets included Cuyapo and Muñoz in Nueva Ecija (Luzon), Passi and Pototan in Iloilo (Visayas), and Kabacan and Midsayap in Cotabato (Mindanao).

Data collection and sampling procedures

The lists of retailers obtained from the National Food Authority offices in each province were used to draw sample respondents from each of the selected retail markets. Those who could not be interviewed were substituted.

The surveys were conducted in two rounds: Round 1 was done for the 1987 dry season (DS) harvest and Round 2 covered January-March 1988 (1987-88 wet season [WS] harvest). One-kilogram milled rice samples were obtained for each grade and type of rice sold in the public markets covered. Analysis of grain samples was supplemented with interviews of retailers to provide relevant background information.

Samples were analyzed for physical and chemical characteristics at the IRRI Cereal Chemistry Department. (Appendix 2a lists the laboratory procedures used. Table 1 illustrates the expected relationships between price and characteristics and Table 2 gives the measurement range for each characteristic.) Physical attributes included percent head rice, grain length, shape, whiteness, translucency, and foreign matter and/or damaged grains. Whiteness index was measured using a Kett whiteness meter. Grain size (or length) was classified as follows: extra long (>7.50 mm), long (6.61-7.50 mm), medium (5.51-6.60 mm), and short (≤ 5.50 mm). Shape and grain size preferences varied across countries and regions.

Table 1. Characteristics of milled rice and their expected relationship with price (Unnevehr et al 1985).

Characteristic	Measure	Expected relationship with price
Physical characteristic		
Whiteness	% of pure white	+
Chroma meter L		+
Head rice	% of unbroken grain	+
Shape	Length/width	+
Length	mm	–
Translucency	% not chalky	+
Foreign matter/damaged grains	% of sample	–
Chemical characteristic		
Apparent amylose content	% of milled rice	–
Gel consistency	mm	+
Alkali spreading value		–
+ (glutinous)		

Table 2. Physicochemical characteristics and price of milled rice sample, by variety group, Philippines, 1987-88.[a]

Characteristic	Variety group	
	Modern	"Traditional"
Samples (no.)	618	94
Price (₱/kg)		
Mean	6.44 b	7.43 a
Range	4.00 - 8.50	5.00 - 12.00
Head rice (%)		
Mean	69.73 b	72.70 a
Range	20.00 - 98.70	53.00 - 89.00
Foreign matter/damaged grains (%)		
Mean	2.81 a	1.76 a
Range	0.0 - 34.48	0.10 - 11.60
Length (mm)		
Mean	6.31a	5.90 b
Range	4.49 - 7.26	4.82 - 6.85
Shape (L/W)		
Mean	3.08 a	2.74 b
Range	1.67 - 3.54	1.92 - 3.41
Translucency (%)		
Mean	68.54 a	57.13 b
Range	12.00 - 100.00	11.00 - 100.00
Whiteness index (%)		
Mean	39.39 a	34.29 b
Range	9.30 - 51.50	13.70 - 46.80
Alkali spreading value		
Mean	5.44 a	5.63 a
Range	3.00 - 7.00	3.50 - 7.00
Apparent amylose content (%)		
Mean	24.98 a	24.31 b
Range	14.80 - 29.20	17.90 - 28.20
Gel consistency, 90 mg (mm)		
Mean	37.85 a	35.61 a
Range	26.00 - 95.00	26.00 - 65.00

[a]Means followed by the same letter are not significantly different at the 5% level by DMRT.

In the international market, the demand for long-grained rice is strong, while in Southeast Asia, the demand is for medium to medium-long rices (Khush et al 1979, Unnevehr et al 1985). Greater quantities of impurities reduce the price of milled rice. Head rice content, whiteness, and translucency are positively related to price—i.e., whiter, more translucent milled rice grains and higher head rice content are expected to command higher prices. Shape and grain size as well as translucency are varietal characteristics but are also affected by postproduction management. Whiteness, head rice content, and foreign matter/damaged grains are likewise affected by cultivation practices and postproduction handling and technology.

Chemical characteristics—which include apparent amylose content (AC), alkali spreading value, and gel consistency (GC)—affect cooking and eating qualities of rice. Apparent amylose content is considered the most important chemical characteristic. It determines the texture of cooked rice and also directly affects water absorption and volume expansion during cooking (Juliano 1979). Within the same amylose group, varieties with softer GC are preferred. Most TVs have intermediate AC, cook moist and tender, and do not harden upon cooling. However, many MVs (except IR64) have high AC which causes hardening following cooking. A soft texture is usually preferred; hence, price varies inversely with AC.

Gel consistency, similar to apparent AC, is another measure of texture. Varieties having the same AC may be tested for differences in tenderness using the GC test (Cagampang et al 1973). Gel consistency is expected to vary positively with price. Gelatinization temperature (GT), a physical property of starch, is defined as the range of temperature within which the starch granules begin to swell irreversibly in hot water (Khush et al 1979). It determines cooking time and is measured by the alkali spreading value. A low alkali spreading value (2-3) indicates a high GT (>74 °C), implying longercooking time; a high value (6-7) indicates low GT (<70 °C) and shorter cooking time; and a medium value (4-5) means an intermediate GT (70-74 °C). Among high-amylose rices (mostly MVs), those with intermediate GT have softer cooked rice than those with low GT. The same holds true for intermediate-amylose rices. However, among glutinous rices, low GT is normally preferred over high GT. Hence, for MVs, a negative relationship between alkali spreading value and price is expected—i.e., the higher the alkali spreading value, the lower the price. For glutinous varieties, the relationship should be positive.

Results and discussion

Physicochemical characteristics and price of modern and traditional milled rice

The samples consisted of 618 MVs and 94 varieties with “traditional” names; the latter are actually MVs with some characteristics similar to those of TVs. Table 2 compares the price and physicochemical characteristics of MVs and “traditional” varieties. The mean price of TVs (₱7.43/kg) was significantly higher than that of MVs (₱6.44/kg). The price of TVs ranged from ₱ 5.00 to ₱ 12.00/kg; for MVs, the range was ₱ 4.00-₱ 8.50/kg. Traditional varieties included the lower priced ordinary type with inferior eating quality. The special aromatic types with good eating quality were more expensive.

With regard to physical characteristics, MVs had a significantly lower mean head rice content at 69.7% compared with the TVs’ 72.7%. Extreme values of head rice content were found in the MV samples—i.e., from a very low 20 to a very high 98.7%. Meanwhile, head rice content in TVs ranged from 53 to 89%. Modern varieties contained a wider range of impurities (0-34.5%) than TVs (0.10-11.6%). Modern varieties had significantly longer grains (6.31 mm) than the TVs (5.90 mm), but both belonged to the medium-length category. The samples from both groups included short to long grains. While the mean grain shape of MVs was slender and that of the TVs was medium, both included samples which were bold/round (only 1% each) and slender. Modern varieties had significantly more translucent (68.5%) and whiter grains (39.4%) than TVs (mean translucency, 57.1%; whiteness index, 34.3%). The ranges in translucency did not vary much between the two groups. With whiteness though, MVs had a wider range of values than the TVs. This characteristic is affected by milling degree, by grain discoloration caused by postharvest environments, and by varietal characteristics (especially in terms of grain color). (Some traditional grains are nonwhite.)

As for chemical characteristics, MVs had a medium alkali spreading value (5.44), while the TVs had a high value (5.63), implying that MVs are faster cooking than TVs. The samples from both variety groups gave alkali spreading values that ranged from low to high. The mean apparent AC of MVs (24.98%) fell within the intermediate category and was significantly higher than that of MVs (24.31%) although the samples from both groups had low to high values. The average GC of MVs (37.85 mm) did not significantly differ from that of TVs (35.61 mm), with both values falling within the hard-texture category. Both groups, however, had samples with soft, medium, and hard GC.

Implicit prices of milled rice characteristics at the retail level

Tables 3 and 4 present the results of the hedonic price estimates for the DS and WS samples. Separate estimates were made for MVs and for those labeled "traditional." In addition to the quality characteristics previously discussed, the regressions included a dummy variable, age, which indicated whether the rice has been stored from a previous season; and location dummies for the eight survey sites outside Manila. Aged ("laon") rice is preferred because it has greater volume expansion during cooking.

The results for the pooled samples are similar for the two seasons, with few exceptions. In the DS samples, head rice content, length, foreign matter/damaged grains, alkali spreading value, AC, GC, and age were all significantly related to price, as expected. There were similar results in the WS for length, damaged grains, AC, and age, further confirming the importance of these variables. Other WS results differed, however. Head rice was not significant although translucency was, and whiteness had a significant negative coefficient.

The unexpected findings regarding whiteness were attributed to the presence of several samples of a traditional, red-pericarped upland variety (Dinorado). This rice

Table 3. Estimates of implicit prices of quality characteristics, 1987 DS.[a]

	Modern[b]	"Traditional"	Pooled
Head rice	0.01**	0.01	0.01**
Whiteness	0.02*	–0.02	–0.02
Translucency	0.00	0.00	0.00
Length	–0.10	–0.78	–0.39**
Foreign matter/damaged grains	–0.03*	–0.07	–0.07**
Alkali spreading value	–0.04	0.54	0.12*
Amylose	0.04	–0.34**	–0.10**
Gel consistency	0.00	0.05	0.01**
Age	0.18**	0.40	0.21**
Adjusted R^2	0.66	0.37	0.57
n	303	47	352

[a] Eight location dummies were included and seven were significant. They are not reported due to space limitations.
[b] * = significant at the 10% level, ** = significant at the 1% level.

Table 4. Estimates of implicit prices of quality characteristics, 1987-88 WS.[a]

	Modern[b]	"Traditional"	Pooled
Head rice	0.00	–0.02	0.00
Whiteness	0.02*	–0.10**	0.03**
Translucency	0.01**	0.07**	0.01**
Length	–0.27**	–2.56**	–0.75**
Foreign matter/damaged grains	–0.02**	–5.03*	–0.04**
Alkali spreading value	0.00	–0.15	0.07
Amylose	–0.04*	–0.19*	–0.17**
Gel consistency	0.00	0.01	0.00
Age	0.33**	0.95*	0.32**
Adjusted R^2	0.57	0.52	0.57
n	310	45	356

[a]Eight location dummies were included in the regression and six were significant. They are not reported due to space limitations. [b]* = significant at the 10% level, ** = significant at the 1% level.

has a distinctive pink color after milling. Because this variety has many preferred taste characteristics and a low whiteness rating, the influence of whiteness in this set of samples was obscured.

A comparison of these pooled results with those for modern and "traditional" rices reveals what these variety labels mean to consumers. In the DS samples, consumers paid higher prices for MVs which were aged and with better physical quality (more head rice, greater whiteness, and less foreign matter). For "traditional" rices, only AC was significant. Thus, when purchasing MVs, consumers look for physical quality. When buying "traditional" varieties, they pay for better cooking quality.

In the WS samples, preferences for MVs and TVs did not differ much, except for whiteness. The negative sign in the TV regression reflects the presence of pink upland rices previously mentioned. The significant positive coefficient for whiteness in the MV regression confirms the importance of this characteristic.

In general, the pooled results agree with those from the consumer survey reported in Abansi et al (1992). They confirm that Filipino consumers prefer more whiteness, shorter grains, less foreign matter, less damaged grains, and lower AC. The strong preference for aged rice confirms the importance of volume expansion, which was also identified in the same consumer survey.

Conclusions

This chapter presents an analysis of samples collected from 10 retail markets during two seasons. Significant differences in several quality characteristics were observed among rices given MV names and those labeled with traditional names. The latter tended to have the preferred cooking quality and shape characteristics. Thus the "traditional" variety label indicates that these varieties have some traditionally desirable characteristics. This was further confirmed by a comparison of hedonic prices for MVs and TVs. Consumers selected MVs on the basis of physical quality, and they chose so-called TVs on the basis of cooking quality.

Estimates of hedonic prices from the two seasons showed some differences and many similarities. The differences are partly due to the presence of a unique upland variety in the WS samples. Consumers reveal a preference for more whiteness, shorter grains, fewer damaged grains/foreign matter, less AC, and greater volume expansion during cooking.

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Rice grain characteristics affecting retail price in Thailand[1]

J. Sriswasdilek, N. Kongseree, and K. Attaviriyasook[2]

Rice has long been the most important crop in Thailand, occupying more than 57% of agricultural land in 1986-87 (OAE 1988). Thailand produces rice not only for domestic consumption but also for export. In 1977-81, the volume of annual export was 1.6-3.0 million t with a value of about 10-26 billion baht. About 3.5-4.6 million t valued at approximately 20-26 billion baht were exported annually from 1982 to 1987.

In Thailand, two main groups of rice—nonglutinuous and glutinous—are consumed domestically, the choice depending on ethnic and regional preferences. The main objectives of this study are to: 1) describe characteristics of rice grain in retail markets, and 2) estimate how and how much each grain characteristic affects the retail price.

Research methodology

The three major rice-consuming provinces—Bangkok, Chiang Mai, and Khon Kaen (Fig. 1)—were selected for two rounds of rice sampling and price collection. The first round collection (Round 1)—with sample sizes of 109 nonglutinous (nonwaxy) rice from Bangkok, 131 nonglutinous and 111 glutinous (waxy) rice from Chiang Mai, and 124 nonglutinous and 125 glutinous rice from Khon Kaen—was done from 27 Sep to 19 Oct 1987. The second round collection (Round 2) was conducted from 19 Mar to 17 Apr 1988 with sample sizes of 115 nonglutinous rice from Bangkok, 140 nonglutinous and 120 glutinous rice from Chiang Mai, and 157 nonglutinous and 107 glutinous rice from Khon Kaen. Each province was divided into two areas, urban and rural. Rice samples were randomly collected from different retailers including supermarkets, grocery stores, and retail market terminals. Table 1 summarizes the sample sizes classified by location, round of collection, and type of rice.

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1. Survey sites of the grain quality study, Thailand.

Table 1. Sample sizes classified by location, round of collection, and type of rice.

Location	Round 2		Round 2	
	Nonglutinous rice	Glutinous rice	Nonglutinous rice	Glutinous rice
Bangkok				
Urban	54	–	52	–
Rural	55	–	63	–
Chiang Mai				
Urban	79	54	83	60
Rural	52	57	57	60
Khon Kaen				
Urban	63	57	85	55
Rural	61	68	72	52
Total	364	236	412	227

The rice samples were then analyzed for physical and chemical characteristics (see Appendix 2a). The quality characteristics considered for glutinous rice were broken grains, length, defective grains, other rice, apparent amylose content, alkali spreading value, and moisture content. Except for moisture content, the same quality characteristics were analyzed in nonglutinous rice in addition to whiteness, chalkiness, elongation ratio, and aroma.

The mean, standard deviation, and range were computed for each characteristic. To estimate the implicit values of quality characteristics, a model of consumer demand for goods characteristics developed by Ladd and Suvannunt (1976) was employed (see Unnevehr 1992). For this study, the model used was:

$$P = a + b_1Q_1 + b_2Q_2 + ... + b_nQ_n + u$$

where P = price of rough rice/milled rice; a = constant; b_is = parameter estimates, i = 1,2, ... n; Q_i s = specific rough rice/milled rice characteristic, i = 1,2, ... n; and u = random error.

Results and discussion

Characteristics of milled rice and rough rice grains

Tables 2 and 3 summarize the means of characteristics of milled nonglutinous and glutinous rice.

Nonglutinous rice

Round 1. Among the three locations, the price of rice from Round 1 samples was highest in Chiang Mai (8.44 baht/kg) and lowest in Khon Kaen (7.39 baht/kg). The average price for the three locations was 7.89 baht/kg while the price range was widest in Bangkok—from 5.50 to 12.50 baht/kg. Whiteness, length, defective grains, alkali spreading value, and elongation ratio did not vary much; the averages were 45.95%, 7.27 mm, 0.58% 6.41, and 1.75, respectively. However, percentages of broken grains, chalkiness, other rice (glutinous rice), and amylose content varied considerably. Broken grains had the highest mean (17.87%) in Khon Kaen and the lowest (14.44%) in Chiang Mai. The mean of chalkiness was highest in Bangkok and lowest in Chiang Mai—12.99 and 8.68%, respectively. The percentages of glutinous rice were 0.97 in Khon Kaen and 0.19 in Bangkok and the means of apparent amylose content were approximately 24% in Khon Kaen and 21% in Chiang Mai.

Within Bangkok, aromatic rice which had lower means of broken grains, chalkiness, and apparent amylose content but higher mean of elongation ratio was more expensive than nonaromatic rice. However, other characteristics (whiteness, length, defective grains, percentage of glutinous rice, and alkali spreading value) of these two groups of rice were similar.

Between packed and unpacked rice in Bangkok, the former commanded a higher price despite a higher percentage of broken grains. It would appear that the packaging itself contributed to this higher price since there was not much difference in other characteristics.

In Chiang Mai, aromatic rice and packed rice expectedly commanded higher prices than nonaromatic rice and unpacked rice. The lower percentages of broken

Table 2. Means of characteristics of milled nonglutinous rice, 1987-88, Thailand.[a]

Characteristic	Round 1			Round 2			Pooled	
	Bangkok	Chiang Mai	Khon Kaen	Bangkok	Chiang Mai	Khon Kaen	Round1	Round2
Price (baht, kg)	7.80 (1.08)	8.44 (1.23)	7.39 (0.72)	9.11 (0.76)	9.68 (1.08)	8.93 (0.58)	7.89 (2.12)	9.23 (0.89)
Whiteness (%)	46.24 (3.79)	45.65 (2.74)	46.00 (2.52)	46.66 (2.12)	46.85 (2.33)	47.58 (2.46)	45.95 (3.03)	47.07 (2.36)
Broken grains (%)	15.87 (12.21)	14.44 (11.90)	17.87 (13.49)	13.50 (8.71)	17.39 (10.10)	14.97 (5.92)	16.04 (12.62)	15.38 (8.44)
Length (mm)	7.35 (0.21)	7.33 (0.16)	7.13 (0.27)	7.34 (0.09)	7.34 (0.16)	7.18 (0.20)	7.27 (0.24)	7.28 (0.18)
Chalkiness (%)	12.99 (8.40)	8.68 (9.40)	9.12 (7.71)	9.24 (7.78)	6.31 (7.86)	9.06 (9.97)	10.11 (8.74)	8.18 (8.79)
Defective grains (%)	0.62 (1.51)	0.60 (0.95)	0.51 (0.82)	1.14 (3.15)	0.71 (1.73)	0.26 (0.31)	0.58 (1.11)	0.66 (1.98)
Glutinous (other) rice (%)	0.19 (0.23)	0.47 (0.78)	0.97 (1.41)	0.30 (0.45)	0.52 (0.57)	1.12 (2.53)	0.56 (1.00)	0.69 (1.65)
Apparent amylose content (%)	23.54 (3.98)	20.87 (5.27)	24.32 (5.10)	22.07 (3.81)	18.48 (4.55)	21.33 (4.76)	22.84 (5.08)	20.57 (4.69)
Alkali spreading value	6.25 (0.57)	6.57 (0.78)	6.37 (0.61)	6.47 (0.49)	6.81 (0.33)	6.59 (0.43)	6.41 (0.68)	6.63 (0.44)
Elongation ratio	1.77 (0.14)	1.79 (0.17)	1.70 (0.13)	1.74 (0.12)	1.82 (0.13)	1.80 (0.12)	1.75 (0.15)	1.79 (0.12)

[a]Figures in parentheses are standard deviations.

Table 3. Means of characteristics of milled glutinous rice, 1987-88, Thailand.[a]

Characteristic	Round 1		Round 2		Pooled	
	Chiang Mai	Khon Kaen	Chiang Mai	Khon Kaen	Round 1	Round 2
Price (baht/kg)	6.54 (0.88)	6.28 (0.64)	6.61 (0.91)	6.78 (0.50)	6.40 (0.77)	6.69 (0.75)
Broken grains (%)	18.38 (9.47)	18.53 (9.78)	27.73 (13.05)	29.32 (11.48)	18.46 (9.62)	28.48 (12.34)
Moisture (%)	14.21 (0.67)	14.36 (1.05)	11.99 (0.64)	11.88 (0.45)	14.29 (0.89)	11.94 (0.56)
Length (mm)	7.12 (0.21)	6.97 (0.18)	7.09 (0.42)	6.90 (0.15)	7.04 (0.21)	7.00 (0.33)
Defective grains (%)	0.97 (1.75)	0.74 (1.46)	0.52 (0.77)	0.39 (0.54)	0.85 (1.60)	0.46 (0.68)
Nonglutinous (%)	3.84 (5.10)	4.92 (2.73)	4.80 (2.41)	5.67 (2.21)	4.42 (4.05)	5.21 (2.35)
Apparent amylose content (%)	3.44 (0.95)	4.57 (1.03)	3.81 (0.92)	5.32 (0.90)	4.04 (1.14)	4.52 (1.18)
Alkali spreading value	6.86 (0.24)	6.81 (0.25)	6.80 (0.23)	6.82 (0.18)	6.84 (0.25)	6.81 (0.21)

[a]Figures in parentheses are standard deviations.

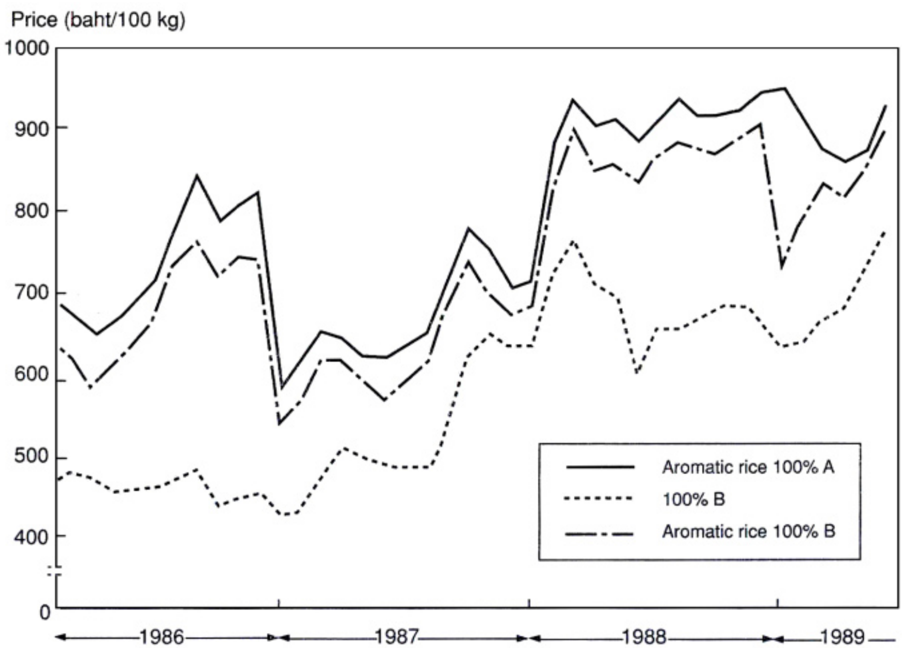
grains, chalkiness, and apparent amylose content in both aromatic and packed rice could have affected the higher price.

In Khon Kaen, aromatic rice received a slightly higher price than nonaromatic rice while there was almost no price difference between packed and unpacked rice. In contrast to nonaromatic rice, aromatic rice had lower percentages of chalkiness and apparent amylose content. Packed rice, on the other hand, had a lower percentage of broken grains than unpacked rice.

When the three locations were evaluated, it was apparent that aromatic rice received a considerably higher price than nonaromatic rice; meanwhile, the price of packed rice was marginally higher than that of unpacked rice. Aromatic rice had much lower percentages of broken grains, chalkiness, and apparent amylose content. The characteristics of packed and unpacked rice were similar.

Round 2. The price of nonglutinous rice during the second-round survey was higher than that during the first-round survey in all three locations. The price trends presented in Figure 2 supported this finding. Among the three locations, the price of nonglutinous rice was again highest in Chiang Mai (9.68 baht/kg) and lowest in Khon Kaen (8.93 baht/kg). The price in the three locations averaged 9.23 baht/kg. The widest price range was reported in Chiang Mai—6.00- 11.64 baht/kg.

Whiteness, length, alkali spreading value, and elongation ratio did not vary much among the three locations. Their averages were 47.07%, 7.28 mm, 6.63, and 1.79, respectively. Percentages of broken grains, chalkiness, defective grains, glutinous rice, and apparent amylose content varied considerably. Broken grains had the highest mean



2. Price of milled nonglutinous rice in Bangkok retail market (Jan 1986-May 1989).

in Chiang Mai (17.39%) and the lowest in Bangkok (13.50%). The mean of chalkiness was highest in Bangkok (9.24%) and lowest in Chiang Mai (6.31%). The percentages of defective grains were 1.14 in Bangkok and 0.26 in Khon Kaen, while percentages of glutinous rice were lowest in Bangkok (0.30%) and highest in Khon Kaen (1.12%). The means of apparent amylose content were approximately 22% in Bangkok and 18% in Khon Kaen.

As expected, aromatic rice and packed rice in Bangkok received higher prices than nonaromatic rice and unpacked rice, respectively. The lower percentages of chalkiness, defective grains, and apparent amylose content could have caused the price difference between aromatic and nonaromatic rice. Packed rice had a lower percentage of defective grains but a higher percentage of broken grains than unpacked rice.

In Chiang Mai, there was almost no difference in price between aromatic and nonaromatic rice but packed rice received a slightly higher price than unpacked rice. In comparison with nonaromatic rice, aromatic rice had lower percentages of chalkiness and apparent amylose content but a higher percentage of broken grains. Packed rice had lower percentages of broken grains, chalkiness, defective grains, and amylose content than unpacked rice.

In Khon Kaen, aromatic rice with lower means of chalkiness and amylose content received a slightly lower price than nonaromatic rice. This contradiction was difficult to explain since other characteristics including whiteness, broken grains, length, defective grains, percentage of glutinous (other) rice, alkali spreading value, and elongation ratio were similar for the two groups of rice. Packed rice and unpacked rice in Khon Kaen had almost the same price. Packed rice had a lower percentage of chalkiness but its other characteristics were similar to those of unpacked rice.

Looking at all three locations together, it was found that aromatic rice received a slightly lower price than nonaromatic rice while packed rice received a higher price than unpacked rice. These results from Round 2 may reflect the age of the aromatic rices since much aroma is lost after storage. Aromatic rice had lower percentages of chalkiness, defective grains, and amylose content than nonaromatic rice whereas packed rice had lower percentages of defective grains and other (glutinous) rice than unpacked rice.

Glutinous rice

Round 1. The price of rice in Chiang Mai was higher (6.54 baht/kg) than that in Khon Kaen (6.28 baht/kg), while a wider price range (4.50-9.54 baht/kg) was observed in Chiang Mai. All characteristics studied including broken grains, moisture content, length, defective grains, other (nonglutinous) rice, amylose content, and alkali spreading value did not vary much between the two locations. These characteristics averaged 18.46%, 14.29%, 7.04 mm, 0.85%, 4.42% 4.04%, and 6.84, respectively.

In Chiang Mai, packed rice which had lower percentages of broken and defective grains received a much higher price than unpacked rice (8.00 vs 6.46 baht/kg). In Khon Kaen, packed rice which had a lower percentage of defective grains received a slightly higher price (6.53 baht/kg) than unpacked rice (6.27 baht/kg). The two rice groups had similar broken grains, moisture content, length, other (nonglutinous) rice, amylose content, and alkali spreading value.

When samples from the two locations were considered together, it was found that packed rice was more expensive than unpacked rice (7.27 vs 6.36 baht/kg). This could be attributed to lower percentages of broken and defective grains in packed rice—14% broken and 0.45% defective grains were found in packed rice as against 19 and 0.87% in unpacked rice.

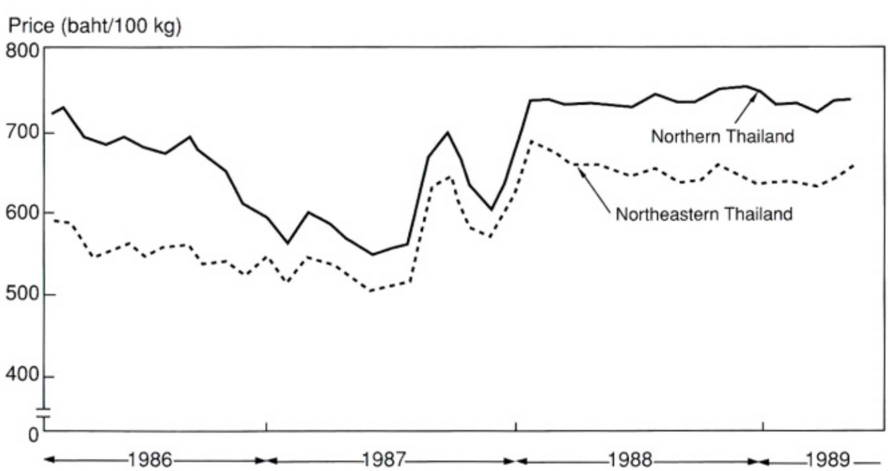
Round 2. Similar to nonglutinous rice, the price of glutinous rice during Round 2 was higher than that during the first-round survey. On the average, prices were 6.40 and 6.69 baht/kg for the first- and second-round surveys, respectively (Fig. 3).

The price of milled glutinous rice in Khon Kaen (6.78 baht/kg) was a little higher than that in Chiang Mai (6.61 baht/kg) where a wider price range was also observed (4.00-8.81 baht/kg). All characteristics including broken grains, moisture content, length, defective grains, other (nonglutinous) rice, amylose content, and alkali spreading value did not vary much between the two locations, averaging 28.48%, 11.94%, 7.00 mm, 0.46%, 5.21%, 4.52% and 6.81, respectively.

In Chiang Mai, packed rice was considerably more expensive than unpacked rice (7.80 vs 6.59 baht/kg) even though all characteristics other than broken grains percentage were similar. The percentage of broken grains was 14.38% in packed rice as opposed to 27.96% in unpacked rice.

Packed rice in Khon Kaen was slightly less expensive (6.40 baht/kg) than unpacked rice (6.79 baht/kg). The percentage of nonglutinous rice was observed to be higher in packed rice while the other characteristics were similar for the two rice groups.

Combining all samples from the two locations, it was found that packed rice commanded 7.33 baht/kg as against 6.68 baht/kg for unpacked rice. While the percentage of broken grains in packed rice was 18.67% as compared with 28.61% in unpacked rice, all other characteristics were similar.



3. Price of milled glutinous rice in retail markets of northern and northeastern Thailand (Jan 1986-May 1989).

Quality characteristics affecting price

Tables 4 and 5 present the regression of price on characteristics of nonglutinous and glutinous rice.

Nonglutinous rice

Round 1. Whiteness, chalkiness, and defective grains had low negative effects while aroma and packing had positive effects on price in Bangkok. Since aroma and packing were dummy variables found to significantly affect price, regression analyses were separately run for aromatic rice, nonaromatic rice, packed rice, and unpacked rice. The result for aromatic rice was different from that for nonaromatic rice. Chalkiness and defective grains reduced the price of aromatic rice while whiteness and broken grains reduced the price of nonaromatic rice. While the price of packed rice was reduced by whiteness and increased by aroma, that of unpacked rice was affected by more factors—alkali spreading value and aroma had positive effects on price while broken grains, chalkiness, and defective grains had negative effects. Packing increased price for both groups of rice in Bangkok only.

Table 4. Regression of price on nonglutinous rice graln characteristics, 1987-88, Thailand.[a]

Characteristic	Round 1[b]			Round 2			Pooled	
	Bangkok	Chiang Mai	Khon Kaen	Bangkok	Chiang Mai	Khon Kaen	Round 1	Round 2
Constant	9.49	14.11	4.27	12.74	6.20	6.46	6.40	2.46
Whiteness (%)	–0.07**	–0.03	0.06*	0.05	–0.05	0.00	–0.03	0.01
	(–4.27)	(–0.64)	(2.13)	(1.43)	(–1.16)	(0.07)	(–1.59)	(0.38)
Broken grains (%)	–0.01	–0.02**	–0.01	–0.03**	–0.03**	–0.01	–0.01**	–0.01**
	(–1.91)	(–2.68)	(–1.52)	(–3.46)	(–3.10)	(–1.11)	(–3.61)	(–3.16)
Length (mm)	0.26	–0.46	0.15	–0.48	–0.12	0.55*	0.46*	0.73**
	(0.85)	(–0.82)	(0.62)	(–0.63)	(–0.22)	(2.40)	(2.43)	(3.17)
Chalkiness (%)	–0.03*	–0.01	–0.03*	–0.05**	–0.02	–0.01*	–0.02**	–0.02**
	(–2.41)	(–1.06)	(–2.36)	(–4.17)	(–0.98)	(–2.22)	(–2.66)	(–2.77)
Defective grains (%)	–0.21**	0.00	–0.07	–0.01	–0.13**	–0.16	–0.14**	–0.05*
	(–4.80)	(0.00)	(–0.79)	(–0.56)	(–2.75)	(–1.10)	(–3.47)	(–2.45)
Glutinous (other) rice (%)	–0.04	–0.18	0.05	–0.21	–0.33*	0.01	–0.07	–0.02
	(–0.16)	(–1.78)	(1.07)	(–1.66)	(–2.37)	(0.38)	(–1.54)	(–0.65)
Apparent amylose content (%)	–0.04	–0.06*	–0.02	–0.04	0.01	–0.04**	–0.07**	–0.04**
	(–1.32)	(–2.40)	(–0.93)	(–1.37)	(0.48)	(–3.10)	(–4.71)	(–3.17)
Alkali spreading value	0.13	0.14	0.14	–0.19	0.67*	–0.12	0.10	0.12
	(1.01)	(1.13)	(0.94)	(–1.06)	(2.28)	(–0.90)	(1.29)	(1.10)
Elongation ratio	0.03	–0.18	–0.39	0.04	1.50	0.21	0.31	0.86*
	(0.07)	(–0.35)	(–0.85)	(0.07)	(2.03)	(0.55)	(1.01)	(2.41)
Aroma	0.68.	0.46*	0.10	0.03	–0.13	–0.38**	0.28**	–0.39**
	(3.10)	(2.08)	(0.46)	(0.12)	(–0.42)	(–3.32)	(2.08)	(–3.17)
Packaging	0.50**	0.09	–0.18	0.67**	–0.26	0.04	0.18	0.19
	(3.99)	(0.41)	(–1.13)	(4.80)	(–1.00)	(0.24)	(1.76)	(1.93)
Summary statistic								
n	109	131	124	115	140	157	363	412
R^2	0.73	0.55	0.32	0.50	0.36	3.30	0.50	0.31
F	23.44**	13.05**	4.88*	9.22**	6.66**	5.73**	32.16**	16.51**

[a]Figures in parentheses are *t*-values. [b]** = significant at the 1% level, * = significant at the 5% level.

Table 5. Regression of price on glutinous rice grain characteristics, 1987-88, Thailand.[a]

Characteristic	Round 1[b]		Round 2		Pooled	
	Chiang Mai	Khon Kaen	Chiang Mai	Khon Kaen	Round 1	Round 2
Constant	11.12	7.16	1.92	12.92	6.99	3.34
Broken grains (%)	–0.04**	–0.03**	–0.04**	–0.01*	–0.04**	–0.03**
	(–6.26)	(–4.44)	(–7.26)	(–2.10)	(–8.49)	(–6.86)
Moisture (%)	–0.39**	0.05	0.03	–0.03	–0.10	0.02
	(–3.72)	(0.69)	(0.31)	(–0.31)	(–1.70)	(0.24)
Length (mm)	–0.13	–0.27	0.22	–1.05**	0.27	–0.05
	(–0.42)	(–0.92)	(1.20)	(–3.17)	(1.31)	(–0.38)
Defective grains (%)	–0.02	–0.02	0.07	–0.18*	–0.02	–0.11
	(–0.58)	(–0.61)	(0.68)	(–2.18)	(–0.75)	(–1.60)
Nonglutinous (%)	0.01	–0.04	0.03	0.04	–0.01	0.05*
	(0.97)	(–1.56)	(1.05)	(1.85)	(–1.05)	(2.44)
Apparent amylose content (%)	0.06	0.12	0.12	–0.05	0.04	0.07
	(0.88)	(1.87)	(1.56)	(–0.89)	(0.99)	(1.85)
Alkali spreading value	0.36	0.05	0.48	0.27	–0.07	0.55*
	(1.30)	(0.17)	(1.53)	(1.07)	(–0.36)	(2.52)
Packaging	0.82**	0.32	0.48	–0.57	0.64**	0.30
	(2.74)	(1.29)	(0.95)	(–1.20)	(3.17)	(0.80)
Summary statistics						
n	111	125	120	107	236	227
R^2	0.54	0.23	0.50	0.20	0.32	0.32
F	15.11**	4.34**	13.90**	2.97**	13.44**	12.65**

[a]Figures in parentheses are *t*-values. [b]** = significant at the 1% level, * = significant at the 5% level,

In Chiang Mai, only broken grains, amylose content, and aroma significantly affected rice price at 95% (or more) level of significance. The first two characteristics reduced the price while the last one increased it. When aromatic rice and nonaromatic rice were separately analyzed, the results showed that brokens and other (glutinous) rice had negative effects on price of aromatic rice. Chalkiness and amylose content had negative effects on price of nonaromatic rice.

In Khon Kaen, only two characteristics affected the price of rice at the 95% level of significance—whiteness increased while chalkiness decreased the price.

Combining all samples from the three locations, it was found that broken grains, chalkiness, defective grains, and amylose content reduced the price while length and aroma increased it. Price of aromatic rice was negatively affected by broken and defective grains but positively influenced by elongation ratio. Broken grains, chalkiness, and amylose content reduced the price of nonaromatic rice.

Round 2. Due to small sample sizes for aromatic rice and/or packed rice, regressions of price on rice characteristics for the following groups were not run: aromatic and nonaromatic rice in Bangkok, aromatic and nonaromatic rice in Chiang Mai, packed and unpacked rice in Chiang Mai, aromatic and nonaromatic rice in Khon Kaen, and packed and unpacked rice in Khon Kaen.

In Bangkok, broken grains, chalkiness, and packing were the only characteristics that affected rice price at the 99% levels of significance. The first two characteristics had negative effects and the last one had positive effects. When packed and unpacked rice were separately analyzed, broken grains and amylose content reduced the price of packed rice at the 95 and 99% levels of significance, respectively. Broken grains affected the price of unpacked rice in a similar manner. However, chalkiness negatively affected the price of unpacked rice at the 99% level of significance.

As compared with results obtained in Bangkok, the price of rice in Chiang Mai was affected by a larger number of characteristics—brokens, defective grains, other (glutinous) rice, alkali spreading value, and elongation ratio. The first three characteristics had negative effects while the last two had positive effects at the 95% (or more) level of significance.

Contrary to expectations, aroma was found to have a negative effect on the price of rice in Khon Kaen. Chalkiness and amylose content also had negative effects and at 95% (or more) level of significance, only length had a positive effect on price.

When all the samples from the three locations were considered together, it was found that length, elongation ratio, and packing increased the price but broken grains, chalkiness, defective grains, amylose content, and aroma reduced it. Only chalkiness affected the price of aromatic rice at the 95% (or more) level of significance. As percentage of chalkiness increased, the price of rice declined. The price of packed rice was significantly affected by whiteness, length, brokens, chalkiness, and amylose content. The first two characteristics positively affected price while the last three affected it negatively. Characteristics affecting the prices of nonaromatic rice and unpacked rice were similar to those affecting all rice samples.

Glutinous rice

Round 1. Since the sample size for packed rice in each study location was small, regression of price on rice characteristics was not separately run for packed and unpacked rice. Among the eight characteristics considered in the regression analysis, only broken grains, moisture content, and packing affected the price of rice in Chiang Mai at not less than 95% level of significance. The first two characteristics negatively affected price while the last one was a positive factor. Only broken grains affected price in Khon Raen at the 95% (or more) level of significance; as percentage of broken grains increased, price declined at a very small magnitude.

For all samples from the two locations, it was found that broken grains and packing were the only two characteristics affecting rice price at the 95% (or more) level of significance; the latter increased it but the former decreased it.

Round 2. The results from the second-round survey were substantially at variance with those from the first-round survey. Few rice characteristics in Chiang Mai and more rice characteristics in Khon Kaen affected the price of rice during the second-round survey. At not less than 95% level of significance, only broken grains had an effect (negative) on rice price in Chiang Mai. In Khon Kaen, broken grains, length, and defective grains negatively affected price. No other characteristics affected price at not less than 95% level of significance and no reason can be given for the negative effect of length on price.

For all samples from the two locations, only broken grains, other (nonglutinous) rice, and alkali spreading value affected price at not less than 95% level of significance. An increase in the percentage of brokens decreased rice price but increases in percentage of nonglutinous rice and alkali spreading value increased it. Again, no reason can be given for the positive effect of percentage of nonglutinous rice.

Summary and conclusions

In addition to domestic consumption, Thailand produces an approximate annual average of 3.4 million t of rice for export, contributing 12% of annual export earnings (about 19.9 billion baht). It has, therefore, been necessary to maintain high-quality rice.

Results showed that for nonglutinous rice, price during Round 2 was higher than that during Round 1. Effects of grain characteristics on retail price varied among the three locations and between the two rounds of sample collection. However, brokens and chalkiness showed negative effects on price in both rounds and in almost all locations while aroma showed a positive effect on price in the first round. During both surveys, sample characteristics of nonglutinous rice did not vary much across locations. On the other hand, aromatic, nonglutinous rice generally commanded a considerably higher price than did nonaromatic, nonglutinous rice. Packed rice was more expensive than unpacked rice although there was not much variation in all the sample characteristics.

The study characteristics of glutinous rice did not vary much across locations in both surveys. Seasonal variation in prices of glutinous rice between the two surveys was also relatively small. As in the case of nonglutinous rice, packed glutinous rice commanded a higher price than the unpacked one. The price differential between these two groups of glutinous rice was substantially higher than that among groups of nonglutinous rice.

In general, broken grains, chalkiness, defective grains, and apparent amylose content affected rice price negatively while length, aroma, elongation ratio, and alkali spreading value did so positively. Packing also affected price positively.

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Understanding grain quality in the Malaysian rice industry[1]

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In spite of a large number of studies on the breeding and technical aspects of milled rice and rough rice quality in Malaysia (Husain 1984, Azudin and Zainuddin 1986, Lim et al 1986, Samsudin et al 1989, Wahab et al 1986), the economic aspects have received comparatively scant attention. This may have stemmed from the fact that rice is a controlled commodity in Malaysia; prices are institutionally determined and have remained largely unchanged in real terms since 1974. Recent views of rice policy (Tamin and Sahathavan 1987, Tan 1987, World Bank 1988) have consistently highlighted the increasing need to consider consumer preference and pricing of rough and milled rice in relation to reforms in the rice industry. From another perspective, Ryland and Menz (1989) have suggested the use of implicit pricing models fashioned after that of Ladd and Suvannunt (1976) for quantifying the qualitative aspects of benefits derived from improved grain storage systems, as an extension of the model developed in their study of bulk handling of rough and milled rice in Malaysia. Lately, there have been plans to link the rough and milled rice markets. Consequently, a common understanding of the changing importance and relevance of rice grain quality is vital, particularly to a research institution like MARDI.

This study is designed to assess the optimal strategy for rice quality improvement at the national level by establishing (through a hedonic price model) the economic value to consumers of the different physical and chemical quality characteristics that affect appearance, cooking, and eating quality. It also intends to examine variations in consumer taste across regions and between rural and urban markets. Estimates of the implicit values of different quality characteristics should prove useful in measuring or indicating trade-offs in the formulation and evaluation of research and investment strategies.

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The Malaysian rice industry

Demand for rice in Malaysia has always exceeded domestic production. The country has elected to remain a net importer of rice, judging from its policy of emphasizing production in granary areas in 1984. In 1985, Malaysia produced 1.26 million t of rice and was 75% self-sufficient, with Peninsular and East Malaysia (Sabah and Sarawak) achieving 84 and 43% self-sufficiency, respectively. This translated into a national per capita consumption of 108 kg in 1985 (100 and 141 kg, respectively, for Peninsular and East Malaysia). During the 1980-85 period, per capita consumption fluctuated, increasing from 108 kg in 1980 to 115 kg in 1981, and declining thereafter to 108 kg in 1985. Over a longer period, the same declining trend was observed in the peninsula. This decline in per capita consumption in the face of absolute increases in population implies that rice is considered an inferior good. The lower per capita consumption level in the peninsula essentially supports this hypothesis. Another reason may be the perceptible switch to other cereals as a result of changes in lifestyle and taste. Yet another plausible explanation is that the figures reported are underestimated since illegal border transactions are not captured in official statistics.

According to the Household Expenditure Survey conducted in Peninsular Malaysia in I980 (Department of Statistics 1986), 28.4% of the monthly household budget was spent on food, 15% of which went to rice. The survey also indicated slight differences in food expenditure pattern between rural and urban households and among different ethnic groups. Comparing these results with those of a similar survey conducted in 1973, the relative importance of rice declined from 24.1 to 15% while that of other items (e.g., milk, cheese, eggs, oils and fats, tea, and coffee) did not change much. In absolute terms, however, expenditure on rice has recorded a marginal increase. In view of the fact that per capita consumption has declined over the period and that rice prices have been held at the same level since 1974, the above findings would tend to suggest a switch to higher grade rice over time.

Rice marketing functions are performed by an entire range of agents. On one level are the private millers and traders who have been an integral part of the system since the early emergence of rice markets. On another level are the rural cooperatives and farmers' associations who have undoubtedly contributed to the post-independence drive toward a self-reliant and prosperous peasantry. On the third and perhaps the most pervasive level is the National Padi and Rice Board, better known by its Bahasa Malaysia acronym, LPN (Lembaga Padi dan Beras Negera), which was established in the 1970s. In 1974, LPN became the sole importer of rice. Rice prices and their marketing margins were fixed according to regions and have remained largely unchanged till the present.

Today, the rice milling industry is facing a crisis as a result of heavy government intervention in the past. The government is aware of the situation and is examining ways of relinking the unwittingly dislocated rough and milled rice markets. Currently, rice processing is not attractive as the milling margins have been largely fixed since 1974 while operating costs have undoubtedly increased over time. In line with the privatization policy of the government, however, LPN is seriously diminishing its role in the primary marketing of rough rice and the milling of rice. This should be viewed from the wider perspective of the elected structural adjustments, the general thrust of which is to reduce subsidies and rationalize the extent of government intervention in the agricultural sector. Consequently, policies regarding self-sufficiency and pricing have been revised.

Rice grain quality

It is largely in relation to such impending changes that there has been a surge of interest in rice grain quality. At the same time, it has been recognized that with rapid economic growth, grain quality considerations are bound to become increasingly important and that grain quality preferences may not only vary from region to region but also between rural and urban areas within a region and between ethnic and income groups.

However, existing views relating to consumer preferences are, at best, obtained through tasting panels conducted in relation to varietal development rather than through formal economic studies. Conventional wisdom and/or prejudices accumulated through time also provide relevant insights. Insofar as the breeders are concerned, rice grain quality improvement relates to developing varieties that have medium to long, slender grains, with a high percentage of head rice after milling, intermediate amylose content and gelatinization temperature, and soft gel consistency[3] (Lim et al 1986). These characteristics constitute the objectives of MARDI's breeding program, insofar as rice grain quality is concerned.

Research methodology

The hedonic model's basic argument is that consumers demand rice for its taste and nutritional value, and the utility obtained is the sum of the utilities obtained from the different characteristics of rice. From this perspective, the model discussed in Unnevehr (1992) can be represented by

$$P_r = \sum_{j=1}^{m} X_{rj} P_{rj} + u \tag{1}$$

where P_r = market price of rice, X_{rj} = quantity of characteristics j in one unit of rice, P_{rj} = implicit value of characteristic j, and u = random error term.

Therefore, if the characteristics that define grain quality can be measured, the implicit value of these characteristics can be estimated by least-square regression of the observed market price on the measures of quality. The independent variables (X_{rj}s) should explain the variance in rice price while the corresponding estimated coefficients (P_{rj}s) should measure the implicit value of each grain characteristic.

[3]In the Malaysian context, grain length refers to that of whole kernel milled rice and is considered long if it is >6.2 mm; medium, if 5.2-6.2 mm; and short, if <5.2 mm. Grain shape is dependent on the length-width ratio where ^{3} 3.0 is termed slender: 2.0-2.9 ih medium; and £1.9 is bold. Amylose content is termed waxy if it is 1-9%; low, if 10-20%; intermediate, if 20-25%; and high, if 25-32%.

Study areas

The study examined three somewhat distinct regions: Kedah represents the rice production surplus area, Johor is a rice-deficit area, and Kuala Lumpur is metropolitan. The retail markets in Kedah and Johor were further disaggregated into rural and urban markets. To capture a diverse spread of consumer preferences, 'rice markets' within each region were selected to reflect ethnic groups. Samples were also drawn from central markets, supermarkets, and provision shops in the urban markets to cover outlets for different income groups. It was decided at the outset to exclude exotic rice (Basmati), pulut (glutinous rice), sample grades, and brokens. Sample grades were excluded as consumers tend to use them to feed pets while brokens were left out as they are used for making cakes and other traditional food. With this caveat, samples were obtained for each grade or type of rice sold by randomly selected retailers. A total of 269 samples were collected (breakdown provided below).

Region	Category	No. of sites	No. of samples
Kedah	Rural	10	45
	Urban	3	55
Kuala Lumpur	Urban	5	55
Johor	Rural	10	58
	Urban	3	56
Total		31	269

All samples were then sent to the Cereal Laboratory at Bumbong Lima for analysis. Seven physical (whiteness, chalkiness, head rice, length, shape, mixture, and damaged grains) and three chemical (amylose content, alkali spreading value, and gel consistency) characteristics were considered, the measurement procedures of which are discussed in Appendix 2a.

Results and discussion

Retail market component

The correlation matrices generated for the various levels of data aggregation consistently indicated high correlations between independent variables. Table 1 provides an indication of the extent of correlation between urban and rural markets, confirming the existence of multicollinearity problems. The correlation coefficients between the various characteristics and price, however, conformed to general expectations about signs and interrelationships.

Because the comparison of means between the different regions (Table 2) indicated a high incidence of unequal variances, *t*-tests instead of the Duncan Multiple Range Test (DMRT) were run. The means were significantly different for most variables except those for Kuala Lumpur and Johor where only chalky grains and head rice were significantly different. The comparison of means between rural and urban classes (Table 3) indicated that they were significantly different for price and whiteness. Taken together, they caution against simply pooling the regional or area data.

Table 1. Correlation coefficients for price and quality characteristics of rice in Malaysian urban and retail markets.[a]

	Price	Whiteness	Chalkiness	Head rice	Length	Shape	Mixture	Damaged grains	Amylose content	Alkali spreading value	Gel consistency
Price	1.00	0.41**	–0.25*	0.47**	0.73**	0.66**	–0.19	–0.43**	–0.61**	–0.10	0.37**
Whiteness	0.25**	1.00	0.05	–0.05	0.28**	0.20*	0.08	–0.29**	–0.11	–0.34**	0.23*
Chalkiness	–0.24**	0.36*	1.00	0.12	–0.04	0.01	–0.07	–0.04	0.09	–0.17	–0.22*
Head rice	0.39**	–0.01	–0.09	1.00	0.44**	0.43**	–0.15	–0.16	–0.36**	0.05	0.08
Length	0.68**	0.27**	0.01	0.34**	1.00	0.91**	–0.36**	–0.26**	–0.61**	0.15	0.36**
Shape	0.73**	0.28**	–0.01	0.34**	0.91**	1.00	–0.43**	–0.27**	–0.66**	–0.15	0.32**
Mixture	–0.31**	–0.13	–0.01	–0.06	–0.39**	–0.40**	1.00	0.04	0.31**	0.13	–0.20*
Damaged grains	–0.33**	–0.48**	–0.08	–0.15	–0.33**	–0.32**	0.12	1.00	0.17	0.10	–0.15
Amylose content	–0.37**	–0.02	0.11	–0.09	–0.31**	–0.35**	0.15	0.05	1.00	–0.01	–0.23*
Alkali spreading value	–0.11	–0.04	0.07	0.03	–0.02	0.01	–0.04	0.02	0.09	1.00	–0.14
Gel consistency	0.45**	–0.19*	–0.45*	0.22**	0.34**	0.32**	–0.07	0.02	–0.21**	–0.15	1.00

[a] * = significant at the 5% level, ** = significant at the 1% level.

Table 2. Comparison of average characterletics and price among Kuala Lumpur, Kedah, and Johor retail markets.[a]

Variable	(a) Kuala Lumpur		(b) Kedah		(c) Johor		*t*-Test		
	Mean	Std dev	Mean	Std dev	Mean	Std dev	(a)-(b)	(a)-(c)	(b)-(c)
Price (Ringgit/kg)	1.23	0.29	0.92	0.12	1.14	0.20	2.62@**	1.96@	10.68@**
Whiteness (%)	37.50	5.48	30.66	6.90	36.02	3.72	6.33**	1.80@	6.95@**
Chalky grains (%)	16.80	9.39	16.18	5.37	13.10	6.66	0.45@	2.62@*	3.74@**
Head rice (%)	82.01	8.41	76.27	11.72	78.56	12.66	3.52@**	2.10@*	1.36
Length (mm)	6.43	0.43	6.05	0.29	6.49	0.47	5.91@**	0.72	8.27@**
Shape (L/W)	3.05	0.24	2.88	0.16	3.02	0.26	4.94@**	0.85	4.90@**
Mixture (%)	29.72	21.28	30.54	15.87	29.34	20.84	0.25@	0.11	0.47@
Damaged grains (%)	1.79	2.19	3.13	4.47	1.64	2.19	2.51@**	0.44	3.03@**
Amylose content (%)	23.51	3.80	25.72	2.23	24.90	7.26	3.96@**	1.63@	1.15@
Alkali spreading value	5.21	1.12	5.86	0.78	5.41	1.01	3.85@**	1.14	3.72@**
Gel consistency (mm)	32.87	6.95	27.61	2.54	32.31	6.19	5.43@**	0.53	7.43@**

[a]* = significant at the 5% level. ** = significant at the 1% level. @ refers to situations where variances are unequal.

Table 3. Comparison of average characteristics and price between rural and urban retail markets.[a]

Variable	Urban		Rural		*t*-test
	Mean	Std dev	Mean	Std dev	
Price (Ringgit/kg)	1.12	0.25	1.00	0.20	4.11@**
Whiteness (%)	35.08	6.21	33.12	5.87	2.58*
Chalky grains (%)	15.10	7.45	14.41	6.41	0.30
Head rice (%)	79.35	11.38	76.90	12.11	1.68
Length (mm)	6.34	0.44	6.27	0.46	1.15
Shape (L/W)	2.99	0.23	2.95	0.24	1.32
Mixture (%)	30.33	19.88	29.11	18.06	0.51
Damaged grains (%)	2.04	3.01	2.51	3.68	2.15
Amylose content (%)	24.73	6.31	25.23	2.83	0.88@
Alkali spreading value	5.49	0.98	5.61	1.01	0.96
Gel consistency (mm)	31.13	6.13	29.94	5.24	1.63

[a]* = significant at the 5% level, ** = significant at the 1% level, @ refers to situations where variances are unequal.

Table 4. Stepwise regression of price on selected physicochemical characteristies of milled rice at retail markets, by area.[a]

Area Characteristic	Kedah Urban	Kedah Rural	Kuala Lumpur Urban	Johor Urban	Johor Rural
Head rice	0.005**	0.003**	0.006*	0.004**	
Whiteness					
Chalkiness	–0.004*			–0.017**	
Length		0.113**			
Shape	0.182**		0.513**	0.204**	0.606**
Mixture					
Damaged grains	–0.010**	–0.012**			
Amylose content	–0.016**		–0.033**	–0.027**	
Alkali spreading value					
Gel consistency					
Intercept	0.821	–0.037	–0.077	0.910	–0.657
R^2	0.715	0.590	0.685	0.774	0.489

[a]* = Significant at the 5% level, ** = significant at the 1% level.

In examining the results of the stepwise regressions, we need to look at the signs, the significance, and the magnitude of the coefficients. Initial runs were carried out for each area and the results are presented in Table 4. With perhaps the exception of ‘Johor rural,’ all the regressions have reasonably high R^2 and all the significant variables have the expected signs. The characteristics of head rice and shape were significant in 4 of the 5 regressions, amylose content in 3, while damaged grains and chalkiness were significant in 2.

Subsequently, a set of regressions was run for each region followed by one of pooled data incorporating dummy variables for region and area. The results are presented in Table 5. All the dummy variables were significant, confirming the differences in average prices between regions as well as in areas suggested earlier in the *t*-tests. In all the regional regressions as well as in the overall (pooled) one, not only

Table 5. Stepwise regreassion of price on selected physicochemical characteristics of milled rice at retail markets, by region.

Region Characteristic	Kedah Surplus	Kuala Lumpur Metropolitan	Johor Deficit	All
Head rice	0.008**	0.006**	0.003**	0.003**
Whiteness	0.004**			
Chalkiness	–0.007**		–0.006**	–0.007**
Length	0.123**			
Shape		0.513**	0.497**	0.448**
Mixture				
Damaged grains	–0.011**			–0.011**
Amylose content		–0.033**		–0.006**
Alkali spreading value				
Gel consistency				
Dummy 1	na	na	na	1.295**
Dummy 2	na	na	na	–0.808**
Dummy 3	na	na	na	0.027**
Intercept	–0.270	–0.077	–0.525	–0.237
R^2 square	0.631	0.635	0.568	0.715

[a]* = significant at the 5% level, ** = significant at the 1% level. na = not applicable.

were the signs of the significant variables stable but the relative magnitude of the coefficients was also largely maintained. It is comforting to note their consistency and closeness to those considered important by rice breeders at MARDI (Lim et al 1986).

Conclusions

The study has indicated the relevance of the hedonic model for understanding rice quality preferences. Malaysian consumers prefer more head rice, lower amylose content, and longer shape. The high amylose content of locally produced rice indicates substantial scope for improvement in local quality.

The retail market component of the present study indicates that observed rice price variation is due to variation in quality characteristics of rice; that the implicit values of characteristics are different across regions and between rural and urban markets; and that consumers significantly prefer rice with higher length-width ratio, higher percentage head rice, less chalky grains, less damaged grains, and intermediate amylose content. The negative implicit price of amylose and the high amylose content of locally produced rice indicate that there would be substantial returns to reducing amylose content of Malaysian MVs.

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Notes

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Influence of rice grain properties on market price in Bangladesh[1]

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Although Bangladesh is at present deficient in food and while higher yields continue to be the prime objective of rice research, it is believed that as the country progresses toward self-sufficiency, quality will become more important in developing new rice varieties.

Poor quality rice is sold at a lower price and is also difficult to market as evidenced by the fact that many self-sufficient countries and those countries that are close to self-sufficiency are facing marketing problems. If farmers do not get an attractive price, rice production is discouraged and will eventually decline. Hence, the market price will be an important factor in attaining self-sufficiency in rice, and price has a direct positive correlation with certain quality characteristics.

Grain quality depends on varietal characteristics, cultivation environment, post-harvest handling, and rice processing technology. To assess the optimal strategy for improving quality, we need to determine the economic value of the different physical and chemical quality characteristics that affect appearance and the cooking and eating quality of commercial rice grades for consumers.

The objectives of this study are to:

1. determine the physical and chemical properties of commercial grades of rice in the urban and rural markets,
2. estimate the impact of rice processing system on the quality of rice,
3. establish the contribution of physical and chemical properties of rice in determining market price, and
4. inform rice breeders about quality characteristics which determine price.

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Research methodology

Sample collection

Parboiled rice is the preferred staple in Bangladesh. In 1987, rice samples were collected from four big cities and rural markets of the country's four divisions—Dhaka, Rajshahi, Khulna, and Chittagong. The names of the markets and periods of sample collection are given in Table 1. To collect 30-40 samples, at least three shops were selected from each market. All available grades of rice were obtained from these shops.

Samples were collected in January-February and again in July-August, representing the period after the aman and boro seasons, respectively, when almost all commercial grades were available. The total collection consisted of 516 parboiled rice samples from city markets, 211 parboiled rice samples from rural markets, and 146 raw rice samples from different city and rural markets. The collected samples were analyzed for 21 physical, chemical, and cooking properties to assess their contribution to market price as well as their interrelationship.

In economic literature, the analysis of the values of various quality factors falls under the area of hedonic pricing. Hedonic pricing thus involves implicit price of characteristics or attributes of a commodity rather than the price of the commodity itself (Unnevehr et al 1985).

The general form of the hedonic price functions estimated in this study is as follows (see Unnevehr 1992):

Table 1. Rice markets and time of sample collection in 1987.

Division	City market	Collection month	Rural market	Collection month
Dhaka	Kawran bazar Lalbag	Jan-Feb Jul-Aug	Savar	Jan-Feb
Rajshahi	Shahab bazar	Jan-Feb Jul-Aug	Jhalmalia Baneswar	Jan-Feb Jul-Aug
Khulna	Bara bazar Daulatpur Khalishpur	Jan-Feb Jul-Aug	Dumuria Chuknagar	Jan-Feb Jul-Aug
Chittagong	Reazuddin market Karnaphuli market Pahartali market Kalurghat	Jan-Feb Jul-Aug	Patia Chiringa Hazirhat	Jul-Aug

$$P_{ai} = P(V_{i1},..., V_{ij}; D_i, U_i) \quad (1)$$

where P_i = observed price of rice at the ith market, V_{ij} = amount of some characteristic j per unit of rice at the ith market, D_i = seasonal dummy, and U_i = a disturbance term.

Although many researchers have used a semilogarithmic relationship between prices and characteristics (Griliches 1971), this study uses linear specification of the hedonic price function since rice samples are continuously variable with respect to quality characteristics in question. The equation has been estimated in the study using the ordinary least squares (OLS) method based on pooled time series (for two seasons) cross-section data.

Results and discussion

Rice grain characteristics influence market price either positively or negatively. The expected direction of influence for different rice grain characteristics is shown in Table 2.

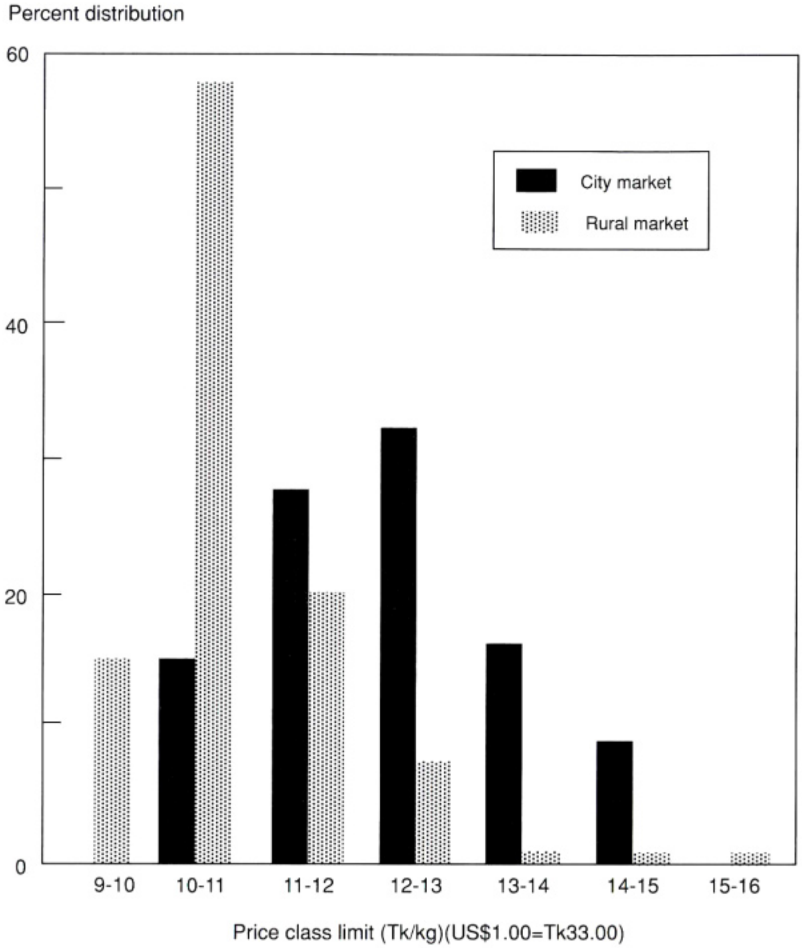
The maximum and minimum price per kilogram of rice varied between Tk8.00 and Tk17.00 in city markets and between Tk8.00 and Tk14.00 in rural markets (Fig. 1). The frequency distribution showed that more than 80% of the rices were sold at a price between Tk10.00 and Tk14.00 in city markets while more than 90% were sold at a price between Tk10.00 and Tk12.00 in rural markets.

The price of rice varied from region to region. Among city markets, the highest price was paid in Chittagong (Tk11.93) and the lowest was recorded in Khulna (Tk10.54) (Table 3). In Dhaka and Rajshahi cities, rice was sold at an average price of Tk11.39 and Tk11.02, respectively.

Regression analysis showed that price was significantly lower in Rajshahi and Khulna city markets than in Dhaka city markets (Table 4). Chittagong city markets had

Table 2. Expected relationship between price and grain sample characteristics, Bangladesh, 1988.

Grain characteristic	Measure	Expected relationship	Grain characteristic	Measure	Expected relationship
Appearance	1-5	+	Brokens	%	–
Brightness	1-5	+	Damaged grains	no./100 g	–
Polish	1-3	+	Black grains	no./100 g	–
Chalkiness	0-9	–	Moisture	%	–
Length (L)	mm	+	Alkali spreading value	1-7	–
Breadth (B)	mm	–	EWC	%	–
L-B ratio	ratio	+	Gel consistency	mm	+/–
1,000-grain wt	g	–	Amylose content	%	+
Weight/length	mg/mm	–	Cooking time	min	–
Contrasting grains	%	–	Elongation ratio	ratio	+
Yellow grains	%	–	Imbibition ratio	ratio	+



1. Frequency distribution of price of commercial grades of rice in city and rural markets, Bangladesh, 1988.

prices similar to those in Dhaka city markets. There was no variation in price from season to season in the city markets.

The average prices among rural markets were Tk10.02, Tk9.81, and Tk9.34 for Dhaka, Rajshahi, and Khulna regions, respectively (Table 5). The average prices in Khulna and Rajshahi were similar but Dhaka prices were significantly different from those in the other two regions. Regression analysis showed that price was significantly higher in Dhaka than those in Khulna and Rajshahi rural markets (Table 6). There was no price variation from season to season in the rural markets.

A comparison was made between city and rural market prices. As the samples were collected from Dhaka rural markets in January-February only and as samples from Chittagong rural areas were mostly raw, the Dhaka city samples taken in July-August and the Chittagong city samples were not considered. It was observed that the price in city markets was significantly higher than that in rural markets (Table 7).

Table 3. Mean values of price and grain quality characteristlcs of parboiled rice, by major regions, city markets, Bangladesh, 1988.[a]

Grain characteristic	Dhaka (N = 238)	Rajshahi (N = 70)	Khulna (N = 158)	Chittagong (N = 50)
Price (Tk/kg)	11.39 b	11.02 c	10.53 d	11.93 a
Appearance (1·5)	3.13 a	3.50 b	3.19 a	3.50 b
Length (mm)	5.08 b	5.29 a	5.22 a	4.89 c
Breadth (mm)	2.01 a	1.94 b	3.03 a	1.94 b
L-B ratio	2.55 b	2.76 a	2.59 b	2.56 b
1,000-grain wt (g)	14.97 b	14.60 b	16.57 a	14.47 b
Weight/length (mg/mm)	2.94 b	2.77 c	3.18 a	2.98 b
Contrasting grains (%)	1.90 ab	1.70 b	1.88 ab	2.19 a
Yellow grains (%)	0.57 b	0.92 b	4.00 a	0.44 b
Brokens (%)	10.61 a	10.65 a	10.14 ab	8.75 b
Damaged grains (no./100 &)	3.81 b	5.90 ab	10.53 a	9.36 a
Black grains (no./100 g)	21.46 b	12.05 c	31.52 a	13.22 c
Moisture (%)	14.38 b	14.12 b	14.66 a	13.62 c
Alkali spreading value	3.08 b	3.10 b	3.40 a	3.15 ab
EWC(%)	44.10 a	44.84 a	44.16 a	44.93 a
Gel consistency (mm)	73.75 c	94.33 a	84.92 b	90.86 a
Amylose content (%)	27.89 a	27.72 ab	27.18 c	27.32 bc
Cooking time (min)	26.24 b	26.30 b	28.43 a	25.37 b
Elongation ratio	1.43 b	1.41 b	1.46 a	1.47 a
Imbibition ratio	4.22 b	4.44 a	4.24 b	4.32 ab

[a]Means in the same line followed by the same letter are not significantly different at the 5% level by DMRT.

Table 4. Ordinary least square regression estimates of parboiled rice quality characteristics contributing to market price, city markets, Bangladesh, 1988.[a]

Variable	Dhaka	Rajshahi	Khulna	Chittagong	All cities
Intercept	13.972	0.922	11.741	10.206	13.187
1,000-grain wt (g)	–0.133**	–0.026*	–0.066*	–0.177	–0.123**
L-B ratio	1.296**	1.433*	0.860**	–0.259	1.034**
Amylose content (%)	–0.089	0.418*	–0.060	–0.072	–0.051
Moisture (%)	–0.199**	0.018	–0.196**	–0.684**	–0.190**
Brokens (%)	0.001	0.000	0.004	–0.036	0.007
EWC(%)	–0.020	–0.038	0.021	0.009	0.009
Yellow grains (%)	0.001	–0.017	0.002	0.065	0.008
Black grains (no./100 g)	0.004	–0.009	–0.003	–0.029	0.000
Cooking time (min)	–0.123**	–0.004	–0.060**	–0.120	–0.102**
Imbibition ratio	0.987**	–0.010	0.717*	1.306	0.758**
Rajshahi dummy	-	-	-	-	–1.155**
Khulna dummy	-	-	-	-	–0.695**
Chittagong dummy	-	-	-	-	–0.171
Jul-Aug dummy	-	-	-	-	0.076

[a]** = significant at the 1% level, * = significant at the 5% level,

Table 5. Mean values of price and grain quality characteristics of parboiled rice, by major regions, rural markets, Bangladesh, 1988.[a]

Grain characteristic	Dhaka (N = 41)	Rajshahi (N = 110)	Khulna (N = 60)
Price (Tk/kg)	10.02 a	9.81 a	9.34 b
Appearance	3.09 a	2.80 b	2.66 b
Length (mm)	5.11 a	5.06 a	5.00 a
Breadth (mm)	2.15 a	2.12 a	2.19 a
L-B ratio	2.34 a	2.41 a	2.31 a
1,000-grain wt (g)	16.80 a	16.82 a	17.10 a
Weight/length (mg/mm)	3.29 a	3.35 a	3.45 a
Contrasting grains (%)	2.08 a	2.29 a	2.49 a
Yellow grains (%)	6.25 a	1.12 b	2.67 a
Brokens (%)	9.14 b	10.64 b	17.24 a
Damaged grains (no./100 g)	15.31 a	21.85 a	24.54 a
Black grains (no./100 g)	21.95 b	19.20 b	37.02 a
Moisture content (%)	15.37 a	15.27 a	15.39 a
Alkali spreading value	3.06 b	3.64 a	3.63 a
EWC(%)	45.73 b	49.05 a	46.17 ab
Gel consistency (mm)	91.09 ab	89.57 b	93.91 a
Amylose content (%)	26.74 b	27.86 a	27.10 b
Cooking time (min)	29.30 a	28.84 a	28.42 a
Elongation ratio	1.46 a	1.42 b	1.47 a
Imbibition ratio	4.13 a	4.20 a	4.14 a

[a]Samples of Chittagong rural areas were not included as they were mostly raw rice. Means in the same line followed by the same letter are not significantly different at the 5% level by DMRT.

Table 6. Ordinary least square regression estimates of parboiled rice quality characteristics contributing to market price, rural markets, Bangladesh, 1988.[a]

Variable	Dhaka	Rajshahi	Khulna	All rural
Intercept	10.560	1.381	6.481	
1,000-grain wt (g)	–0.113**	–0.114**	–0.020	–0.074**
L-B ratio	0.998**	1.760**	1.275*	1.504**
Amylose content (%)	0.024	0.212**	0.215*	0.147**
Moisture (%)	–0.004	–0.028	–0.166	–0.081
Brokens (%)	–0.012	–0.003	–0.009	–0.007
EWC (%)	–0.420	0.024	–0.003	–0.028
Yellow grains (%)	–0.008	–0.018	–0.014	–0.005
Black grains (no./100 g)	0.002	–0.009	–0.001	0.000
Cooking time (min)	0.020	–0.027	–0.040	0.014
Imbibition ratio	–0.185	0.125	–0.083	0.162
Rajshahi dummy	–	–	–	–0.372**
Khulna dummy	–	–	–	–0.484**
Jul-Aug dummy	–	–	–	0.107**

[a]Samples from Chittagong rural markets were not included as they were mostly raw. ** = significant at the 1% level, * = significant at the 5% level.

Table 7. Mean values of price and grain quality chacteristics of parboiled rice, by city and rural markets, Bangladesh, 1988. [a]

Grain characteristic	City markets	Rural markets
Price (Tk/kg)	10.87 a	9.72 b
Appearance (1-5)	3.25 a	2.82 b
Length (mm)	5.14 a	5.06 b
Breadth (mm)	2.01 b	2.15 a
L-B ratio	2.58 a	2.38 b
1,000-grain wt (g)	16.07 b	16.90 a
Weight/length (mg/mm)	3.14 b	3.37 a
Contrasting grains (%)	1.96 b	2.28 a
Yellow grains (%)	3.15 a	2.56 a
Brokens (%)	9.81 b	12.23 a
Damaged grains (no./100 g)	10.25 b	21.37 a
Black grains (no./100 g)	27.13 a	24.80 a
Moisture (%)	14.41 b	15.33 a
Alkali spreading value	3.34 b	3.53 a
EWC (%)	44.30 b	46.87 a
Amylose content (%)	27.10 b	27.43 a
Gel consistency (mm)	86.27 b	91.10 a
Cooking time (min)	27.70 b	28.83 a
Elongation ratio	1.47 a	1.45 b
Imbibition ratio	4.26 a	4.17 b

[a] Means in the same line followed by the same letter are not significantly different at the 5% level by DMRT.

Raw rice was found in the rural areas in Khulna and Chittagong. Almost all samples in Chittagong rural areas were raw; more than 60% of both city and rural area samples in Khulna were likewise raw. Raw samples were also found in Chittagong city markets. The prices of raw and parboiled rice were very similar in the cities and rural areas (Table 8).

Physical characteristics

Appearance. The term is used to indicate the combination of whiteness, brightness, color, coarseness, presence of brokens, etc. Its measure has been indicated by giving numerical values upon visual observation; poor appearance is given a value of 1 while excellent appearance is given a 5. More than 80% of rice in city markets had appearance grades between 3 and 5 and more than 90% rice in the rural markets had ratings between 2 and 5. Dhaka and Rajshahi city samples had better appearance than Chittagong and Khulna city samples (Table 3). Rural samples had similar appearance for all regions (Table 5). City samples had better appearance than rural samples and parboiled rice had better appearance than raw rice (Table 7,8).

From the correlation matrix, it was observed that appearance had a positive correlation with price, degree of polishing, length and L-B ratio, and a negative correlation with kernel breadth, 1,000-grain weight, broken grains, moisture content, contrasting grain, and yellow, damaged, and black grains for both city and rural markets. Raw rice appearance also had a similar relationship with grain properties.

Chalkiness. The white powdery portion of a rice grain is known as the chalky part. It is a genetic character for raw rice but an acquired character for parboiled rice. The

Table 8. Mean values of price and grain quality characteristics, by raw and parboiled rice, Bangladesh, 1988.

Grain characteristic	Raw rice	Parboiled rice
Price (Tk/kg)	10.31 a	10.28 a
Appearance (1-5)	2.64 b	3.06 a
Length (mm)	4.85 b	5.16 a
Breadth (mm)	2.39 a	2.08 b
L-B ratio	2.07 b	2.50 a
1,000-grain wt (g)	19.45 a	16.81 b
Weight/length (mg/mm)	4.01 a	3.27 b
Contrasting grains (%)	1.33 b	2.00 a
Yellow grains (%)	2.32 a	3.51 a
Brokens (%)	19.72 a	12.76 b
Damaged grains (no./100 g)	0.24 b	13.65 a
Black grains (no./100 g)	2.42 b	31.31 a
Moisture (%)	13.47 b	14.83 a
Alkali spreading value	6.83 a	3.64 b
EWC (%)	27.86 b	45.34 a
Amylose content (%)	24.86 b	27.07 a
Gel consistency (mm)	54.62 b	85.46 a
Cooking time (min)	24.37 b	28.10 a
Elongation ratio	1.59 a	1.47 b
Imbibition ratio	4.06 b	4.22 a

chalky part of raw rice disappears on parboiling but a new white portion may reappear if grains are underparboiled. The chalkiness of both raw and parboiled rice is measured by giving numerical values (0-9) upon visual observation. The value 0 is given to translucent grains and the value 9 is given to those which have 20% of the grain chalky (IRTP 1988). In all city and rural markets, more than 95% of parboiled rice and 90% of raw rice were translucent or had very little chalkiness. Accordingly, no statistical analysis was done on this property.

Degree of polishing and whiteness. The degree of polishing determines the whiteness of rice in the market. The correlation matrix showed that these two factors highly correlated with each other. The degree of polishing was also positively correlated with L-B ratio and negatively correlated with breadth, 1,000-grain weight, broken grains, and moisture content. It has a positive correlation with price.

Length. Grain length is measured by slide calipers and expressed in millimeters. Rice grains were 4.1-6.6 mm long. In both city and rural markets, more than 80% of the samples were 4.5-6.0 mm long. More than 60% of the city samples and 70% of the rural samples had lengths between 4.5 and 5.5 mm. Similar grain length was observed in Rajshahi and Khulna city samples (Table 5) as well as in Dhaka and Chittagong city samples (Table 3). The aman samples had significantly longer grains than the boro samples. Grain length was similar in all rural markets. The city rice samples had longer grains than the rural samples. Parboiled rice samples were longer than raw rice samples (Table 8).

The correlation matrix showed that the length of parboiled rice was positively correlated with appearance, degree of polishing, L-B ratio, 1,000-grain weight, and broken grains but negatively correlated with moisture content. Grain length of raw rice had similar relationships (except with degree of polishing which had a negative correlation).

Breadth. The widest part of the grain is called breadth. It is measured by slide calipers and expressed in millimeters. The breadth of rice grain varied from 1.3 to 3.0 mm in city markets and from 1.6 to 2.8 mm in rural markets. The average breadth among samples from city and rural markets was 2.0 and 2.1 mm, respectively. The frequency distribution showed that in both city and rural markets, 85% of the samples had breadth between 1.8 and 2.4 mm; more than 70% of the city samples had breadth between 1.8 and 2.2 mm; and about 50% of the rural samples had breadth between 2.2 and 2.4 mm. This showed that rice in rural markets was bolder than that in city markets.

The rice samples in Dhaka and Khulna had similar mean breadth while those in Rajshahi and Chittagong cities had the same average breadth (Table 3). The breadth of aman samples was significantly higher than that of boro samples. The samples in all rural markets had similar breadth (Table 5). The city samples had significantly higher breadth than the rural samples (Table 7). Raw rice showed significantly higher breadth than parboiled rice (Table 8).

The correlation matrix showed that breadth had a positive correlation with 1,000-grain weight and moisture content and a negative correlation with appearance, degree of polishing, L-B ratio, and broken grains.

L-B ratio. This refers to the ratio of grain length to its breadth (in mm). The ratio varied from 1.70 to 3.60 for city samples and from 1.60 to 2.80 for rural samples. The average was 2.58 and 2.38 for city and rural markets, respectively. More than 80% of the samples had a L-B ratio between 2 and 3. The values were similar for Dhaka, Khulna, and Chittagong cities but were significantly different in Rajshahi (Table 3). The values for all rural markets were similar (Table 5). The city market samples had a significantly higher L-B ratio than the rural market samples (Table 7). The value was higher for parboiled rice than for raw rice (Table 8).

The correlation matrix showed that it was positively correlated with price, appearance, degree of polishing, length, broken grains, gel consistency, amylose content, and volume expansion but negatively correlated with breadth, 1,000-grain weight, moisture content, alkali spreading value, equilibrium water content (EWC), cooking time, and elongation ratio. The correlation values with alkali spreading value, EWC, gel consistency, and amylose content were low.

The regression analysis showed that L-B ratio had a significant positive contribution to the price of parboiled rice in both city and rural markets, except in Chittagong (Table 4,6). It did not contribute to the price of raw rice (Table 9).

1,000-grain weight. Expressed in grams, it is determined by weighing 3 replications of 1,000 grains. Grain coarseness as shown by 1,000-grain weight, varied-from 10.5 to 25.1 g in city markets and from 10.9 to 23.1 g in rural markets. The average values were 15.36 and 16.30 g for city and rural markets, respectively. The frequency distribution showed that samples were well-distributed between the values 10 and 17 g. Dhaka, Rajshahi, and Chittagong city samples had similar values; these were significantly different from values observed in Khulna city samples (Table 3). All rural samples had similar values (Table 4). Grain weight was significantly higher in raw rice than in parboiled rice (Table 8). This may be explained by the fact that all raw rices in

Khulna city and rural markets have coarse grains. In Chittagong, both coarse and fine raw rices were sold.

The correlation matrix showed that 1,000-grain weight was positively correlated with length; breadth; brokens; moisture content; contrasting, yellow, damaged, and black grains; alkali spreading value; EWC; gel consistency; cooking time; and elongation ratio. It was negatively correlated with price, appearance, degree of polishing, L-B ratio, amylose content, and imbibition ratio. Low values of broken grains, contrasting and damaged grains, amylose content, and elongation ratio were reported.

The regression analysis showed that 1,000-grain weight had a significant negative contribution to price for both city and rural parboiled rice but no significant contribution for raw rice (Table 4,6,9).

Weight/length. As another indicator of grain coarseness, weight/length varied between 2.00 and 4.80 mg/mm for city samples and between 2.00 and 4.40 mg/mm for rural samples (average 2.99 and 3.337 mg/mm, respectively). Dhaka and Chittagong samples had similar average values whereas Khulna and Rajshahi samples differed significantly (Table 3). All rural samples had similar values (Table 5). The values differed significantly between city and rural samples and between raw and parboiled rice. Rural and parboiled rice samples have coarser grains.

Contrasting grains. It varied between 0.30 and 10.50% for city samples, and between 0.09 and 30.70% for rural samples, averaging 1.88 and 2.28%, respectively. Dhaka, Khulna, and Chittagong samples had similar values of contrasting grains (Table 3).

A significant difference existed between Rajshahi and Khulna samples. All rural samples had similar percentages of contrasting grains (Table 5). Rural samples had more contrasting grains than city samples (Table 7). Contrasting grain content was higher in parboiled rice than in raw rice (Table 8).

Table 9. Ordinary least square regression estimates of raw rice characteristics contributing to market price, Bangladesh, 1988.[a]

Variable	Khulna	Chittagong	All
Intercept	3.420	17.719	9.413
1,000-grain wt (g)	0.158**	–0.267**	–0.053
L-B ratio	–0.170	0.191	–1.081
Amylose content (%)	–0.072	0.091	0.031
Moisture (%)	0.305**	–0.572	–0.062
Brokens (%)	–0.003	–0.041*	–0.004
Gel consistency (mm)	0.000	0.005	–0.015
Yellow grains (%)	–0.024*	–0.024*	–0.009*
Black grains (no./100 g)	–0.004	–0.024	–0.010
Cooking time (min)	–0.156**	–0.130	–0.055*
Imbibition ratio	1.255*	1.485**	0.469**
Khulna dummy	—	—	0.332*

[a] * = significant at the 1% level, ** = significant at the 5% level.

The regression analysis showed that contrasting grains did not have any significant contribution to price (Table 10).

Yellow grains. For city samples, yellow grain content varied between 0 and 64%; for rural samples, variation ranged from 0 to 56.60%, averaging 1.67 and 2.56%, respectively. All city samples, except those in Khulna, had similar yellow grains (Table 3). Likewise, all rural samples, except those in Rajshahi, had comparable yellow grain content. The city samples had more yellow grains than the rural samples, while the parboiled samples had more yellow grains than the raw samples (Table 5,7,8).

The correlation matrix showed that for parboiled rice, the presence of yellow grains was positively correlated with 1,000-grain weight, contrasting grains, damaged grains, black grains, and moisture content, and negatively correlated with price and appearance. Regression analysis showed that it did not have any significant contribution to price except for Pajam for which it had a negative contribution (Table 4,6,10).

Damaged grains. Expressed as number of grains/l00 g sample, these are selected and counted from 150-g rice sample. It varied between 0 and 276 grains/100 g for city samples, and between 0 and 300 grains/100 g for rural samples, averaging 6.70 and 21.37 grains/100 g, respectively. There was significant variation in damaged grain content among city market samples but none among the rural market samples (Table 3,5). Rural samples had more damaged grains than city samples and parboiled samples had more damaged grains than raw samples (Table 7,8).

The correlation matrix showed that damaged grain was positively correlated with 1,000-grain weight, contrasting grains, yellow grains, black grains, and moisture content but was negatively correlated with price and appearance.

Black grain content. The values varied between 0 and 315 grains/100 g for city samples, and between 0 and 135 grains/100 g for rural samples, averaging 23.15 and 24.81 grains/100 g, respectively. They were uniformly distributed between class intervals. The content varied significantly from one city to another (Table 3). Dhaka and Rajshahi rural samples had similar black grain content; these were significantly different from those found in Khulna rural samples (Table 5). The city and rural

Table 10. Ordinary least square regression estimates of rice acquired quality characteristics contributing to market price, by grades, Bangladesh, 1988. [a]

Variable	Pajam (N = 81)	Purbachi (N = 75)	IRRI (N = 59)	Aman (N = 33)
Intercept	9.948	20.454	18.003	17.424
Contrasting grains (%)	–0.018	0.036	–0.104	0.011
Brokens (%)	–0.025	–0.005	–0.006	–0.022
Yellow grains (%)	–0.166*	–0.011	–0.018	–0.002
Black grains (no./100 g)	0.001	–0.003	0.010	0.007
Moisture (%)	–0.146**	–0.441**	–0.242	–0.193**
EWC (%)	–0.040	–0.009	0.000	0.006
Cooking time (min)	–0.090*	–0.423	0.016	–0.063
Elongation ratio	0.551	–0.920	–1.555	–1.876
Imbibition ratio	1.379**	–0.430	0.298	0.170

[a] ** = significant at the 1% level, * = significant at the 5% level.

samples had the same amount of black grains (Table 7). Parboiled rice had more black grains than raw rice (Table 8).

The correlation matrix showed that black grains had a positive correlation with 1,000-grain weight, contrasting grains, damaged grains, and moisture content and a negative correlation with price and appearance. Regression analysis showed that black grains did not have any significant contribution to price (Table 4,6,10).

Brokens. Whole grains and grains having 4/5th of the length of the grain is termed head rice. The rest are taken to be brokens. The brokens are separated from the rice sample (150 g) on visual observation and their presence is expressed as % of the sample. Brokens varied between 1.6 and 38% in city markets, and between 2.8 and 53% in rural markets, the average being 10.3 and 12.2%, respectively. More than 75% of the samples had brokens within the 5-15% class interval. Dhaka, Rajshahi, and Khulna city samples had similar amounts of brokens, different from those of Chittagong samples (Table 3) which had less brokens. For rural markets, Dhaka and Rajshahi samples had similar brokens which were significantly different from those of Khulna samples (Table 5). Rural samples had more brokens than city samples and raw rice had more brokens than parboiled rice (Table 73).

The correlation matrix showed that percentage of brokens had a positive correlation with length, L-B ratio, 1,000-grain weight, and moisture content and a negative correlation with appearance, degree of polishing, and breadth. Among city samples, it had an unexpected positive correlation with price. However, the value was very low. For rural and raw samples, percentage of brokens negatively correlated with price. Its negative correlation with degree of polishing was also not expected. Regression analysis showed that it had a significant negative contribution to the price of rural and raw samples (Table 6,9). The contribution was insignificant for city samples (Table 4).

Moisture. Moisture was determined by a Kett moisture meter and expressed as % of the grains (wet basis). Moisture in rice grains varied between 11.4 and 17.2% in city markets and between 12.5 and 19.0% in rural markets. The frequency distribution showed that more than 85% of the samples had moisture content between 14 and 17%. Dhaka, Khulna, and Chittagong samples had significantly different moisture contents while Dhaka and Rajshahi samples had similar moisture contents (Table 3). There was significant variation among the parboiled and raw rice samples (Table 5,8), none among the rural samples.

The correlation matrix showed that moisture was positively correlated with breadth, 1,000-grain weight, brokens, contrasting grains, yellow grains, and damaged grains; it was negatively correlated with price, appearance, degree of polishing, length, and L-B ratio. Regression analysis showed a significant negative contribution of moisture to price of parboiled rice but not that of raw rice (Table 4,9). It also had a negative contribution to price of parboiled Pajam and Purbachi rices (Table 10).

Alkali spreading value. An indirect measure of the gelatinization temperature for raw rice, this indicates the degree of parboiling in parboiled rice (Little et al 1958). The more severe parboiling is, the higher the alkali spreading value. As for raw rice, it is also given numerical values (1-7). The alkali spreading value varied between 1.8 and 6.0 for city samples and between 2.0 and 6.0 for rural samples, averaging 3.18 and 3.54, respectively. Most samples had alkali spreading value between 3 and 4, indicating that they were optimally parboiled. The samples from Dhaka, Rajshahi, and Chittagong cities had similar values—significantly lower than those from Khulna (Table 3). Among rural markets, Rajshahi and Khulna cities had similar values but these were different from those observed in Dhaka (Table 5). Higher values were obtained from rural samples than from city samples (Table 7).

The correlation matrix showed that it was positively correlated with 1,000-grain weight, EWC, amylose content, cooking time, and elongation ratio. On the other hand, it was negatively correlated with price, L-B ratio, gel consistency, and volume expansion.

Amylose. Amylose content was determined by the simplified method of Juliano (1971). The color was measured at 620 nm for the standard and 590 nm for the samples. Data were expressed on milled rice dry weight basis using potato amylose as standard. It varied between 17.3 and 30.3%, the average being 27.5%. Most samples had amylose content between 26 and 28%. The correlation matrix showed very law correlation of amylose content with other properties but positive correlation with price. From the regression analysis, it can be seen that amylose content had an insignificant contribution to price except in rural markets where it had a significant positive contribution (Table 4,6,9).

Equilibrium water content (EWC). This is the water content (wet basis) of 2 g milled rice soaked 23 h at 28-30°C (Ali and Bhattacharya 1972). Equilibrium water content indicates the degree of parboiling: the higher the value, the more advanced the parboiling. It varied between 43.5 and 66.6% for urban samples and between 38.3 and 68.0% for rural samples (averaging 44.3 and 46.8%, respectively). All city samples had similar EWCs (Table 3). The values obtained from Dhaka rural samples differed from those of Rajshahi rural samples (Table 5). Rural samples had higher EWC (Table 7).

The correlation matrix showed that EWC had a positive correlation with 1,000-grain weight, alkali spreading value, gel consistency, amylose content, cooking time, and elongation ratio and a negative correlation with price, L-B ratio, and imbibition ratio. The correlation values with L-B ratio, gel consistency, amylose content, and elongation ratio were low. Regression analysis showed that it had no significant contribution to price (Table 4,6,10).

Gel consistency. Rice flour (100 mg) was dispersed in 100- × 13-mm culture tubes with 2 ml 0.2 N KOH in a boiling water bath for 8 min, cooled for 5 min, placed in an ice bath for 20 min, placed on a table for 1 h, and its gel length determined (Cagampang et al 1973). Gel consistency varied from 28 to 100 mm for urban samples and from 52 to 100 mm for rural samples, the average being 81.4 and 91.1 mm, respectively. There was insignificant variation from city to city (except in Rajshahi and Chittagong where values were similar) (Table 3). Dhaka and Rajshahi rural samples had similar gel consistency values; these were different from those of Khulna samples (Table 5). Rural samples had higher values than city samples (Table 7).

Gel consistency had a positive correlation with L-B ratio, 1,000-grain weight, EWC, amylose content, and cooking time. For parboiled rice, it was negatively correlated with price, alkali spreading value, elongation ratio, and volume expansion. None of the correlation values was high except those with 1,000-grain weight and amylose content. Gel consistency of raw rice correlated positively with price and alkali spreading value and negatively with L-B ratio, 1,000-grain weight, EWC, amylose content, cooking time, elongation ratio, and volume expansion.

Cooking time. Cooking time is determined by cooking 5 g of whole rice grain in boiling water. Completeness of cooking is measured by determining the hardness of cooked rice through palpation (10 cooked grains/min) (Ranghino 1966). It varied between 19 and 36.5 min, with an average of 26.8 min for urban samples and 27.6 min for rural samples. The frequency distribution showed that more than 60% of the city samples had cooking time between 23 and 29 min. Meanwhile, more than 60% of the rural samples had values between 25 and 31 min. Cooking time was similar among Dhaka, Rajshahi, and Chittagong city samples and was significantly shorter than that observed in Khulna samples (Table 3). All rural samples also had similar values (Table 5). Rural samples had longer cooking time than city samples while parboiled rice cooked longer than raw rice (Table 7,8).

The correlation matrix showed that cooking time positively correlated with 1,000-grain weight, alkali spreading value, EWC, gel consistency, amylose content, and elongation ratio for all samples. Correlations were positive for rural parboiled rice but unexpectedly negative for city and raw samples. Regression analysis showed that for city and raw rice, cooking time had a significant negative contribution to price [Table 49). However, it did not have any contribution to price of rural samples (Table 6). For Pajam rice, it had a significant negative contribution (Table 10).

Elongation ratio. This ratio is determined on 15 whole cooked and raw grains selected from rice prewashed in water 30 min before cooking for 10 min. Elongation ratio varied between 1.2 and 1.9 for city samples and between 1.3 and 1.7 for rural samples, the average being 1.45 for both samples. Most samples had values between 1.3 and 1.5. Raw rice had a higher value than parboiled rice (Table 8). Although the correlation values with other properties were low, they had an unexpected negative correlation with price. Since most of the values were very close, a regression analysis was not done.

Imbibition ratio. This is determined by obtaining the ratio of volume of cooked rice to that of uncooked rice. The volumes of cooked and uncooked rice are determined by water displacement. The volume expansion varied between 3.1 and 4.5 for city samples (av 4.27) and between 3.4 and 4.9 for rural samples (av 4.17). Variation was not observed among the different samples except in Rajshahi city samples (Table 3,5).

The correlation matrix showed that it had a positive correlation with price, L-B ratio, and amylose content and a negative correlation with 1,000-grain weight, alkali spreading value, EWC, gel consistency, cooking time, and elongation ratio. The correlation values for alkali spreading value, amylose content, and cooking time were low. For city, raw, and Pajam rice, it had a significant positive contribution to price but surprisingly no contribution among the rural samples (Table 4, 6, 9, 10).

Pajam, Purbachi, IRRI, and Aman are some of the more popular and readily available commercial grades of rice in the Bangladesh markets. It was assumed that within grades, no variation in intrinsic properties exists. Thus, regression analysis was done only on acquired properties to find their contribution to price. It was observed that moisture content had a significant negative contribution in all grades except IRRI rice (Table 10). Yellow grains and cooking time had significant negative contributions and imbibition ratio had a significant positive contribution.

The price difference from one region to another depends on marketing costs and also on income which influences demand for grain properties. People living in capital and port cities—as Dhaka and Rajshahi—have comparatively higher income. Rice is also sold at a higher price in these cities than in the other two cities where people have comparatively lower income. The city people have higher income than rural people.

Elasticity of price with respect to rice quality characteristics showed that 1,000-grain weight, L-B ratio, moisture content, cooking time, and imbibition ratio (which had either negative or positive contribution to price) had the greatest influence in Dhaka city markets and the least impact in Rajshahi city markets. In rural markets, among the significant contributing properties, amylose content had the least influence in the Dhaka region while 1,000-grain weight had the least influence in the Khulna region. Moisture content, cooking time, and imbibition ratio had the greatest influence on the price of Pajam rice.

Summary and conclusions

Prices vary from market to market both in the cities and in the rural areas. Sometimes the variation is statistically significant and sometimes it is not. There is variation in price between city and rural samples, the former being higher. Similar grades of parboiled and raw rice are sold at the same price.

The properties of commercial grades are of two types: intrinsic and acquired. Both properties may influence market price either positively or negatively. Appearance, degree of polishing, length, L-B ratio, amylose content, elongation ratio, and imbibition ratio are expected to have positive effects. Grain chalkiness, breadth, 1,000-grain weight, weight/length, contrasting grains, yellow grains, broken grains, damaged grains, black grains, moisture content, alkali spreading value, EWC, and cooking time are expected to have a negative influence on price.

Appearance is an acquired characteristic which is influenced mainly by degree of polishing and brightness of grains. As expected, it has a positive correlation with price. Regression analysis to find its contribution to price is considered redundant as it shows a high correlation with most of the properties.

Thousand-grain weight is another intrinsic characteristic related to the coarseness of grain. Although the L-B ratio is a measure of coarseness, 1,000-grain weight gives a better indication of coarseness among Bangladesh rices. Thousand-grain weight has a low correlation with L-B ratio and a negative contribution to price of parboiled rice in city and rural markets; for raw rice, it has an insignificant negative contribution. This relationship indicates that parboiled fine rice is sold at a higher price; the same is expected of raw rice, but this is not observed for undetermined reasons.

Length, breadth, and L-B ratio, intrinsic characteristics of rice grains, are highly correlated. Therefore, regression analysis is done only on L-B ratio. As expected, it has a significant positive contribution to price for all markets except in Chittagong where it has an insignificant negative contribution.

The presence of broken grains depends on some intrinsic characteristics as well as on improper drying. Broken grains correlate positively with length and L-B ratio and negatively with breadth, indicating that length of grain has a greater influence on broken grains. In rural samples and raw rice samples, broken grains have a low negative significant contribution to price. In the city markets, brokens have an insignificant contribution to price, which is not expected. The commercial grades for city markets are processed in big rice mills where small brokens are generally separated out. This practice is not followed in small rice mills where rice is processed for rural markets. This may explain the positive and negative contribution observed in city and rural markets, respectively.

Moisture content in many samples is high. Rice traders sometimes keep moisture high to have a higher milling outturn. Moisture content has a negative significant contribution to price among city and raw samples but a negative insignificant contribution among rural rice samples which, in general, have high moisture content with little variation from sample to sample.

Imbibition ratio is a property preferred by rural people because it is more “filling.” Urban people, particularly the well-to-do, do not bother about imbibition ratio. Surprisingly, imbibition ratio has a significant positive contribution to price in city markets and has insignificant positive contribution to price of raw rice in rural samples.

Since it is not expected that within a grade there would be variation in intrinsic properties, regression analysis is done on acquired properties of four commercial grades to determine their contribution to price. Pajam is a fine-grade rice while Purbachi, IRRI, and Aman are coarse-grade rices. Only four acquired properties of Pajam have a significant contribution to price. Data show that acquired properties influence the price of only fine-grade rice, since coarse rice is consumed by the lower income group who give low priority to rice grain quality.

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Rice grain quality and the marketing system

Socioeconomic evaluation of rough rice and milled rice quality at commercial mill levels in West Java[1]

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The adoption of high-yielding varieties (HYVs) in Indonesia brought about major changes not only in preharvest production management but also in postharvest processes which include treatment of the rice grain. The biological properties of HYVs and some other factors changed the way rice grain is treated in postharvest processes. For example, a shorter growth period increases wet-season harvest; shattering changes the form of rice grain; and shorter plant height that necessitates the use of sickles causes incorporation of immature grains during harvest due to variation in grain maturity.

It was not common for farmers to use custom milling of rice for home consumption until the late 1960s. As the small milling industry developed in the early 1970s, farmers began to use custom milling at a low cost. The development of milling mechanization in Java was generated by government measures and by sales promotion by the private sector. As a result, a great amount of quantity loss was averted, and many rural women were liberated from the drudgery of hand-pounding work.

There is wide diversity in the size and type of rice mill operations in Java. In the Javanese context, small mills are classified as those that can process less than 1 t rice/d; the medium-sized mills can process 1-2 t; and large mills can handle more than 2 t. With the exception of a small number of very large mills, the majority of the medium- and large-scale mills have been developed by linking together a series of small hullers, polishers, and separators. The smaller milling units are linked together with a mechanical assembly belt, while manual labor is employed to transfer the rice from the hullers to the separators and on to the polishers. The tendency of the mills to expand

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by putting together a series of small milling units provides them with flexibility to simultaneously operate at different levels of milling, cleaning, and polishing.

Between 1970 and 1985, there has been a major changeover from the Engelberg type of mills to the smaller Japanese and Taiwanese rice mills. The newer milling technology relies on rubber roll huskers combined with some form of polisher. It is more flexible than the Engelberg-type mills. Many of the smaller rice mills which are not equipped with a paddy separator or rotating grader have difficulty milling rice to government procurement standards (BULOG 1987). Modern rice varieties (MVs) have thicker husks and tend to be more brittle than traditional varieties (TVs). Consequently, milling recovery rates of MVs average 66% (CBS 1986) compared with 70% of TVs (BULOG 1978).

Moisture content, cleanliness, and variety are the quality indicators usually used by the mills to buy rough rice. On the other hand, the government procures rough rice based on physical storage characteristics only. The rice mills dry and clean the rough rice, although preliminary drying and cleaning may be conducted by the farmers. The rice mills grade, pack, and label milled rice for shipment to wholesale and retail markets (Harteveld 1986, BULOG 1987).

The objectives of this study were to

1. investigate the nature of incentives and factors that determine the degree of postharvest technology and handling used by processors,

2. evaluate the existing quality assessment method used by the mill for rough rice and milled rice, and

3. evaluatefactors that determine the variability of net profit earned by the mill and its responsiveness to change in input factor price.

Research methodology

Field survey

A field survey was conducted at the mill level in West Java to gather information on rough rice quality assessment and postharvest factors affecting grain quality. Fifty-three commercial rice mills in four districts (Karawang, Subang, Sumedang, and Cianjur) were randomly selected during the peak milling period in the 1987-88 wet season. From each mill, samples of rough rice at the point of first purchase and just before milling were collected. Milled rice samples were also collected and grouped according to brand. All samples were analyzed for physical and chemical characteristics at the Grain Quality Laboratory of the Sukamandi Research Institute for Food Crops (SURIF).

Grain quality assessment. Characteristics of rough rice identified by the mills as price determinants were analyzed—moisture content, empty grains/foreign material, opaque grains, yellow grains, and milling recovery rate. For milled rice, the characteristics analyzed were head rice, whiteness, milling degree, yellow grains, chalkiness, and amylose content. Input and output data were also collected to estimate the profitability of milling activities.

Results and discussion

Physical characteristics of rough and milled rices

Table 1 presents a summary of physical characteristics of rough and milled rice samples collected at the mill level. The average head rice is approximately 79%; however, this can go as high as 95% and as low as 50%. Milling degree of milled rice varied from 70% to as high as 95%, with an average of approximately 85%. The moisture content of milled rice was reported to be about 15% on the average, higher than the "ideal" 14% under laboratory conditions.

The quality of milled rice is highly dependent on the quality of rough rice purchased by the mills. Data from this survey show that rough rice bought by the mills was quite wet, had a relatively high percentage of empty grains and foreign materials, a high percentage of damaged grains, and a moderate amount of opaque grains.

The empty grains and foreign material contained in rough rice averaged 4.15%. There was a great deal of apparent variation in foreign material and empty grain content. At the mill level, this ranged from 1.60 to 18.83% of rough rice.

On the average, less than 2% of rice was composed of opaque grains, levels of which varied from 0.06% to as high as 7.22% of rough rice. Level of yellow grains, indicative of damage during harvest or first drying, was 3.24% on the average.

Millers reported that in the immediate postharvest period, less than one-fourth of the rough rice had received primary drying in farmers' fields while more than three-fourths had been sold wet direct from the fields (Tabor 1988). In this survey, the moisture levels refer to those of rough rice available at the mills; therefore, there may be rough rice already partly dried and rough rice just brought in from the fields, or a mixture of both. In the immediate postharvest period, moisture content of rough rice could range between 27 and 22%. After drying, rough rice at an average 14% moisture content is milled; however, premilling moisture content could be as high as 17% (Table 1).

Recovery rates depend heavily on moisture content of rough rice and damaged grain (Tomomatsu and Halim 1989). The rough rice samples collected at the mills were

Table 1. Physical characteristics of rough and milled rice at the mill level in West Java, Indonesia, 1988.

Characteristic[a]	Average	Minimum	Maximum
Head rice	79.06	50.00	95.00
Whiteness	51.56	44.25	55.13
Yellow grains	1.10	0.18	3.87
Milling degree	85.28	70.00	95.00
Moisture content	14.79	13.00	16.00
Milling recovery rate	62.60	40.00	71.43
Initial moisture content of rough rice	18.00	22.30	27.00
Milling moisture content of rough rice	14.00	17.00	15.25
Empty grains	4.15	1.60	18.83
Opaque grains	1.58	0.06	7.22
Yellow grains of rough rice	3.24	0.69	8.51

[a] Expressed in percentage.

sent to the Grain Quality Laboratory where they were hand-milled under "ideal milling conditions"—i.e., 60.3% average recovery rate (Tabor 1988). In this particular sample, the rates varied between 40 and 71.43% but the average recovery rate was approximately 62.60%, which is about the same as that under ideal milling conditions. This indicates that the quality of rough rice monitored during the survey was relatively good. Average head rice content was 79.04%, average whiteness score was 51.56%, and average yellow grain content reached 1.10% (Table 1).

Socioeconomic characteristics

The overall socioeconomic characteristics of rice mills in West Java are presented in Table 2. Varying from 1 to 20 t, the average daily mill capacity was about 5.76 t. The average purchase price paid for rough rice varied from Rp 190 to Rp 290 for a kilogram of TV. The wide range of difference in the value of rough rice indicated the difference in quality between MVs and TVs.

Operational characteristics of mills. At the time of the survey, the average amount of rough rice milled was about 7.29 t/d, which was above the average milling capacity of 5.76 t. This figure is understandable particularly during the peak season when more farmers avail of mill services for their postharvest activities.

Rough rice milled during the survey varied from 0.4 to 25 t/d; such a wide range is explained largely by the difference in mill sizes. Meanwhile, the amount of milled rice produced from the abovementioned rough rice varied from 2.64 to 16.25 t/d (Table 2).

The mills reported that milling charges depend on the by product extraction rate. After milling, the farmer gets the milled rice while the miller retains the byproducts which include brewer's grain and bran. The higher the milling degree and the lower the milling recovery, the greater the amount of brewer's grain and bran retained as byproducts.

The results of the survey showed that the average brewer's grain produced from 7.29 t of rough rice was about 83.57 kg or about 0.01 kg brewer's grain/kg of rough rice. From 7.29 t rough rice milled, about 353.59 kg bran was also produced (or about 0.05 kg bran/kg rough rice. The average selling price of brewer's grain and bran was reported to be about Rp 227.93kg and Rp 99.54/kg, respectively. Meanwhile, the average additional income earned from selling brewer's grain and bran was about Rp 3.85 and Rp 8.05/kg of milled rice, respectively (Table 2).

Processing and marketing costs. The postharvest processing cost includes the costs of farm-to-mill transportation, loading and unloading, drying, milling, and others. Transportation cost reportedly varied from Rp 1 to Rp 10/kg of rough rice, with an average of about Rp 4.50/kg. The wide range of transportation cost was mainly due to the differences in road conditions and in the distance between farm and mill. Loading and unloading cost was relatively small and varied from Rp 0.50 to Rp 5.00/kg of rough rice. Milling cost reportedly varied from Rp2.50 to Rp 17.50/kg. Again, this wide range of milling cost reflected the difference in rice variety (MVs and TVs), inasmuch as cost is proportional to the value of rice. Other postharvest processing costs ranged from Rp 0.50 to Rp 4.00/kg rough rice.

Table 2. Socioeconomic characteristics of rice mills, West Java, Indonesia, 1988.

Characteristic	Average	Minimum	Standard
Mill capacity (t/d)	5.76	1.00	20.00
Mill vintage[a]	1.91	1.00	3.00
Price of rough rice (Rp/kg)	244.53	190.00	290.00
Transportation cost of rough rice (Rp/kg)	4.46	1.00	10.00
Loading and unloading cost (Rp/kg)	1.67	0.50	5.00
Drying cost (Rp/kg)	2.38	1.25	6.00
Milling cost (Rp/kg of milled rice)	9.14	2.50	17.50
Other costs (Rp/kg)	1.87	0.50	4.00
Amount of rough rice milled (t/d)	7.30	0.40	25.00
Milled rice produced (t/d)	4.68	0.26	16.25
Brewer (kg/d)	83.57	2.00	396.00
Price of brewer (Rp/kg)	227.93	100.00	350.00
Bran (kg/d)	353.59	9.00	1625.00
Price of bran (Rp/kg)	99.54	35.00	200.00
Additional income from brewer (RP/kg rice)	3.85	0.03	21.46
Additional income from bran (Rp/kg rice)	8.05	0.95	24.53
Transportation cost of milled rice (Rp/kg)	8.57	1.00	20.00
Loading and unloading of milled rice (Rp/kg)	1.31	0.10	5.00
Commission (Rp/kg)[2]	2.75	0.30	9.00
Price of milled rice (Rp/kg)	424.71	380.00	670.00
Mill profit (Rp/kg)	18.15	1.50	45.96

[a]Vintage refers to the average age of the equipment: 1 = mills with equipment < 3 yr old, 2 = mills with equipment between 3 and 5 yr old, and 3 = mills with equipment > 5 yr old (Tabor 1988). [2]Commission is paid to a man who acts as an intermediary between mills and farmers or rice collectors.

For the purpose of marketing their milled rice, mills incurred expenses to cover transportation cost from the mill to the market, loading and unloading cost, and commission. Transportation cost varied from Rp 1 to Rp 20/kg of milled rice with an average of Rp 8.57/kg, while average loading and unloading cost was about Rp 1.31/kg. Commissions accounted for about Rp 2.75kg of rice. Mills sold their milled rice at Rp 424.7l/kg, varying from Rp 380.00 (MVs) to Rp 670.00 (TVs). Finally, the net profit earned by the mills in their postproduction activities varied from Rp 1.50 to Rp 45.96/kg of milled rice (Table 2).

Specifically, processing and marketing costs are also classified according to mill capacity. For example, the lowest total cost of about Rp 17.15/kg of rough rice was paid by a mill with capacity ranging from 5 to less than 8 t/d. Total cost of postharvest activities include transportation, loading and unloading, drying, milling, and other costs. Among the cost components, milling cost was the highest for all sizes of mills. The data also indicate that the total processing cost increased for mills with milling capacity of >8 t/d—about Rp 20.89kg of rough rice (Table 3).

Similarly, marketing costs were lowest for mills with capacity between 5 and <8 t/d (only Rp 9.18/kg of rice). Meanwhile, transportation cost seemed to be the most important variable cost for all mills (Table 4).

Table 3. Cost of milling activities, by milling capacity, West Java, Indonesia, 1987.

Type of cost (Rp/kg)	Milling Capacity (t/d)		
	1-<5	5-<8	>8
Transportation cost	4.65	3.25	5.57
Loading and loading cost	1.25	1.45	2.42
Drying cost	2.38	2.07	3.50
Milling cost	9.52	9.38	1.15
Commission	2.63	1.00	8.25
Total	20.43	17.15	20.89

Table 4. Marketing cost of milled rice paid by the mills, West Java, Indonesia, 1987.

Type of cost (Rp/kg)	Milling capacity (t/d)		
	1-<5	5-<8	>8
Transportation cost	9.13	7.09	9.00
Loading and unloading cost	1.61	0.96	1.25
Commission	3.55	1.13	2.60
Total	14.29	9.18	12.85

Table 5. Quality characteristics used by mills for grading milled rice, West Java, Indonesia, 1987.

Characteristic	Percentage of mills using these criteria
Head rice	89.09
Milling degree	87.27
Moisture content	43.64
Mixed grains	36.36

Rice quality assessment. Some quality characteristics preferred by the mills in grading their milled rice were head rice, milling degree, moisture content, and mixed rice. The survey reported that most mills used head rice to determine the grade of their milled rice (e.g., 89.09% of 53 mills interviewed). The second best characteristic was milling degree used by about 87.27% of mills for product grading. Only a few mills (36.36%) used mixed rice as a criterion to determine rice grade (Table 5).

Some rice quality criteria were particularly important in determining the price mills were willing to pay to the farmer or collector. For about 28.97% of the rice mills, moisture content was the most important price determinant; for 27.59% of the mills, it was empty and mixed grain; while 16.55% considered grain appearance (filled grain, shape, and surface of the rough rice grain). Another 10.34% considered green and broken grain as the most important characteristic (Table 6). Other criteria used by the mills to determine price of rough rice were size of grain, smell, and duration of the grain in storage.

Table 6. Quality characteristics used by mills to determine quality of rough rice, West Java, Indonesia, 1987.

Characteristic	Percentage of mills using these criteria
Moisture content	28.97
Green and damaged grains	10.34
Milling recovery	4.14
Appearance	16.55
Empty grains	27.59
Varieties	2.76
Others	8.97

Table 7. Net profit (Rp/kg) of mills, by market location, West Java, Indonesia, 1987.

Market	Average	Maximum	Minimum
Local market	19.93	37.40	6.72
Small town market	30.02	42.46	12.08
Provincial market	15.31	34.38	1.50
Jakarta market	17.44	45.96	2.65

Table 8. Net profit (Rp/kg) of mills, by type of transaction, West Java, Indonesia, 1987.

Place of transaction	Average	Maximum	Minimum
Direct to buyer	18.88	45.96	1.50
At the mill site	16.10	40.13	2.65

Profits of mills. The net profits of rice millers based on various classifications are presented in Tables 7, 8, 9, and 10. Mills usually bring their products to local markets, small town markets, provincial capital markets, and to metropolitan Jakarta. The highest average net income per kilogram of milled rice earned by the mills in small town markets was about Rp 30.02. The wide range of profit (Rp 12.08-Rp 42.46/kg) may be explained by the differences in the quality of rice marketed. Meanwhile, the mills obtained the lowest net profit from provincial capital markets, receiving only Rp 15.31/kg (Table 3).

In contrast with mills which sold milled rice to buyers who went there, mills earned a net profit of about Rp l8.88/kg when they transported and sold their product directly to buyers (Table 8).

Rice brand is another factor which determines the net profit of the mills. Brand 2 was the most profitable, giving the mills anet profit of about Rp 21.44/kg of milled rice marketed. The lowest net profit (Rp 13.56/kg) was given by brand 3 (Table 9).

From the point of view of profit, the most efficient mill size was that with about 5-4 t/d capacity. This mill size also showed the smallest range of profit variation (Rp 3.65-Rp 37.63/kg). Mills with >8 t/d capacity obtained a net profit of only Rp 14.89/

kg of milled rice (Table 10). Brewer's grain and bran generated an additional income of about Rp 3.85 and Rp 8.05/kg of milled rice, respectively (Table 11).

Simple correlation analysis

On the average, there are no particularly strong correlations between vintage and milling capacity and between cost of milling and either quality of rough rice or quality of rice milled under ideal conditions. This implies that the quality of rough rice milled is relatively independent of the primary characteristics of the mill. The results showed that smaller mills charged higher milling fees than the larger mills. In almost all cases, mills with a capacity of <2 t/d reported higher milling charges than did those with a capacity >2 t. This strong negative correlation between milling capacity and milling charges indicates positive economies of scale in milling at least through the medium-scale range of mills (Table 12).

As expected, the price paid for rough rice was inversely related to moisture content of rough rice. In West Java, the higher price of rough rice was associated with higher whiteness content, higher amylose content, lower chalkiness level, and greater volume expansion. There was a strong positive correlation between the price paid for rough rice and the price received for milled rice, a sign of arelatively good price transmission from the mill to the farmgate level.

There was a clear negative relationship between ideal rice milling recovery rate and the mount of empty grains and foreign materials found in rough rice. A small association between amylose level and opaque grain content was found, but this

Table 9. Net profit (Rp/kg) of mills, by brand group, West Java, Indonesia, 1987.

Brand[a]	Average	Maximum	Minimum
Brand 1	17.73	40.13	1.50
Brand 2	21.44	45.96	4.64
Brand 3	13.56	42.46	2.76

[a] Brand 1: local varieties; brand 2: modern varieties; brand 3: without mark.

Table 10. Net profit (Rp/kg) of mills, by milling capacity, West Java, Indonesia, 1987.

Milling capacity (t/d)	Average	Maximum	Minimum
1-<5	18.99	45.96	2.65
5-<8	19.79	37.63	3.65
> 8	14.89	37.40	1.50

Table 11. Additional returns (Rp/kg) from byproducts produced by the mills, West Java, Indonesia, 1987.

By product	Average	Maximum	Minimum
Brewer	3.85	21.64	0.30
Bran	8.05	24.53	0.95

Table 12. Correlation matrix of characteristics of rough rice, West Java, Indonesia, 1987.[a]

	WHI	HEA	DBR	AMI	YLL	CKY	TRA	VOL	MLRC	MOCG	EGF	OPQG	YLLG	HGB	PMLR	VTG	CPCI	MILC
WHI	1.00																	
HEA	–0.25	1.00																
DBR	0.43	–0.42	1.00															
AMI	–0.10	–0.32	0.58	1.00														
YLL	–0.19	0.09	–0.32	–0.07	1.00													
CKY	0.31	0.21	–0.29	–0.41	0.32	1.00												
TRA	0.17	–0.01	–0.05	–0.23	0.22	0.50	1.00											
VOL	0.06	–0.09	0.32	0.35	–0.01	–0.34	–0.10	1.00										
MLRC	–0.21	0.09	–0.28	–0.08	0.05	0.05	0.01	–0.14	1.00									
MOCG	–0.11	0.14	–0.09	–0.13	–0.02	0.14	0.19	–0.21	0.12	1.00								
EGF	0.25	–0.20	0.47	0.29	–0.10	–0.25	–0.04	0.25	–0.71	–0.26	1.00							
OPQG	0.11	–0.15	0.30	0.32	0.20	–0.13	–0.13	0.36	–0.32	–0.16	0.19	1.00						
YLLG	0.02	0.14	–0.27	–0.18	0.53	0.37	0.30	–0.24	–0.07	–0.07	–0.06	0.30	1.00					
HGB	0.28	–0.18	0.63	0.43	–0.14	–0.37	–0.17	0.40	–0.33	–0.28	0.66	0.28	–0.13	1.00				
PMLR	0.54	–0.35	0.78	0.34	–0.32	–0.12	–0.20	0.07	–0.18	0.07	0.37	0.07	–0.17	0.44	1.00			
VTG	–0.28	0.02	–0.14	0.22	0.17	–0.11	0.06	–0.01	–0.04	–0.04	–0.06	0.06	0.16	–0.25	–0.21	1.00		
CPCT	0.17	0.12	–0.11	–0.23	–0.12	0.28	–0.03	–0.13	0.20	0.20	–0.05	–0.18	0.02	0.03	0.10	–0.32	1.00	
MILC	–0.13	0.18	–0.20	–0.11	0.03	0.09	0.13	–0.25	0.07	0.20	–0.02	–0.17	–0.03	–0.35	–0.25	0.27	–0.42	1.00

[a] WHI =whiteness of rice, HEA = head rice, DBR = dummy variable for traditional brand choice, AMI = amylose content of rice, YLL = yellow grains of rice, CKY = chalkiness of rice, TRA =translucency of rice, VOL = volume of rice, MLRC = milling rocovery, MOCG = moisture content of rough rice, EGF = empty grains and foreign materials.

appeared to be related to harvesting practices for particular varieties rather than to an intrinsic property of opaque grains. There was, as expected, a positive association between yellow grain content of milled rice and that of rough rice (Table 12).

Conclusions

Data on rice mill activities collected in West Java show a wide range of differences in the price of rough rice, reflecting the differences existing between MVs and TVs. Among postharvest cost components, milling cost is highest for all sizes of mills; the lowest marketing cost is incurred by mills with a milling capacity of about 5-8 t/d. For all sizes of mills, transportation costs seem to be the main variable cost in marketing.

Variability in transportation cost is mainly due to differences in road conditions and the distance between the farm and the mill. The variation in milling charges is determined by the byproduct extraction rate. The higher the extraction rate and the higher the milling degree, the greater the amount of brewer's grain and bran retained as byproducts.

The mills could receive the highest average net profit per kilogram of milled rice (about Rp 30) if they market their product in small towns. The lowest average net profit (about Rp 15/kg) is earned by mills which sold milled rice at the provincial capital. The type of rice mill also determines the net profit of the mills and the most efficient mill size which generates the highest net profit is that with 5-8 t/d capacity.

Head rice, milling degree, moisture content, and mixed rice are the quality characteristics used by the mills in grading their milled rice. Moisture content is the most important price determinant of rough rice. Empty and mixed grain, grain appearance, and green and broken grains are the other factors which reportedly determine the price of rough rice. Prices of rough and milled rice are correlated in a similar fashion for most quality characteristics, indicating good transmission of quality incentives.

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The impact of postharvest operations on rough rice and milled rice quality in the Philippines[1]

E.P. Bonifacio and B. Duff[2]

Rough rice is transformed into a consumable product through a series of farm and market activities which terminate at the consumer's table. The efficiency of the rice postharvest system as measured by quantitative losses has been the focus of a large number of farm and mill level studies over the last decade (Araullo et al 1974, Manalabe 1987). A majority of solutions have focused on technology as the answer to the inefficiencies in the rice postharvest system. While there is a general consensus that quantitative losses are significant and should be reduced, very little attention has been paid to the nature or value of qualitative losses or the economic incentives required to ensure adoption of technology to improve grain quality. The economics of losses has been ignored, as has the impact of new technology on the distribution of benefits among the agents of the marketing system—farmers, processors, traders, retailers, and consumers. It remains to be determined if the benefits of higher efficiency in the processing of rice translate into higher farm-level prices for good quality rough rice.

In this chapter, an attempt is made to identify the potential for improving rice quality at the mill level through the use of loss assessment and hedonic pricing techniques. Specifically, the objectives were to:

1. evaluate rough rice and milled rice quality,
2. determine quality changes resulting from milling and premilling operations, and
3. estimate the implicit values for rough rice and milled rice quality characteristics at the mill level.

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Research methodology

To capture quality differences across regions, the major rice-producing and rice-consuming areas (Luzon, Visayas, and Mindanao) were identified using a 5-yr average of surplus-deficit data. Major rice-surplus areas identified were Nueva Ecija, Iloilo, and North Cotabato. Rice-deficit areas were Metro Manila, Cebu City, and Davao City (Fig. 1). The analysis was based on 65 samples collected from 11 Engelberg mills (16 from Round 1 and 49 from Round 2), 7.4 samples from 14 village rubber roll mills (26 from Round 1 and 48 from Round 2), and 112 samples from 34 commercial mills (36 from Round 1 and 76 from Round 2).[3]

Changes in grain quality produced during milling and production operations were assessed for each mill type following the grain quality loss assessment procedure illustrated in Figure 2. Samples of rough rice collected from the mills were analyzed for moisture content, immature grains, dockage, grain shape, and cracked grain. A portion of each sample was also submitted for laboratory milling and subsequently analyzed for milling recovery, milling degree, percent head rice recovery, purity, chalkiness, percent yellow grains, whiteness, shape, apparent amylose content, gel consistency, and alkali spreading value. Milled rice samples were also collected from each mill and analyzed for comparable characteristics identified in the laboratory analysis of rough rice samples.[4]

Quality losses resulting from production and milling operations were evaluated by comparing the quality characteristics obtained from field samples of rough rice and milled rice with check samples obtained from closely controlled production and postproduction operations. The results permitted comparison of a) rough rice samples after processing using the same milling and quality assessment procedures employed with check samples; b) milled rice samples obtained from actual field milling with check samples obtained using an optimized assessment procedure. The significance of differences in losses was evaluated using analysis of variance techniques.

The implicit values of milled rice quality characteristics[5] were estimated using the consumer goods characteristics model (CGCM) developed by Ladd and Suvannunt (1976) (see Unnevehr 1992). For rice, the CGCM is expressed mathematically as:

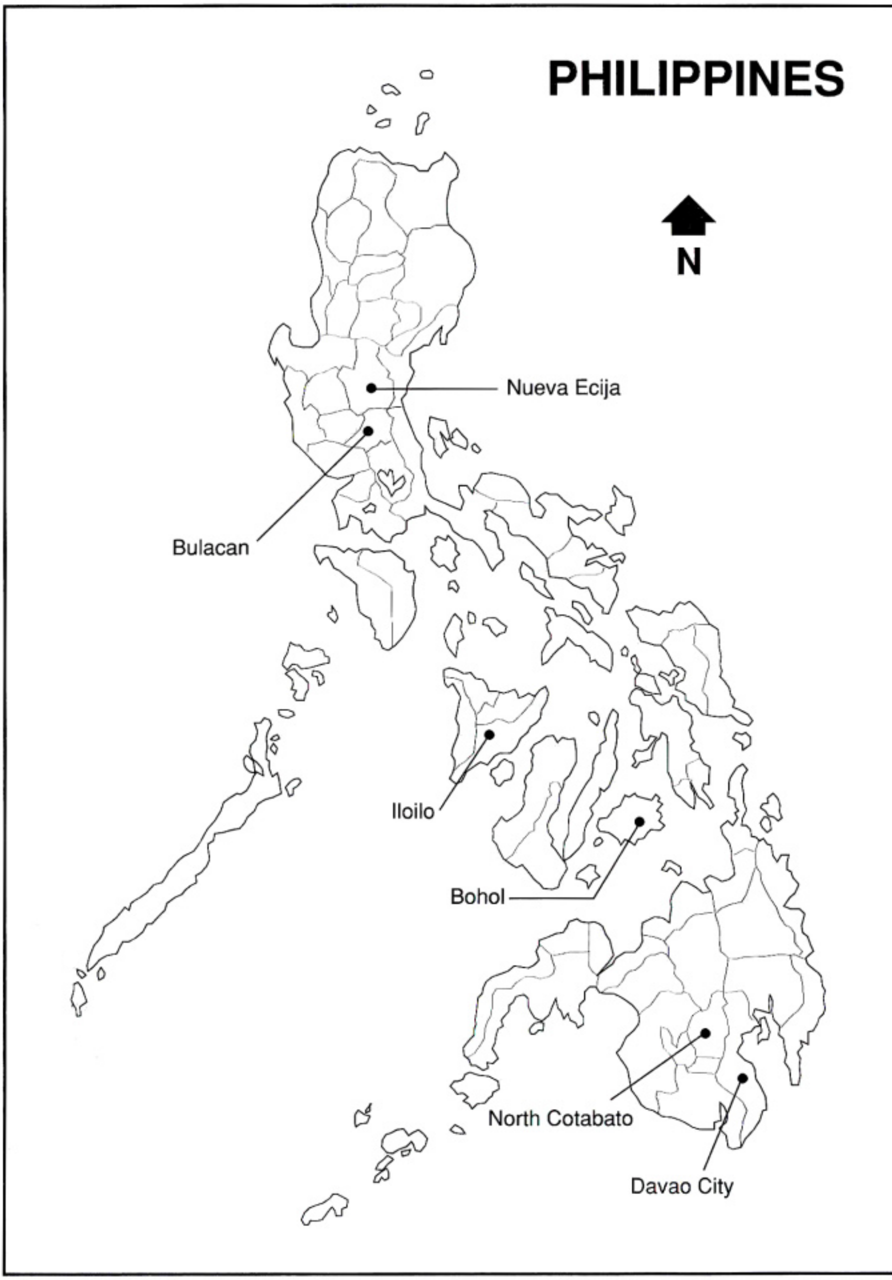
$$Pr = \sum_{j=1}^{m} X_{rj}\, P_{rj}$$

where P_r = price of rough/milled rice, X_{rj} = quantity of rough/milled rice characteristic j, P_{rj} = implicit price of rough/milled rice characteristic j, and j = rough/milled rice characteristic.

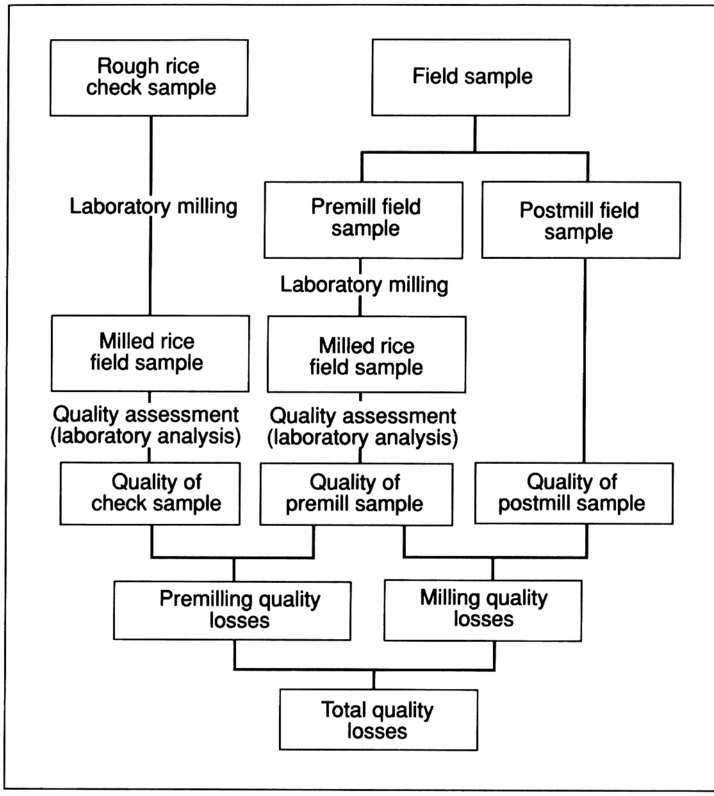
[3] Interviews and sample collection during Round 1 were conducted during the peak milling period in May and June 1987. Round 2 was conducted during the peak milling period in Novembcr and December 1987,

[4] Rough rice and milled rice samples were analyzed for physical and chemical characteristics at the Grain Quality Laboratory or the IRRI Plant Breeding Depertment (Appendix 2a,b).

[5] A short description of rice characteristics (i.e., head rice, purity, shape, gel consistency, apparent amylose content, and alkali spreading value) and their expected relationship with price is found in Appendix 3.



1. Survey sites of mill-level grain quality study.



2. The process of rough rice quality assessment.

The hedonic models for milled rice were estimated using ordinary least squares, regressing observed market price on measures of quality. These estimates were used to measure the implicit value of each quality characteristic. Validation of the model was based on interview responses from millers, the results of quality evaluation, and the expected correlation of each characteristic with price.

To test whether rough rice prices reflect milled rice prices, the following regression is also estimated

$$P_P = a + b\,P_R + \sum C_i Y_i$$

where P_p is the price of rough rice, P_R is the price of milled rice, and Y_i are variables influencing rough rice quality only. These include the presence of chalky, immature, or cracked grains and moisture content at sampling.

Differences in grain quality for alternative milling systems

Table 1 illustrates quality differences resulting from premilling and milling operations expressed as percent milling recovery and head rice. The loss assessment procedure outlined in Figure 2 was used to estimate gain quality differences in each milling system.

Table 1. Magnitude of grain quality differences for alternative types of rice mills, Philippines, 1987.

Mill type	Milling recovery (%)	Head rice (%)
Commercial		
(A-B)[a]	0.35	2.58
(B-C [b]	-0.71	9.75**
(A-C)[c]	-0.36	12.36**
Rubber roll		
(A-B)	2.44**	3.10*
(B-C)	2.73**	13.17**
(A-C)	5.17**	16.27**
Engelberg		
(A-B)	2.43**	6.06**
(B-C)	12.26**	23.68**
(A-C)	13.69**	29.74**

[a]Quality losses due to premilling operations. [b]Quality losses due to milling operations. [c]Quality losses due to production operations. * = significantly different from zero at the 5% level. ** = significantly different from zero at the 1% level.

The effect of premilling factors on milling recovery and head rice was found to be insignificant in commercial mills but significant in rubber roll and Engelberg systems. In rubber roll mills, differences of 2.44 and 3.10% were observed in milling recovery and head rice percentage, respectively. For Engelberg mills, the corresponding figures were 2.43 and 6.06%. These values show the extent of losses attributable to premilling factors—i.e., inherent varietal characteristics, production and postproduction operations.

Quality changes produced by milling operations were also investigated. In commercial mills, differences in milling recovery were insignificant at -0.71% but in rubber roll and Engelberg mills, the effect of milling operations on milling recovery was significant, 2.73 and 11.26%, respectively. This represents the milled rice lost for possible human consumption. Significant quantities of milled rice (11.26%) were lost in Engelberg mills, but the byproducts from the milling process were ultimately used for animal feed. Head rice losses were significant in all mill types (commercial mills, 9.75%; rubber roll mills, 13.17%; and Engelberg mills, 23.68%).

Analysis of prices

Table 2 presents the average characteristics of milled rice samples. Only samples from commercial mills were used for the price analysis. The samples collected at the mill level did not show as much variation and variety as the retail samples used for analysis by Abansi et al (1992) and Maranan et al (1992). Retail markets draw on a wide range of suppliers, while local mills may not buy and sell more than a few varieties. In this survey, the samples from Round 2 included a few TVs while no TVs were found among Round 1 samples.

The results of the hedonic price analysis therefore varied across rounds and only a few characteristics were significant in each round. Head rice content and alkali

Table 2. Average characteristics of milled rice samples.

Characteristic	Round 1[a]		Round 2	
Head rice	66.4	(13.1)	6.3	(13.6)
Whiteness	35.6	(4.0)	37.8	(3.0)
Shape	3.2	(0.3)	3.1	(0.3)
Alkali spreading value	5.3	(1.4)	5.0	(1.3)
Amylose	24.1	(1.7)	23.8	(2.9)
Gel consistency	82.3	(15.6)	72.9	(20.6)

[a]Figures in parentheses are standard deviations.

Table 3. Estimates of implicit prices of rice at the mill.[a]

Variable	Round 1	Round 2
Head rice	0.01*	0.01
Whiteness	0.03	–0.03
Shape	–0.29	–1.40**
Alkali spreading value	0.14*	0.11
Amylose	–0.00	–0.05*
Gel consistency	0.00	0.01**
Visayas dummy	–0.20	–0.67**
Mindanao dummy	–0.06	–0.08
Adjusted R^2	0.11	0.42

[a]* = significant at the 10% level. ** = significant at the 1% level.

spreading value were significant determinants of price in Round 1, and the signs of these variables were as expected (Table 3). Shape, gel consistency, and amylose content influenced the price of milled rice in Round 2, and all had the expected signs. Taken together, these results are similar to those in the retail surveys (Abansi et al 1992, Maranan et al 1992): the signs of significant variables match in both. However, these estimates also show that the measurement of implicit prices is highly dependent on variation in the sample.

The regressions of rough rice prices on milled rice prices are shown in Table 4. The price of milled rice is a highly significant determinant of price of rough rice and explains more than 50% of the variation. The measures of chalkiness, cracked grains, immature grains, and moisture content at the time rough rice samples were collected were also included in the regressions. It is hypothesized that these rough rice characteristics might influence the value of rough rice independently of the value of milled rice. Chalkiness had a significant negative effect on price of rough rice in Round 1 while moisture content had a significant positive effect. The samples collected during the dry season had fairly low moisture content (12.3% av), and those that were overdried had lower milling recovery. In Round 2, none of the added variables had a significant influence on rough rice prices.

The fact that milled rice prices are the principal determinants of rough rice prices means that any quality premiums in milled rice prices are reflected in some fashion in

Table 4. Estimates of rough rice determinants. [a]

Variable	Round 1	Round 2
Milled rice	0.43**	0.42*
Chalkiness	–0.02*	–0.02
Cracked grains	0.01	–0.00
Immature grains	0.01	0.02*
Moisture content	0.07*	0.00
Adjusted R^2	0.50	0.57

[a] * = significant at the 10% level. ** = significant at the 1% level.

Table 5. Correlations of milled rice and rough rice prices with quality characteristics.

	Round 1		Round 2	
	Rough rice price	Milled rice price	Rough rice price	Milled rice price
Head rice	–.01	.14	–.04	–.17
Whiteness	.12	–.06	–.12	–.10
Shape	–.30	–.19	–.56	–.56
Alkali spreading value	.12	.37	.15	.09
Amylose	.09	.28	–.08	–.09
Gel consistency	–.30	–.22	–.10	.06

rough rice prices. To further examine this issue, simple correlation coefficients between both prices and quality characteristics were compared (Table 5). In general, rough rice prices were correlated with quality in the same way milled rice prices were.

The statistics in Tables 4 and 5 show some transmission of quality incentives from the wholesale level. However, the unexplained variation in rough rice prices was still quite large. It is possible that this variation reflects unmeasured differences in moisture content at the time of sale, since rough rice was sampled after that. In spite of this qualification, the results raise the question of whether there are some imperfections in the transmission of price incentives. Umali and Duff (1992) discuss some of the reasons why the market may not be fully competitive at the mill level.

Finally, it is interesting to look at some of the physical determinants of milling and head rice recovery to see the role of varietal characteristics in milling quality. Chalkiness and crack resistance are two varietal characteristics that determine potential milling recovery, although the actual incidence of these characteristics also depends on production environment and postharvest handling.

Table 6 shows that milling recovery was correlated negatively with cracked grains in both seasons and with chalkiness during the dry season. Head rice recovery was correlated negatively with cracked grains and chalkiness, and positively with milling recovery. These results confirm the role that varietal characteristics play in determining milled rice quality.

Table 6. Correlations between rough rice characteristics and milling recovery.[a]

	Cracked grains	Chalky grains	Milling recovery	Head rice recovery
		Round 1		
Cracked grains	1.00	0.41*	–0.42*	–0.42*
Chalky grains		1.00	–0.29*	–0.23
Milling recovery			1.00	.35*
Head rice recovery				1.00
		Round 2		
Cracked grains	1.00	-0.06	–0.31*	–0.39*
Chalky grains		1.00	.03	–0.20*
Milling recovery			1.00	0.23*
Head rice recovery				1.00

** = significant at the 10% level or better.

Conclusions

This chapter presents an analysis of rough rice and milled rice samples collected at rice mills in three regions of the Philippines. A quality loss analysis compares actual milling and head rice recovery with ideal milling conditions. The total recovery of commercial rice mills does not differ significantly from that obtained under ideal conditions, but their head rice recovery is lower. This result may indicate that incentives to improve head rice recovery are not adequate to cover the costs of improvement.

Milling and head rice recovery in commercial mills are significantly and negatively correlated with incidence of cracked and chalky grains in rough rice samples. This confirms the role that varietal characteristics play in milling recovery.

Hedonic price analysis of milled rice samples from commercial mills shows that head rice, shape, and chemical characteristics are significant determinants of price in one season or another. The results reflect the limited variation in the samples collected, but they do agree with the findings of the retail surveys (Abansi et al 1992, Maranan et al 1992).

Rough rice prices are primarily determined by milled rice prices and are correlated with rice characteristics in the same way milled rice prices are. However, the large unexplained variation in rough rice prices raises questions about whether quality signals are fully transmitted from the consumer to the producer.

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The economics of rough rice quality at the farm level

H. Wedgwood and B. Duff[1]

In a perfectly competitive market, consumer preferences would be transmitted back through the pricing system so that the derived demand at each level in the commodity chain would be directly related to consumer preferences. The prices at lower levels of the marketing chain would be derived from the prices paid by consumers at the terminal markets. Therefore, the premiums consumers are willing to pay for higher quality rice would be reflected at the various marketing levels. However, the actual performance of rice markets does not conform to the perfectly competitive model (see Umali and Duff 1992), and hence, it is not necessarily true that the market will provide adequate incentives to produce high or higher quality grain.

This study seeks to explore the patterns of derived demand for rough rice quality at the farmgate and to relate this to demand for rice quality at other stages in the commodity system. The objectives of the study are to:

1) identify the derived demand parameters for rough rice quality at the farmgate level in the rice marketing system, and

2) estimate the economic incentives and constraints in the private market and government sector to improving rough rice quality at the farm level.

The results examine the actual incentives and constraints to improving quality at the farmer level, since milled rice quality is dependent on rough rice quality, which is largely determined (given the fixed quality embedded in varietal characteristics) at the farm postproduction stage. If improved grain quality is to be achieved, consistent with consumer and market intermediaries' preferences as estimated by the other project components, it is essential that farmers have the incentives to supply good quality rough rice to the market.

Research methodology

The data for the study were generated from a marketing case study conducted in Nueva Ecija in Central Luzon and Metro Manila. This represents the largest marketing system

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[1] Research fellow and agricultural economist, IRRI.

in the Philippines and one which is clearly defined—the former systematically produces the greatest marketable surplus of rough rice in the country and the latter is the largest rice-deficit area. Both areas were included in all other project components, thereby, facilitating comparison and validation of results.

Data were collected in November 1987 to coincide with the local wet season harvest peak inasmuch as farmers tend to sell their surplus rough rice in one transaction right after harvest, and rough rice quality is most problematic during the wet season harvest. Field work was integrated with the rice marketing case study referred to earlier, with details of respondents and sample numbers shown in the data collection matrix below.

Type of respondent	No. of respondents	No. of sample sets
Farmer	82	32
Trader	33	36
Miller	27	21
Wholesaler (large)	5	–
Retailer/wholesaler	33	51
Total	180	140

Since millers were considered the fulcrum of the rice marketing system, a complete enumeration of accessible commercial millers in the districts of Gapan and Muñoz, Nueva Ecija, was carried out. Other respondents were identified using a “snow ball” method which spread from and to the miller. (Gapan and Muñoz have the greatest number of commercial mills in Nueva Ecija, indicating that they supply a large part of the area.)

Information on variety selection, seed source, postproduction activities, variety classification, grading methods, price premiums and discounts for quality characteristics, variety mixing, and marketing costs were obtained. Rough or milled rice samples, obtained from respondents at all levels, were analyzed for various quality characteristics at the IRRI Grain Quality Laboratory.[2]

The laboratory results were used to compare quality across market levels and to estimate implicit values for characteristics at the farmgate and retail levels, These were integrated with the interview responses to assess the actual incentives available to farmers for improving quality and to evaluate the effectiveness of the marketing system in transmitting such incentives back to the commodity source.

Results

A rice grain possesses quality characteristics which are genetically determined. From the market perspective, the supply of quality is already fixed and given in the short term at the consumer/retail level. At the mill level, there are some variable quality factors

[2]See Appendix 2a,b for characteristics analyzed and laboratory procedures used.

which can be affected by cleaning, polishing, etc., but the output of milled rice is still highly dependent on the quality of rough rice entering the system. Given that the supply of variety-determined quality factors (e.g., shape and chemical characteristics) is fixed in the short and medium terms, it is at the farm level that the variable elements of rice grain quality are determined. These include a bundle of characteristics affecting the physical quality of rice such as level of cleanliness and purity, the number of damaged grains, the number of cracked grains, and the degree of discolored grains.

The rice variety is chosen by the farmer, cultivated and subjected to a series of postproduction activities (e.g., harvesting, threshing, cleaning, and drying) before being sold at the farmgate level. Research has shown that varying postproduction techniques affect grain quality and that, perhaps, the processes with the greatest impact are drying and management. Delayed, intermittent, and poor drying will result in rapid overall deterioration of grain quality, notably in the color of the grain and the proportion of cracked or broken grains (Frio and Manilay 1985).

Given the importance of rice variety and postproduction activities for the resulting rice quality, farmers were asked about their presale activities and their choice of seed variety for the 1987 wet season. Table 1 shows that all respondents harvested manually but threshed using machines; 92% cleaned their rough rice using a device incorporated within the threshing machine, and only 1.2% used a separate blower. Sixty-one percent of the farmers sold their rough rice wet, 24% sun-dried before sale, and 15% had not yet sold theirs. Eight percent of those who dried used canvas sacks or netting as the drying floor, 18% dried their rice on the highway, 18% in their backyards, 24% in areas owned by private persons, and 32% in public places such as school yards.

Table 1. Plesale activities of farmers, 1987 wet season.

				Drying before sale		
	Harvesting (%)	Threshing (%)	Cleaning (%)	Method (%)	Type (%)	Location (%)
Manual	100.00	0.00				
Machine	0.00	100.00				
Incorporated with machine			91.50			
Separate blower			1.20			
No response			7.30			
Sun-drying				24.00		
Did not dry				61.30		
Not yet sold				14.70		
Pavement					92.00	
Canvas/sack					4.00	
Combination Pavement/sack					2.00	
Net						2.00
Highway						18.00
House/backyard						18.00
Area owned by others						24.00
Public utility area						32.00
Combination						4.00
No response						4.00

Table 2. Factors that affect harvesting-threshing and threshing-drying intervals, 1987 wet season (% of total respondents).

	Weather	Quantity	Did not dry/fast sale	Thresher/ pavement availability/ schedule	Owns thresher/ pavement	Habit/ management practice	Dry on stem	Time constraint	No response	Total
Harvesting-threshing interval										
Immediate	9.8	29.3	1.2	3.7	3.7	2.4	–	–	3.7	53.7
1 d	–	6.1	1.2	2.4	–	1.2	–	–	–	11.0
2 d	–	3.7	–	6.1	–	2.4	–	–	3.7	15.9
3 d	1.2	2.4	–	1.2	–	–	–	–	1.2	6.1
4 d	–	1.2	–	1.2	–	–	–	–	–	2.4
5 d	–	–	–	1.2	–	–	–	–	–	1.2
6 d	1.2	–	–	–	–	–	1.2	–	–	2.4
7 d	–	–	–	1.2	–	–	–	–	–	1.2
>1 wk	–	–	–	–	–	–	–	–	–	–
No response	–	–	–	–	–	–	–	–	6.1	6.1
Total	12.2	42.7	2.4	17.0	3.7	6.0	1.2	–	14.7	100.0
Threshing-drying interval										
Not applicable	–	–	7.3	–	–	–	–	–	–	7.3
Immediate	8.5	14.6	3.7	2.4	2.4	3.7	–	–	13.4	48.8
1 d	–	–	1.2	1.2	–	2.4	–	–	2.4	7.3
2 d	1.2	1.2	–	7.3	–	–	–	–	–	9.8
3 d	1.2	–	–	1.2	–	–	–	–	–	2.4
4 d	–	–	–	2.4	–	–	–	–	–	2.4
5 d	–	–	–	1.2	–	–	–	1.2	–	2.4
6 d	–	–	–	–	–	–	–	–	–	–
7 d	–	–	–	6.1	–	–	–	–	–	6.1
>1 wk	–	–	–	2.4	–	–	–	–	–	2.4
No response	–	–	–	–	–	–	–	–	11.0	11.0
Total	10.9	15.8	12.2	24.2	2.4	6.1	–	1.2	26.8	99.9

Although all respondents used the same technology for harvesting and threshing, and all those who dried their rough rice before selling sun-dried it, the time interval between these operations varied (Table 2). Respondents knew that operations should immediately succeed each other to better preserve grain quality, but only 54% of them threshed immediately after harvest and only 49% dried immediately after threshing. The second most common interval between harvesting and threshing was 2 d (16%), often dependent on thresher availability. Most respondents (43%) cited quality consideration as the reason for immediate threshing.

The availability of pavement or other drying areas was the major determinant of threshing-drying interval for 24% of the farmers, although quality considerations were also important for 15% of the farmers who dried immediately after threshing. Overall quality was cited as the reason for the threshing-drying interval by only 16% of the respondents.

Table 3 describes how farmers selected varieties. The most common variety selected during the 1987 wet season was IR64 with 73% of farmers planting it. Forty-one percent of the respondents chose it because of its high yield, and 24% mentioned quality as a factor. Across all varieties selected, quality was second only (cited by 32% of the respondents) to yield considerations (cited by 56% of the respondents).

The previous discussion has described the grain quality environment at the farm level before rough rice enters the market. It is evident that quality considerations play a significant role in decisionmaking within the overall matrix of constraints and objectives facing the farmer. A part of this matrix is the marketing system and, within that, the marketing system as it pertains to grain quality.

Table 3. Farmers' reasons for selecting a variety, 1987 wet season (% of total respondents).

Reason	IR42	IR68	IR64	IR8	IR60	IR66	IR36	IR69	R129	IR50	IR32	BP112	Total frequency of reasons across varieties	
													No.	%[a]
% of farmers planting (n = 82)	6.1	6.1	73.2	1.2	2.4	7.3	3.7	1.2	3.7	1.2	1.2	1.2	–	–
Disease, pest resistance	1.2		17.0	1.2						1.2			17	20.6
Good eating quality	1.2	3.7	24.4				1.2		1.2				26	31.7
High selling price	2.4		8.5										9	10.9
Good yield	1.2	4.9	41.5			1.2			2.4			4.9	45	56.1
Early maturing	3	3.6	2.4		1.2									
Past experience			2.4										2	2.4
New variety	1.2	1.2	7.3		1.2	6.1	1.2	1.2			8.5		21	27.9
Extension recommendation	1.2		8.5				1.2						9	10.9
Less inputs			1.2										1	1.2

[a]Percentage will not be equal to 100 because farmers gave multiple responses.

Grain quality and the marketing system

The farmer has two types of rough rice marketing outlets in the Philippines—the public marketing system under the National Food Authority (NFA) and the private system. For rice farmers of Nueva Ecija, the private system refers to sale to either a rice trader or a rice miller. Tables 4 and 5 indicate the pattern of selling followed by farmers.

As part of the overall study, retailers, wholesalers, and millers were also asked about their grading system for milled rice. The grading system at the milled rice level is as nonformal as that for the rough rice market, although there is a greater degree of grade control for some characteristics such as head rice percentage and whiteness through blending of varieties and head rice. Table 6 shows that mixing is common at the level of the rice trader, often because traders deal in small lot sizes. Only 22% of the millers interviewed actually mixed varieties but 25.9% bought premixed batches. At the retail level, 34.2% mixed their stock largely because of price Competition. Thus, good and poor quality batches and varieties would be mixed to ensure greater returns to retailers. However, a significant proportion of the retailers (37%) reported that they did not indulge in this practice because it would jeopardize their reputation.

Table 7 lists the methods used for grading rough rice and milled rice. Visual assessment is the predominant method at all levels. An exception is the mill level where the "hampas" method is more common (cited by 37% of the respondents). This procedure, used only for dry rough rice, consists of dehusking the grain manually by flailing a rough rice sample wrapped in cloth to determine more precisely the proportion of cracked and discolored grains. Other methods used are combination of touch and visual inspection of milled rice, biting, hampas, and visual assessment of rough rice. The touch method allows estimation of the age of milled rice while the bite method allows assessment of moisture content.

Table 8 shows the mean price and quality characteristics of all samples obtained from different market levels. At the farm level, prices were not available because oftentimes rough rice had been sold earlier and the price given may not have

Table 4. Farmers' outlets, 1987 wet season.

	No.	%
Buying station	42	63.6
Rice miller	20	30.3
NFA	4	6.1
Total	66	100.00

Table 5. Timetable for selling rough rice, 1987 wet season.

Time after harvest	%	Cumulative %
≤1day	40	40
>1 day - £ 1 week	42	82
>1 week- 1£ mo	10	92
>1 month	8	100

corresponded exactly to that sample. The farmgate level corresponded to prices received by farmers from rice traders.

All samples were analyzed at the IRRI Grain Quality Laboratory, following standard procedures. Rough rice samples were dehusked and polished in the laboratory mill to generate milled rice characteristics. Hence, samples collected at the milled rice stages (mill output and wholesaler/retailer) have no corresponding rough rice charac-

Table 6. Reasons for mlxing varieties, by market level (% of total respondents)[a]

Reason	Viajero		Millers[b]		Wholesaler/retailer	
	Yes	No	Yes	No	Yes	No
Competition	3.0	–	–	–	21.1	–
Small lot size	21.2	–	–	–	–	–
Same shape/appearance	9.1	–	3.7	–	–	–
Same quality	0.0	–	–	–	–	–
Mixed when drying	9.1	–	–	–	–	–
Bought already mixed	0.0	3.0	11.1	25.9	7.9	5.3
Market for mix	3.0	–	–	–	–	–
Leftovers	–	–	3.7	–	–	–
Milling problems	–	6.1	–	–	–	–
Reputation	–	6.1	–	14.8	–	36.8
Lowers price	–	6.1	–	7.4	–	–
Lowers quality	–	9.1	–	7.4	–	7.9
Other reasons	–	–	–	–	–	–
Combination of reasons	12.1	–	3.7	3.7	–	7.9
No reason given	3.0	9.1	–	18.5	5.2	7.9
Total	60.5	39.5	22.2	77.7	34.2	65.8

[a] Most common combinations: viajero = long-grained good and bad quality varieties; miller = long-grained varieties; retailer = good/bad quality, high/low price. [b] Of the 15 millers who milled mixed grains for whatever reason, only 6 adjusted their mills to make the grain whiter. Only one respondent cited reduction of brokens as a reason.

Table 7. Grading methods, by market level.

Method	Farmer		Trader		Miller (rough rice)		Miller (milled rice)		Wholesaler/ retailer	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Hampas	7	8.5	2	6.1	10	37.0	–	–	–	–
Visual	28	34.1	13	39.4	6	22.2	19	70.4	19	50.0
Touch	–	–	–	–	–	–	–	–	–	–
Bite	1	1.2	–	–	–	–	–	–	–	–
Moisture meter	–	–	–	–	–	–	–	–	–	–
Others	2	2.4	3	9.1	1	3.7	1	3.7	–	–
Combination	17	20.7	15	45.5	10	37.0	3	11.1	13	34.2
None	27	32.9	–	–	–	–	4	14.8	6	15.8
Total	82	99.8	33	100.1	27	99.9	27	100.0	38	100.0

Table 8. Price and quality, by commodity chain level.

Item	Fan level				Farm gate level				Mill level (input)				Hill level (output)				Retail level			
	Mean	Std dev	Min	Max	Mean	Std dev	Min	Max	Mean	Std dev	Min	Max	Mean	Std dev	Min	Max	Mean	Std dev	Min	Max
Price (P/kg)	na	na	na	na	2.82 a	0.20	2.50	3.30	3.19 b	0.42	2.60	4.20	5.38 c	0.54	4.90	6.60	6.72 d	0.83	5.50	8.50
Moisture content (%)	14.20 b	2.64	11.00	21.50	15.81 a	2.06	11.90	19.50	14.18 b	1.36	12.30	17.10	na	na	na	na	na	na	na	na
Immature grains (%)	2.24 b	1.53	0.20	6.70	4.36 a	2.51	0.40	13.00	1.97 b	1.46	0.20	6.50	0.03 c	0.08	0.00	0.30	0.01 c	0.012	0.00	0.13
Dockage (%)	0.35 a	0.41	0.00	1.00	0.29 a	0.42	0.00	1.00	0.46 a	0.36	0.00	1.00	na	na	na	na	na	na	na	na
Length (rough rice) (mm)	10.13 a	0.53	8.50	10.70	9.80 a	0.68	8.40	10.50	9.88 a	0.53	8.30	10.40	na	na	na	na	na	na	na	na
Width (rough rice) (mm)	2.51 a	0.06	2.40	2.70	2.55 a	5.76	2.50	2.70	2.52 a	0.07	2.30	2.60	na	na	na	na	na	na	na	na
Shape (rough rice) (L/W)	4.03 a	0.24	3.15	4.24	3.85 b	0.29	3.23	4.20	3.93 ab	0.20	3.32	4.16	na	na	na	na	na	na	na	na
Cracked grains (%)	7.70 a	6.89	0.00	29.00	8.04 a	6.05	0.00	21.00	11.65 a	7.69	2.70	34.00	na	na	na	na	na	na	na	na
Milling recovery (%)	66.04 a	3.50	52.80	69.20	65.70 a	2.20	58.90	68.60	66.14 a	1.94	62.60	68.60	na	na	na	na	na	na	na	na
Head rice recovery (%)	79.76 a	10.03	44.13	90.16	73.77 a	16.25	27.93	87.03	76.21 a	8.51	57.28	88.97	66.21 b	9.64	48.40	86.10	66.74 b	8.61	52.90	33.60
Brokens (%)	20.24 a	10.03	9.84	55.87	26.23 a	16.25	12.97	72.07	23.79 a	8.51	11.03	42.22	33.79 b	9.64	13.90	51.60	32.94 b	8.61	6.40	47.10
Chalkiness (%)	na	na	10.00	20.00	na	na	1.00	10.00	na	na	10.00	20.00	na	na	1.00	10.00	na	na	1.00	10.00
Yellow grains (%)	1.44 a	0.73	0.70	3.00	1.16 a	0.63	0.00	3.30	1.11 a	0.68	0.30	3.70	1.02 a	1.44	0.00	6.20	1.09 a	0.86	0.10	3.10
Whiteness (%)	37.45 a	3.01	32.40	43.90	37.91 a	2.61	32.10	42.40	38.45 ab	3.64	32.00	47.20	39.84 b	2.29	35.30	44.80	38.39 b	1.92	34.40	42.80
Length (milled rice) (mm)	7.10 ab	0.33	6.20	7.50	6.90 a	0.51	5.90	7.50	7.19 a	0.25	6.50	7.40	6.98 ab	0.24	6.50	7.40	7.06 at	0.24	6.30	7.40
Width (milled rice) (mm)	2.12 a	0.06	2.00	2.30	2.14 a	0.07	2.00	2.30	2.14 a	0.05	2.10	2.20	2.14 a	0.06	2.00	2.20	2.16 a	0.08	2.00	2.40
Shape (milled rice) (L/W)	3.35 ab	0.21	2.70	3.65	3.23 b	0.26	2.68	3.57	3.37 a	0.11	3.10	3.52	3.27 ab	0.09	3.09	3.43	3.27 at	0.18	2.63	3.52
Alkali spreading volume	3.59 a	1.19	2.40	7.00	4.44 ab	1.71	2.00	7.00	4.13 abc	1.22	2.90	7.00	3.92 bc	0.73	2.90	5.70	4.81 a	0.92	3.40	7.00
Gel consistency (mm)	93.91 a	8.94	62.00	100.00	86.92 ab	19.34	32.80	100.00	93.30 a	8.23	70.00	100.00	84.11 b	13.08	55.30	100.00	70.96 1	13.39	31.30	88.30
Amylose content (%)	23.16 ab	1.80	21.00	27.80	24.10 a	2.13	21.40	28.80	23.55 ab	1.40	21.60	26.30	22.96 b	0.89	21.70	25.00	24.18 a	1.31	22.00	27.00
		22				28				19				17				31		

Note: Means followed by the same letters are not significantly different at the 5% level using DMRT.

teristics. There are no actual mean values for chalkiness since the standard laboratory procedure only measures a critical range for use in plant breeding assessment.

As expected, mean prices by market level are significantly different from each other, with marketing and processing costs added at each stage. The mean price at the farmgate (across all varieties and moisture contents) was P2.82/kg. At the mill level, the mean price of rough rice was P3.19/kg, reflecting the tendency of millers to buy dry rough rice from traders. Mean prices for milled rice were P5.38/kg at the mill output level and P6.72kg at the wholesaler/retailer level.[3]

The difference in moisture content at the rough rice level corroborates the price results in that the mean moisture contents of samples at the farm and mill levels were similar at about 14% (although this may have been due to short-term storage) while at the farmgate level, it was 16% (semidry). No rough rice sample from the mills had moisture content greater than 17% (semidry), indicating that millers bought predried rough rice at least at semidry levels.[4] This would also be consistent with the millers' large buying areas for rough rice which often reach far north up to Cagayan Valley.

As expected, the mean levels of immature grains at the milled rice stage were significantly less (0.03 and 0.01% at the mill and retail level, respectively) than those at the rough rice stage. However, immature grain values at the farmgate level were significantly higher (4.4%) than those at either the farm or mill input level (about 2%). This may indicate that further cleaning of rough rice is performed at the farm level for home consumption and at the mill level before it enters the mills. Dockage levels of less than 0.5% at all levels indicate a general lack of importance ascribed to impurities in the interviewees' responses. Length and width values for rough rice were similar at all market levels. However, armers may have retained the long, slender grains for either home consumption or for seed. The values for shape (L/W) were 4.03 at the farm level, 3.85 at the farmgate, and 3.93 at the mill input level.

Cracked grain percentages varied widely at all levels although mean values were not significantly different. At the farm level, the range was 0-29%; at the farmgate, 0-21%; and at the mill input level, 3-34%.

Milling recoveries of rough rice samples using the IRRI laboratory mill were also similar at about 66%. Given the similarity in premill characteristic levels and uniform milling technology, this finding was expected, although the lower limit (53%) at the farm level was less than that at the farmgate (59%) and mill levels (63%).

Head rice recovery of milled rice did not differ significantly with means of 79.8, 73.8, and 76.2% for farm, farmgate, and mill input levels, respectively. However, samples from the mill output and retail levels had significantly lower head rice recovery than those obtained from the laboratory mill (66 and 67%, respectively). This may indicate that in the survey area, the laboratory mill is more efficient in preserving head rice quality than a commercial mill. Similar results are reported by Bonifacio and

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[3]Wholesaler/retailer refers mainly to retailers who also conduct wholesale operations. It was impossible to obtain samples from the very large national wholesale market in Divisoria, Manila.

[4]Even within the study area, market practices differ. In Muñoz, there are many traders who sell direct to the miller but since many mills were not operating at the time of the survey due to electricity failure, it was impossible to obtain many samples at the mill level.

Duff (1992). The lower recovery could also be due to the milling of mixed varieties and/ or mixing of good and poor quality rice after milling.

The percentage of chalky grains varied but remained within the 1-10 and 10-20% ranges. Beyond these, it was not possible to describe the characteristic level further using the range measurement. However, measurement of yellowness and whiteness did facilitate comparison. Yellow grains did not vary by market level, having a low mean value of around 1%. Whiteness, by contrast, varied significantly.

The results for length, width, and shape of milled rice indicate that width did not vary by market level, but length did. The length of milled rice at the mill input level (7.19 mm) is greater than that at the farmgate level (6.9 mm); but at other market levels, the length did not differ significantly from either farmgate or mill input level. This may indicate the millers' preference for longer grains.

A hedonic model of demand for quality at the farmgate level

The model is developed using the "hedonic" or "characteristics of goods approach" to determine demand for a product as outlined by Unnevehr (1992). The general model used to estimate implicit values for rough rice characteristics at the farmgate level is:

$$P_f = \sum_{j=1}^{m} X_{rj} P_{rj} + u$$

where P_f = farmgate price, X_{rj} = quantity of characteristic j in one unit of rice, P_{rj} = implicit value of characteristic j, and u = random error term.

The estimating equation is

$$P_f = a - \Sigma b_j Z_j + cD_1 + dD_2 + e$$

where Z is a matrix of physical characteristics including dockage, immature grains, and cracked grains. D_1 is a set of n-1 dummy variables for moisture content (wet, semidry, and dry); D_2 is a dummy variable for variety group (special and others); a, b, c, and d are a set of estimating parameters; and e is the normally distributed random error.

Because the data were not precise, it was deemed appropriate to use dummy variables for the moisture content categories of wet (>18%), semidry (>14-<18%), and dry (<14%) rice, which also reflect the actual moisture content grading categories used in the rough rice market.[5] Various forms for estimating the implicit prices of physical quality attributes were tested—some using separate characteristic levels and some

[5]Because a dummy variable is used, the regression coefficient should be interpreted in terms of absolute intercept changes, and not as implicit prices. Assuming that the overall price-quality relationship does not change, the coefficient shows the significance attached to drying either to dry (MC_1) or semidry (MC_2), taking wet as the base case. With a larger sample, the change in slope could be estimated by running separate regressions for the discrete moisture content categories and testing for differences, Ideally, actual moisture content values would be used to provide estimates of implicit prices, but since the price grading system uses ranges, this specification reflects the actual process.

using a composite variable representing the actual grading procedures whereby lump discounts tend to be made against a set of negative characteristic levels. Since the correlation matrix for farmgate samples exhibits no significant relationship between price and individually varietally determined (chemical and physical) characteristics, a dummy variable taking the value of 1 for special (IR42) and 0 for the rest was used as the most appropriate method for capturing variation in price due to variety. (Descriptive analysis by variety group indicated that the main division was between IR42 and other varieties for varietally determined characteristics.)

The expected relationships of the explanatory variables to price and the regression results are given in Table 9. Only those results considered consistent with the original model and various adaptations of it (taking into account various multicollinearity and diagnostic statistical considerations) are presented here. The estimates generally have the expected signs and exhibit expected levels of coefficients. The variable MC_1, taking the value of 1 if rough rice was dried before sale and 0 if otherwise (using wet rough rice as the base case), is consistently significant at the 1% level and indicates that drying has a highly significant effect on price of rough rice. This is consistent with the earlier analysis of interview responses. MC_2, taking the value of 1 if rough rice was semi-dried before sale and 0 if otherwise, is consistently significant at the 5% level. This indicates that drying from wet to semidry moisture levels similarly has a significant positive effect on price.

The dummy variable for variety, taking the value of 1 for IR42 and 0 for all others, was not significant in all cases (Table 9). However, in equations 2 and 3, it was

Table 9. Farmgate level demand parameter estimates (dependent variable = farmgate price [P/kg]). [a]

Explanatory variable	Equation 1	Equation 2	Equation 3	Equation 4
Intercept	2.5934	1.9085	1.9884	2.6373
MC_1	0.4964***	0.4848***	0.4997***	0.5183**
	(6.411)	(6.161)	(6.724)	(6.184)
MC_2	0.1436**	0.1475**	0.1447**	0.5183
	(2.324)	(2.448)	(2.440)	(2.307)
VARDUM	0.1167	0.1821*	0.1642	0.1284
	(1.205)	(1.786)	(1.694)	(1.294)
PHYQ	0.0031	–0.0021	–0.0009	0.0021
	(0.543)	(–0.333)	(–0.105)	(0.364)
White		0.0174*	0.0171*	
		(1.737)	(1.728)	
Head rice		0.0011		
		(0.651)		
Yellow				–0.0325
				(–0.727)
Standard error of first	0.1273	0.1237	0.1221	0.1286
R^2	0.6556	0.7028	0.6968	0.6637
F-ratio	10.947	8.275	10.110	8.685

[a]Expected relationship to price: MC_1 +, MC_2 +, VARDUM +, PHYQ -, head rice +, brokens -, yellow -, white +. Values in parentheses are *t*-distributions. *** = significant at the 1% level. ** =significant at the 5% level. *=significant at the 10% level.

significant at the 10 and 15% level, respectively, indicating that variety does not have a significant effect on rough rice price. The interview responses at the rough rice marketing levels further confirmed this result, although a strong price discrimination by variety is indicated at the milled rice levels.

Parameter estimates of physical quality showed varying results. (The variable PHYQ is a composite variable of immature grain, dockage, and cracked grain values.) In no equations were the estimates significant, and in two cases, the sign was unexpected. The results in those cases with the expected sign yielded very small implicit values of less than P0.01 per percentage change in physical quality. Physical quality was of minor importance compared with moisture content in farmgate pricing.

The whiteness variable had the expected sign but was significant only at the 10% level and yielded an implicit value of less than P0.02 per percentage change. Since whiteness and yellowness were highly correlated, and yellowness was not significant, whiteness was interpreted as the opposite of yellowness. The result is consistent with earlier results showing damaged grains (closely related to yellowness and whiteness) as unimportant in market pricing of rough rice during this season.

Head rice percentage was included (reflecting both total milling and head rice recovery) and the parameter estimate was insignificant, although it had the expected sign. There may be some multicollinearity between head rice and moisture content even though the correlation matrix showed this to be of low proportion. The diagnostic statistics of the regression experiments are all favorable with the standard errors of the estimates being quite small—about 0.12. R^2 values are generally high in the 0.65-0.70 range, indicating that the equations explain about 65-70% of the variation in price. The F-ratios are well within the limits according to the tabulated F statistics. Judging by these statistics and the equations' consistency with the conceptual model, equations 2 and 3 are regarded the best estimates.

The results imply that about 70% of the variation in price is explained by quality considerations and that the primary quality characteristic is moisture content. The limited explanatory variable of the hedonic approach is expected, given the complex set of circumstances which determines the rice farmers' socioeconomic environment and their impact on farm price. Some of these factors would include aspects such as marketing and credit relationships between buyer and seller, scale of production, marketing methods (for instance, whether rice is picked up by the buyer or delivered to a buying station), liquidity time preference, location of supply relative to processing center, prevailing prices in linked markets (for instance, terminal market wholesaler/ retailer reference price), processing costs, etc.

It can be concluded that the only characteristic which commands a significant price premium is moisture content. This result is consistent with interview responses at the farmer level and with those at the trader level where results are generally ambiguous—about 50% of the respondents did not indicate any premiums for physical quality for most characteristics influenced by farm-level postharvest operations.

Incentives to improve quality at the farmer level in the private market

The preceding analysis outlines the premiums and discounts attached to various rough rice quality characteristics at the farmgate. The actual incentive for the farmer to improve rough rice quality, however, has to be assessed taking into account the costs of the extra postharvest operations required to improve quality. Controlling for other constraints operating on the farmer, he may be expected to undertake quality improvement activities if the incentive is large enough or if the returns obtainable are greater than the extra costs incurred.

With the exception of moisture content, there is no significant price premium at the farmer level for quality characteristics. Variety and other quality variables are not statistically significant and the parameter values are so small that the costs of improving the attributes would exceed the returns to the farmer for doing so. For example, since most rough rice cleaning in Nueva Ecija is done as a single operation incorporated with threshing (see Table 1), further cleaning would incur additional labor costs. Assuming that labor costs for cleaning are equal to those for hauling (since similar actions are involved), the cost would be about ₱0.02/kg.[6] It is clear that the return of ₱0.02 for a 10% decrease in total damaged grains is not sufficient to provide a reasonable incentive for further cleaning.

As to incentives for farm level drying, the costs and returns to drying were compared. Because we are analyzing at the farm level where sun drying is used, mechanical drying was not considered. Based on data collected from the Nueva Ecija rice marketing case study, and in consultation with drying experts at the IRRI Agricultural Engineering Department, the cost of sun drying is estimated to be ₱0.06/kg wet rough rice, labor and transportation costs included. If the drying area is rented, however, the estimated cost increases to ₱0.08/kg. Table 10 examines the real incentives for drying, taking into account shrinkage loss incurred during drying and the costs of the drying operation under three scenarios. There is an initial moisture content of 24% in the first scenario; 20% in the second; and 16% in the third. Incentives are calculated for drying rough rice from these initial levels down to both semidry (16%) and dry levels (14%), using high and low drying cost estimates, respectively.

In the first scenario, the actual premium for drying to the semidry level, taking into account the weight loss, is negative (Table 10). If the cost of drying is entered in the calculation, the real incentive to dry to semidry level is ₱0.24 and ₱0.26/kg for low and high drying costs, respectively. If rough rice is dried to 14%, the actual premium is positive at ₱0.05. But when costs are considered, the real incentive for drying becomes negative at ₱0.01 and ₱0.03/kg for each cost estimate.

In the second scenario, the actual premium for drying to a semidry condition is again negative. Accounting for drying costs, the real incentive is ₱0.07 and ₱0.09/kg for the low and high cost estimates, respectively. However, if rough rice is dried to 14%, the actual premium is positive at ₱0.21. Drying costs reduce the real incentive to ₱0.15 and ₱0.13/kg for low and high cost, respectively.

Rough rice is already semidry in the third scenario so the first part of the incentive calculation is irrelevant. If rough rice is dried to 14%, there is a substantial real incentive of ₱0.21 and ₱0.19/kg given low and high drying cost estimates, respectively.

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[6]Cost taken from the Nueva Ecija rice marketing case study by D. Umali.

Table 10. Incentives for drying in the private market (farmgate level).

		Scenario 1	Scenario 2	Scenario 3
A.	1. Initial moisture content of rough rice (%)	24	20	16
	2. Farmgate av return on rough rice in initial state (₱)	2.66	2.66	2.79
	3. Av moisture content of post-dried rough rice 16% semidry (%)	16	16	16
	4. Quantity of rough rice (less shrinkage) (₱/kg)	0.89	0.95	1.0
	5. Av price/kg of semidry rough rice (₱/kg)	2.79	2.79	2.79
	6. Farmgate av return on quantity of rough rice produced (4x5) (₱)	2.48	2.65	2.79
	7. Real incentive to dry at drying cost of P0.06/kg (6-2 cost) (₱/kg)	–0.24	–0.07	-
	8. Real incentive to dry at drying cost of P0.08/kg (6-2 cost) (₱/kg)	–0.26	–0.09	-
B.	1. Av moisture content of rough rice (%)	24	20	16
	2. Farmgate av return on rough rice (₱)	2.66	2.66	2.79
	3. Av moisture content of post-dried rough rice-14% dry (%)	14	14	14
	4. Quantity of rough rice (less shrinkage) (kg)	0.87	0.92	0.98
	5. Av price/kg of dry rough rice (₱/kg)	3.12	3.12	3.12
	6. Farmgate av return on quantity of rough rice produced (4x5) (₱)	2.71	2.87	3.06
	7. Real incentive to dry at drying cost of P0.06/kg (6-2 Cost) (₱/kg)	–0.01	0.15	0.21
	8. Real incentive to dry at drying cost of P0.08/kg (6-2 Cost) (₱/kg)	–0.03	0.13	0.19

Notes:
1. Moisture content levels (initial) chosen as common levels found in the field; recommended level for harvesting is 24%.
2. Moisture content levels (post drying) taken as 16% for semidry (midpoint in the 14 18% range) and accepted as semidry by both experts and market participants; 14% is recommended for milling and accepted as dry.
3. Shrinkage loss given by UPLB drying experts.
4. Rough rice prices taken from preceding descriptive and regression analysis.
5. Drying costs assumed constant given different initial moisture contents since activities are the same.

To summarize, if rough rice is harvested at the minimum recommended moisture level of 24%,[7] the real incentive at the farmgate level to dry it either to semidry or dry condition is negative. If, however, the grain is harvested at a moisture level lower than that recommended, the incentive to dry to semidry level is still either negligible or negative. On the other hand, the incentive to dry to 14%—recommended for best grain quality—is strongly positive. (The financial loss to the farmer due to yield loss brought about by harvesting at lower-than-ideal moisture levels has not been incorporated into the incentive calculation; it would obviously reduce the overall incentive substantially.)

The incentives are greatest at moisture levels ranging from semidry to dry but the sample data (Table 8) show that most farmers sell their rough rice semidry. Hence, the market intermediary (who dries the rice) realizes the returns on drying, not the farmer. It is obvious that in spite of the incentive for farmers to dry rough rice to 14% if

[7] Harvesting below this level may have negative effects on grain quality and result in subsequent yield loss.

harvested below the recommended moisture level, there are constraints. Table 2 indicates that about one-third of the farmers delay postharvest operations most frequently for lack of facilities, but there are other constraints as well. For instance, the farmers' liquidity time preference and his credit and marketing relations especially within informal credit markets outweigh the real incentive for drying. Because of social and economic relationships, the farmer normally has to sell his rice immediately after harvest and is unable to realize any incentive for drying.

The data for this study were collected at the peak of the 1987 wet-season harvest when there was a marked drought in the area. It seems likely that most samples obtained were sold semidry since they were probably in this state when harvested. Because of the farmers' need to sell immediately after harvest to traders and millers (with whom he often had credit links) who buy at prevailing prices (which at harvest peak are at the lowest levels), it is the traders or millers who implicitly reap the return. Had there not been a drought, rough rice would have been harvested at high moisture levels since with early-maturing varieties, the harvest peak coincides with the height of the rainy season, when it is not only physically difficult to sun-dry rough rice, but even if other constraints allow, there is also a negative real incentive for farmers to dry their crop.

Conclusion

The objectives of this chapter are to identify economically significant rough rice characteristics at the farmgate level and to assess the real incentives for farmers to improve or preserve rough rice quality.

The main findings of the study indicate that the price farmers receive for their rice is highly sensitive to moisture level but largely insensitive to other quality attributes. The relationship between moisture content and other rough rice qualities and potential milled rice attributes is complex, however, and it may be argued that an effective rough rice grading system based on moisture content alone is sufficient to determine milled rice output quality, given a reasonable level of milling technology—cleaning rice properly, adjusting mill clearances according to grain shape, grading milled rice output, etc.

Although private farmgate prices do include a price premium for dried rough rice, they do not provide sufficient price incentives for farmers to dry if it is harvested at recommended moisture content levels and if shrinkage losses and drying costs are considered. The lack of incentives to dry rough rice at the farm level imply imperfections in the marketing system, a topic discussed by Umali and Duff (1992).

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Notes

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The Philippine rice marketing system: implications for grain quality improvement[1]

D.L. Umali and B. Duff[2]

The implicit value that consumers place on particular rice quality characteristics is indicated by the amount consumers are willing to pay for a particular type of rice. However, the decisions that largely determine the quality of rice at the retail level are made on the farm. The efficiency of the marketing system strongly influences the transmission of quality incentives from the retail level back to farmgate prices. A clear understanding of the performance of the marketing system is a valuable input to the formulation of strategies to improve grain quality.

This chapter reports a study of the structure, conduct, and performance of the Philippine rice marketing system and the role of government intervention in the market. Secondary data on prices and government intervention, and primary data from a survey of farmers, traders, millers, and wholesalers/retailers are used in the analysis. The first section presents a model illustrating the role of the marketing system in transmitting signals about consumer preferences to the farmer. The second section describes the structure and organization of the private marketing sector, tracing its growth and development at the national and regional levels. The role of quality in private trader pricing decisions is also examined. The third section investigates the role of the government price stabilization program in the rice marketing system and its impact on rice prices. The spatial price efficiency of the rice marketing system at the regional level is analyzed in the fourth section. Finally, the policy implications of the results of the study are discussed.

Competition in the private marketing system has been increasing in the retail, wholesale, warehousing, and transportation sectors of the marketing system, with the exception of the rice milling sector where government licensing has partly served as

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[1]Reprinted with permission in part from *Advances in grain postharvest technology generation and utilization.* Proceedings of the 11th ASEAN Seminar on Grain Postharvest Technology, 23-26 August 1988, Kuala Lumpur. J. O. Naewbanij, ed. (1990) ASEAN Grain Postharvest Programme. Bangkok, p. 317-349.

[2]This research was undertaken when the first author was a doctoral candidate at the Food Research Institute of Stanford University and the second author was an agricultural economist at the International Rice Research Institute, Los Baños, Philippines.

a barrier to entry. It was also found that private rice traders place significant weight on quality in determining prices for their products.

The results show that Philippine government intervention has succeeded in keeping consumer prices low, which has caused downward pressure on farm prices. Due to inadequate resources and an unrealistically high floor price, the government agency has been unable to defend floor price of rough rice.

There is a low degree of market integration between the farm and wholesale markets. The degree of market connection is higher between the wholesale and retail markets. However, market integration improved in all levels after 1983, when the government reduced its role in the market.

The implications for grain quality are that the lack of integration may hamper the transmission of price signals from the consumer to the farmer, and may prevent farmers from capturing the returns to quality improvements. Furthermore, government intervention tends to distort price signals in the market, including preventing incentives to improve local processing.

A model of rice market price formation

Rice marketing involves the transformation of farm production of rice in form, space, and time. It includes the assembly and storage of rice in a warehouse, milling at a rice mill, and transporting for distribution to consumers. The wholesale rice price/kg (Pw) at time t in terminal market k can be described by a linear function of the retail rice price/kg (Pr) at time t in market j. Similarly, the rice-equivalent farmgate rough rice price/kg (Pf) at time t in producer area l can be expressed as a linear function of the wholesale rice price/kg at time t in market k.

$$Pw_{kt} = \alpha_{jt} + \beta_{jt} Pr_{jt} \qquad \begin{aligned} j &= 1, 2, ..., s \\ k &= 1, 2, ..., y \\ t &= 1, 2, ..., n \end{aligned} \tag{1}$$

$$Pf_{lt} = \theta_{kt} + \omega_{kt}\, \rho Pw_{kt} \qquad l = 1, 2, ..., z \tag{2}$$

where Pr_{jt} = retail rice price/kg at time t in market j, Pw_{kt} = wholesale rice price/kg at time t in market k, Pf_{lt} = farmgate rough rice price/kg at time t in producer area l, and r = technical conversion factor of rough rice into milled rice.[3]

To assess the premiums and discounts associated with particular grain quality characteristics, the Philippine grain quality study utilizes a hedonic model of consumer demand for characteristics of goods (see Unnevehr 1992). Simply, the retail price of rice at time t in market j (Pr_{jt}) can be expressed as a function of the quality of the characteristic (X_{ijt}) and the implicit value of the characteristic (V_{ijt}):

$$Pr_{jt} = f\,(X_{ijt}, V_{ijt}) \qquad \begin{aligned} i &= 1, 2, ..., m \\ j &= 1, 2, ..., s \\ t &= 1, 2, ..., n \end{aligned} \tag{3}$$

[3]An underlying simplifying assumption of this model is that the technical conversion factor is assumed equal and constant for all characteristics and time periods. In reality, however, there can be variations in the rate of conversion; for example, the milling conversion factor of rough rice into milled rice varies according to the degree of mill efficiency,

Substituting equation 3 into equation 1, then substituting equation 1 into equation 2, the farmgate rough rice price can be expressed as:

$$Pf_{lt} = \theta_{kt} + \alpha_{jt}\,\omega_{kt}\,\rho + [\omega_{kt}\,\beta_{jt}\,\rho f\,(X_{ijt}, V_{ijt})] \tag{4}$$

Equation 4 illustrates how the nature of consumer preferences is transmitted back to the farmer, subsequently providing valuable direction to his production and postharvest decisions. The retail price sets the upper limit to how much each characteristic will be valued at the farm level.

The change in the farm price with respect to the change in a specific rice quality can be estimated by:

$$\frac{\partial Pf_{lt}}{\partial X_{ijt}} = \omega_{kt}\,\beta_{jt}\,\rho\left(\frac{\partial f\,(X_{ijt}, V_{ijt})}{\partial X_{ijt}}\right) \tag{4}$$

The degree to which consumer demand for specific attributes is translated back to the farmgate price is dependent upon the technical conversion factor r , and on the transmission or market integration coefficients, $ß_{jt}$ and w_{kt}. Ideally the values of these market integration coefficients should equal one, so that relative values are fully transmitted between markets. When these relative values are only partially transmitted, price signals received at the farm level will be distorted, leading to a misallocation of quality-improving investments by farmers. Equation 5 highlights the fact that the performance of the marketing system influences the incentives for quality irnprovement perceived by farmers. Thus, an understanding of the marketing system, as well as the regional, temporal, and institutional factors which influence it, becomes essential for the effective formulation of grain quality improvement strategies.

The data

Information on the government's price stabilization activities were compiled from various offices of the National Food Authority (NFA)[4] and through interviews with NFA officials. Since NFA requires all rice traders to register with the agency, NFA records provide information on the number of rice retail, wholesale, mill, warehouse, and transport operators; the number of wholesale and retail business units; and the mill and transport capacities for the 12 regions of the philippines.[5] The regional rice production data and rough rice and milled rice prices were collected from the Bureau of Agricultural Economics (BAEcon).[6] Based on the length and completeness of the price series, price data for ordinary rice in 8 of the 12 regions in the Philippines were chosen for analysis. Monthly average wholesale buying prices per bag of rough rice

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[4]NFA's functions were previously performed by the Rice and Corn Administration (1961-71) and the National Grains Authority (1972-80). Text references to NFA are taken to include the current agency as well as its predecessors.

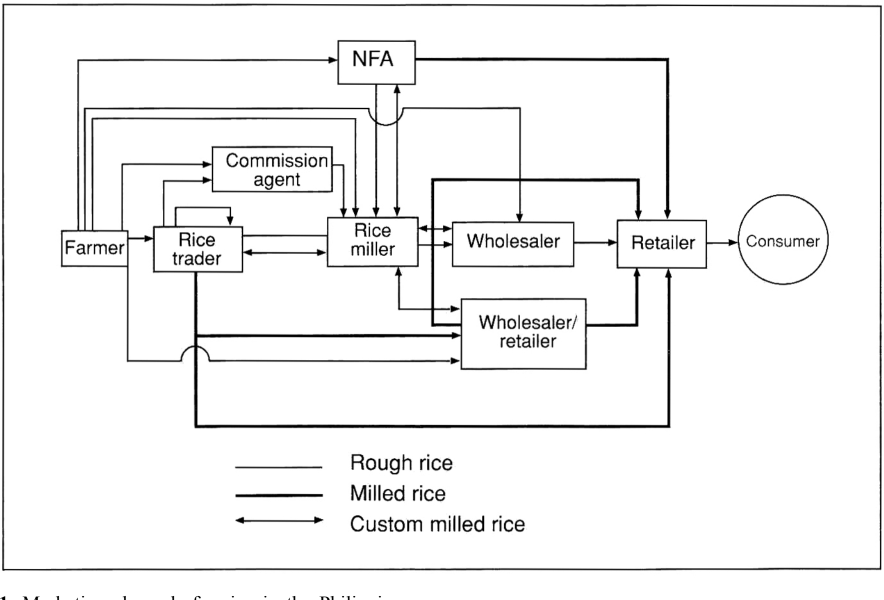
[5]The I2 regions of the Philippines are: Ilocos (Region I). Cagayan Valley (Region 2), Central Luzon (Region 3), Southern Tagalog (Region 4), Bicol (Region 5). Western Visayas (Region 6), Central Visayas (Region 7), Eastern Visayas (Region 8), Northern Mindanao (Region 9), Central Mindanao (Region 10). Northeastern Mindanao (Region 11), and Southwestern Mindanao (Region 12).

[6]In 1988, the Bureau of Agricultural Economics was renamed the Bureau of Agricultural Statistics.

(14% moisture content) by region were collected. Then, for each region, the city which operated as the main terminal market for rice was identified and the monthly average wholesale and retail selling prices per kilogram for ordinary rice in that city were assembled. The regions and their associated terminal markets (in parentheses) include: Region 1 (Laoag City), Region 3 (Metro Manila), Region 4 (Calapan), Region 6 (Iloilo City), Region 8 (Tacloban City), Region 10 (Cagayan de Oro City), Region 11 (Davao City), and Region 12 (Cotabato City). A marketing survey of 127 farmers, 46 rice traders, 38 rice millers, and 63 wholesalers in two rice-surplus provinces in the Philippines (Iloilo and Nueva Ecija) was also conducted in October and November 1987 to collect primary data on private trader operations (Umali 1990).

Rice marketing sector

The marketing of rice in the Philippines is the shared responsibility of the government as represented by NFA and the private sector consisting of rice traders, commission agents, ricemillers, wholesalers, and retailers (Fig. 1). Rice traders purchase rough rice from farmers for resale to rice millers, wholesalers, and retailers. Commission agents also purchase rough rice, but they do so on behalf of rice millers, receiving a fixed fee per bag purchased. Rice millers dry, store, and mill rough rice, subsequently transporting and selling the milled rice to wholesalers and retailers. Wholesalers primarily supply the rice requirement of local retailers, but may also engage in bulk transport and sale of rice to wholesalers and retailers in other deficit regions. Retailers sell rice to consumers and institutional clients. These marketing classifications are not mutually exclusive and traders often assume a combination of these roles; hence, vertical integration forward and backward frequently occurs.



1. Marketing channels for rice in the Philippines.

Only a small percentage of wholesalers and retailers buy rough rice directly from farmers or rice traders, custom mill, and sell it, largely because large-scale custom milling services with high milling efficiency are quite limited.[7] Custom mills are usually small-scale operations with low milling efficiency catering to farmers who mill rough rice for home consumption. The farmers do not mind the low milling efficiency because they can use the byproducts (e.g., bran and small broken rice) as feed for their poultry and livestock.

As of 1986, the private rice marketing system consisted of 61,860 retail store operators, 20,962 wholesale businessmen, 13,022 rice millers, 7,839 warehouse operators, and 5,796 transport operators. The number of entrepreneurs in the retail, wholesale, and warehousing business increased between 1974-77 and 1983-86 (Table 1). Similarly, the number of transport operators increased during the same period, despite a slight decline in 1978-83. The number of millers, however, expanded slightly in 1978-83, but reverted back to the 1974-77 levels by 1983-86. On the other hand, the number of retail and wholesale business units and rice mill, transport, and warehouse capacities registered significant growth from 1974-77 to 1983-86. In the aggregate, competition appears to be increasing in most marketing channels, with the possible exception of the milling sector.

Rice quality in price formation

The results of the rice marketing survey provide additional insights into the role of quality in price formation. According to the survey, the factors which determined the acceptable selling price included prevailing price, a better price, quality, good relations, credit tie-up, NFA price, transport costs, and others (Table 2). The results

Table 1. Average number of rice traders and business units and mill and transpart capacities in the Philippines, by market level, 1974-86.

Market level	1974-77	1978-83	1984-86
Retail			
No. of operators	41,418	50,574	68,542
No. of business units	44,004	56,505	78,756
Wholesale			
No. of operators	6,569	11,376	22,246
No. of business units	7,419	12,467	25,236
Mill			
No. of operators	14,251	14,781	14,296
Capacity (000 t/yr)	5,113	8,608	11.204
Warehouse			
No. of operators		6,827	8,280
Capacity (000 t/yr)		1,204	1,580
Transport			
No. of operators	5,949	5,711	7,105
Capacity (000 t/yr)	57	91	147

Source: Economic Planning Division, National Food Authority, unpublished data.

[7] Custom milling involves milling rough rice for a fixed fee per bag. The customers retain ownership of the rice and its byproducts.

Table 2. Factors determining the acceptable rice selling price, Nueva Ecija and Iloilo, 1987 (Umali 1988).

Factor	% distribution of responses			
	Farmer	Rice trader	Rice miller	Wholesaler/ retailer
Prevailing price	33.72	32.56	31.30	28.09
Better price	15.41	–	–	3.37
Quality	27.03	26.74	31.30	26.97
Good relations	12.50	20.93	17.39	21.35
Credit tie-up	8.14	5.81	4.35	8.99
NFA price	2.33	3.49	3.48	1.12
Transport cost	0.29	6.98	7.83	1.12
Others	0.58	3.49	4.35	8.99

Table 3. Factors determining the acceptable rice buying price, Nueva Ecija and Ilollo, 1987 (Umali 1988).

Factor	% distribution of responses		
	Rice trader	Rice miller	Wholesaler/ retailer
Prevailing price	28.68	26.06	28.87
Expected selling price	22.48	24.65	10.82
Past price	–	0.70	–
Quality	28.68	27.46	25.77
Good relations	10.85	11.27	23.71
Credit tie-up	6.98	3.52	10.82
NFA price	–	1.41	–
Transport cost	2.33	3.52	–
Others	–	1.41	–

show that quality ranked as the second most important factor in pricing decisions after prevailing price. However, it was mentioned by only 27% of the farmers, by 27% of the viajeros (rice traders) and commission agents, by 27% of wholesalers/retailers, and by 31.3% of rice millers. Factors affecting the acceptable buying price consisted of prevailing price, expected selling price, past price, quality, good relations, credit tie-up, NFA price, transport cost, and others (Table 3). Quality and prevailing price were noted most often by rice traders while rice millers consider quality more often when deciding the acceptable selling price for milled rice vis-a-vis buying rough rice. This dichotomy may indicate more differentiation for quality in milled rice markets than in rough rice markets.

Public sector rice marketing activities in 1974-86

The NFA is charged with the implementation of the Department of Agriculture’s (DA) rice policy. It pursues three major programs: the stabilization of ex-farm prices, market development and extension, and industry regulation. The price stabilization program involves setting the rice support and ceiling prices which are to be enforced through the procurement of rough rice during the harvest months, the holding of buffer stocks, the processing and distribution of rice during lean months, and the importation or exportation of rice as required by the domestic supply situation. The NFA is the sole legal importer and exporter of rice in the country. Market development, though listed as one of NFA's major programs, remains largely undeveloped, and little information is available on this program. The industry regulation program requires the registration of all rice traders with the NFA and the payment of license fees.

Although the purpose of registration and licensing of rice traders is primarily to monitor the development of the industry, the task of industry regulation during the period 1974-85 was taken a step further at the rice milling level. Licensing requirements of NFA actively limited the number of new enterprises entering the milling sector. Memorandum No. PPM 06007, issued in May 1983 and entitled "Re-Evaluation of Rice Mill Applications," clearly stated NFA's policy of regulating entry into the milling business:

"As a general rule, no permit to put up a new rice mill shall be issued in localities where there are [sic] excess capacity... However, excess capacity shall not be the sole basis for disapproving applications to install a rice mill. Other factors/criteria should also be given weight, such as but not limited to:

a) economic/financial viability of the project;

b) technical needs and requirements in the area and capacity of the proposed rice mill in terms of input/output per day operations, milling recovery and type of proposed mill...;

c) degree of concentration of facilities in the area taking into consideration the type, capacity and recovery rates of existing rice mills as well as the proximity/distance of the proposed rice mill to the existing ones.

...it is needed to be shown that the purchase and operation of a new rice mill will be profitable and *will not result in ruinous competition with existing facilities in the area* (emphasis added)."

The above criteria were part of the NFA standard operating procedures which, according to the memo, was to "guide management in properly programming and strategically allocating rice mills according to the requirements of a particular locality as well as the adjoining localities thereby insuring applicants a profitable investment." This policy was rescinded in 1985. But from 1974 to 1985, NFA protected the profitability of established mills. This policy may partly explain why the number of mill operators remained stable at about 4,000 during 1974-86 even though milling capacity increased at that time.

Price stabilization activities

The support price of rough rice is the government-guaranteed ex-farm price defended through NFA procurement operations. Ideally, this price is to be enforced nationwide regardless of geographic location to provide farmers a reasonable return on their investment. At the same time, it is designed to inform commercial grains businessmen of the minimum price level they should procure rough rice in order not to place farmers at a disadvantage (NFA 1987). The support prices are generally adjusted each year and they have increased from ₱0.80/kg in 1974 to ₱3.50/kg in 1989. The government-determined rough rice support prices from 1974 to 1989 are listed in Table 4.

To ensure price and supply stability at the consumer level, NFA sought to enforce a rice ceiling/release price.[8] Ideally, this price is to be maintained nationwide regardless of geographic location of stocks of specific quality or specification. The ceiling/release price is to be enforced through the maintenance of buffer stocks in strategic locations in the archipelago and direct rice distribution in cases when prices rise above the official ceiling or when local levels of rice stocks reach a critical level (NFA 1987). The NFA is responsible for importing rice when locally procured rice is not adequate to meet distribution requirements. Table 5 presents a listing of the government-set rice ceiling prices from 1974 to 1989. The rice ceiling and support prices tended to be adjusted at similar times, with increasing frequency during the inflationary years of the 1980s. The ceiling price has increased from ₱1.90/kg in 1974 to ₱5.65/kg in 1989.

To hold prices within the support ceiling price band, NFA procures, processes, and stores rough rice and imports and distributes milled rice. Typically, procurement occurs during surplus periods, while rice injections are needed in times of deficit.

The priority given to different price policy instruments as well as the role of NFA changed as the rice economy weathered swings in the volume of production. As rice output declined prior to 1978, NFA's intervention activities focused on the importation and distribution of rice (Table 6). Net rice imports totaled 205,000 t in 1974, declining to 15,300 t by 1977. Rice distribution remained stable at about 230,000 t. From 1974 to 1977, NFA rice distribution as a percentage of total consumption averaged 4.9%/yr, while NFA rough rice procurement as a percentage of total production averaged 3.5%/yr.

Table 4. Historical rough rice support prices, 1974-89.

Effective date	Official support price (₱ /kg)	Supporting legislation
18 Jan 1974	0.80	Letter of Instruction No. 957
28 Nov 1974	1.00	Letter of Instruction No. 228
29 May 1976-78	1.10	Letter of Instruction No. 413
1 Apr 1979	1.30	Letter of Instruction No. 904
1 Jul 1980	1.40	Unnumbered LOI
21 Oct 1980	1.45	Letter of Instruction No. 11
17 Jun 1981	1.55	Letter of Instruction No. 1147 dated 25 May 1981
22 May 1982	1.70	Letter of Credit No. 48
1 Oct 1983	1.80	Letter of Credit No. 10
28 Nov 1983	2.10	Letter of Credit No. 16
26 May 1984	2.35	Letter of Credit No. 10
9 Jun 1984	2.65	Letter of Credit No. 17, dated 8 Jun 1984
20 Oct 1984	2.90	Letter of Credit No. 25, dated 18 Oct 1984
8 Dec 1984	3.35	Letter of Credit No. 28, dated 7 Dec 1984
6 Jun 1985-89	3.50	Letter of Credit No. 10, dated 6 Jun 1985

Source: Economic Planning Division, National Food Authority, unpublished data.

[8] The release price mechanism was instituted in 1986 and involved the automatic distribution of rice by NFA when market prices reached the release pice level.

Table 5. Historical rice ceiling prices, 1974-89.

Effective date	Official ceiling price (₱/kg)	Supporting legislation
18 Jan 1974	1.90	LOI No. 157, dated 18 Jan 1974
29 May 1976	2.10	LOI No. 413, dated 29 May 1986
July 1977	2.06	LC No. 103, dated19 Jul 1977 (wholesale price ceiling effected). Revoked on 9 May 1979 per LC No. 72, dated 4 May 1979
1 Apr 1979	2.45	LOI No. 903, dated 28 Mar 1979 and LC No. 52, dated 31 Mar 1979
19 Aug 1980	2.60	LC No. 3, dated 19 Aug 1980 and unnumbered LOI, dated 22 May 1980
20 Jun 1981	2.84	LC NO. 3, dated 19 Jun 1981
17 Jun 1982	3.10	LC No. 52, dated 16 Jun 1982
1 Oct 1983	3.30	LC No. 11, dated 27 Sep 1983
28 Nov 1983	3.80	LC No. 17, dated 28 Nov 1983
25 May 1984	4.25	LC No. 12, dated 25 May 1984
9 Jun 1984	4.85	LC No. 25, dated 8 Jun 1984
29 Oct 1984	5.35	LC No. 25, dated 18 Oct 1984
23 Jan 1985-1989	5.65	LC No. 1, dated 22 Jan 1985

Source: Economic Planning Division, National Food Authority, unpublished data.

Table 6. Rice production, net imports, government procurement, distribution and stockholdings, 1974-86, (000 t). [a]

Crop year	Production (A)	Net imports (B)	Procurements (C)	Disbursements (D)	Consumption (E)	Government stocks	C/A (%)	D/E (%)
1974	3638.20	205.00	11.39	44.49	3168.29	680.90	0.31	1.40
1975	3679.00	145.30	92.66	234.56	3458.24	684.30	2.52	6.78
1976	4003.70	55.20	198.81	200.43	3867.56	737.88	4.97	5.18
1977	4190.50	15.30	263.28	229.46	3817.11	787.00	6.28	6.01
1978	4481.70	–13.40	530.60	182.16	3751.97	1122.04	11.84	4.86
1979	4678.10	–38.00	410.45	137.73	4022.35	1356.76	8.77	3.42
1980	5093.40	–236.00	497.21	98.60	4347.97	1519.37	9.76	2.27
1981	5020.00	–175.00	357.37	350.56	4641.34	1351.18	7.12	7.55
1982	5279.10	–0.10	494.84	260.69	4615.90	1585.23	9.37	5.65
1983	5024.84	–36.90	523.10	410.07	4632.90	1661.36	10.41	8.84
1984	5096.60	9.58	311.70	730.52	5147.99	1252.11	6.12	14.19
1985	5330.05	367.98	175.87	336.70	5286.30	1459.27	3.30	6.37
1986	5913.03	355.03	275.19	292.99	5219.39	1796.50	4.65	5.61
Av								
1974-77	3877.85	105.20	141.54	177.24	3577.80	722.52	3.52	4.85
1978-83	4929.52	–83.23	468.93	239.97	4335.40	1432.66	9.55	5.43
1984-86	5446.56	244.20	254.25	453.40	5217.89	1502.63	4.69	8.72

[a]Government stocks = previous year government stocks + net imports + procurement - distribution. Source: Production data were from the Statistics Division of the Bureau of Agricultural Economics. Imports, exports. procurement, and distribution data were from the Market Operations Division of the National Food Authority; the consumption data were from various issues of the *National Economic and Development Authority food balance sheet series.*

From 1978 to 1983, production increased steadily, greatly surpassing consumption. The role of NFA shifted to export of surplus production and increased procurement and stockholding of rice. Net rice exports rose from 13,400 t in 1978 to 236,000 t in 1980, subsequently declining to 36,900 t in 1983. Rough rice procurement was more than double the volume procured during 1974-77, ranging from 350,000 to 520,000 t. NFA procurement as a percentage of total production increased sharply to an average of 9.6%/yr, while NFA distribution as a percentage of total consumption increased slightly to 5.4%/yr.

A prolonged drought in 1983 led to production shortfalls in 1983-84. Consequently, NFA activities reverted back to rice importation and distribution. Net imports rose to almost 370,000 t and government stocks were drawn down.[9] Distribution jumped to 14.2% of consumption in 1983. During 1984-86, NFA distribution rose to an average of 8.7% of total consumption, while NFA procurement as a percentage of total production was cut by almost half to 4.7%.

NFA competed with the private sector in all regions, procuring and distributing rice ubiquitously, regardless of whether they were rice-surplus or -deficit regions (Table 7,8). To a great extent, this produced a strain on NFA's budget and personnel.

Price effects of NFA price stabilization

The effectiveness of NFA in achieving its price objectives can be evaluated by comparing actual market prices to official government prices. As a means of measuring NFA's success in stabilizing rough rice and milled rice prices, two ratios—the ratio of the annual average retail price to the official ceiling price and the ratio of the annual average farmgate rough rice price to the rough rice support price—were estimated. A ratio of retail price to ceiling price greater than 1 implies that NFA was unable to ensure the availability of sufficient rice supplies to keep prices at the ceiling price level. A ratio of rough rice price to support price greater than 1 indicates that NFA succeeded in purchasing enough supplies from the farm-level markets to raise farm prices to the support price level.

The efforts of NFA to defend the rice support and ceiling prices have been met with mixed success. Its performance varied by region, but overall, NFA has been reasonably successful in keeping rice prices within policy limits. The annual average retail price was above the average ceiling price in 1974. For the next 9 yr, during the remainder of the rice-importing years (1975-77) and the entire duration of the rice-exporting years (1978-83), retail prices were below ceiling prices (Table 9). Since 1984, however, retail prices have risen above the ceiling price as a result of unfavorable weather, delayed arrival of imports, and declining levels of rice injections (Bouis 1982, Unnevehr 1985).

On the other hand, government price intervention was not nearly as successful in defending farm-level support prices. Despite NFA rough rice procurement, annual average farm prices remained below average support prices in 12 out of the last 13 yr (Table 10).[10] From 1975 to 1986, farm prices remained on average 14% below support

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[9]An election had also been scheduled in 1986 by the Marcos government. Although production had recovered, substantial imports were still made which, according to some officials, were destined for distribution during the clection.

[10]This estimate is an understatement of the true gap since the ratio is derived hy using the arithmetic mean of monthly farm prices, not a weighted mean. The majority of farm sales occur at harvest, when prices are at their lowest point.

Table 7. NFA regional rough rice procurement in the Philippines, 1974-86 (000 t).

Crop year	Region[a]													
	NCR	1	2#	3#	4	5#	6#	7	8	9	10	11	12#	Total
1974	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1975	2.81	8.12	23.18	11.03	12.70	10.86	6.64	0.24	2.05	–5.05	3.21	1.95	4.84	92.66
1976	6.42	10.77	48.42	15.87	23.80	4.58	22.97	1.00	7.56	11.37	10.77	17.35	17.93	198.81
1977	9.46	34.895	38.88	22.81	36.30	12.53	38.30	1.00	7.63	10.01	10.69	17.86	22.97	263.28
1978	19.74	50.11	107.98	34.23	54.20	11.17	49.31	1.58	9.03	23.65	16.60	73.73	79.26	530.60
1979	12.33	52.99	47.49	23.68	37.00	16.53	46.14	0.96	9.03	17.43	20.62	64.33	61.92	410.45
1980	24.68	71.88	100.24	27.35	42.10	27.19	56.23	1.44	12.85	10.87	15.36	52.48	54.54	497.21
1981	7.57	27.42	21.54	33.47	70.40	12.22	37.35	1.40	8.93	12.90	11.36	60.44	52.38	357.37
1982	33.18	63.85	99.43	49.40	77.10	27.17	38.78	0.54	9.55	9.71	12.96	35.54	37.63	494.84
1983	42.08	96.96	98.57	45.81	55.90	27.90	36.11	0.69	7.92	16.36	19.27	40.28	35.27	523.10
1984	4.63	23.95	3.11	34.80	57.60	16.15	46.11	1.38	8.86	10.97	9.89	51.22	43.03	31.170
1985	11.84	32.93	11.24	28.94	48.20	10.59	8.43	0.02	2.68	2.66	5.26	3.84	9.22	175.87
1986	14.12	37.11	36.41	21.73	57.60	7.34	35.11	1.13	2.74	7.09	10.60	18.76	25.44	275.19
Av														
1974-77	6.23	17.92	36.82	16.57	24.27	9.32	22.63	0.75	5.74	8.81	8.22	12.39	15.25	184.91
1978-83	23.26	60.53	79.21	35.66	56.12	20.36	43.99	1.10	9.55	15.15	16.03	54.47	53.50	468.93
1984–86	10.20	31.33	16.92	28.49	54.47	11.36	29.89	0.84	4.76	6.91	8.58	24.61	25.90	254.26

[a] NCR = National Capital Region, # = surplus regions. Source: Market Operations Division, National Food Authority.

Table 8. NFA regional rice disbursement in the Philippines, 1974-86 (000 t).

Year	Region													
	NCR	1	2#	3#	4	5#	6#	7	8	9	10	11	12#	Total
1974	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1975	94.74	28.98	1.39	9.75	13.94	11.44	5.45	13.61	17.02	16.82	15.34	2.31	3.77	234.56
1976	85.19	19.94	2.06	16.82	15.41	14.19	7.88	5.04	14.62	10.53	4.85	0.60	3.28	200.43
1977	86.16	25.26	1.72	19.58	18.74	12.11	16.73	2.95	13.01	9.49	10.58	5.17	7.97	229.46
1978	63.84	18.50	3.11	21.49	13.74	9.13	10.81	8.75	10.21	6.91	8.49	2.59	4.57	182.16
1979	39.34	11.36	1.61	27.29	11.81	3.69	4.02	1.53	7.71	5.94	6.93	13.05	3.44	137.73
1980	26.52	3.95	1.12	4.82	4.30	4.85	6.07	9.40	4.42	6.12	5.84	11.36	9.84	98.60
1981	39.41	22.94	9.61	32.88	38.10	35.73	21.72	32.91	17.10	25.85	29.39	27.56	17.35	350.56
1982	31.42	14.58	7.36	8.38	29.59	38.73	11.88	16.79	23.74	18.73	23.43	16.02	20.04	260.69
1983	72.41	12.87	5.38	12.05	26.68	33.03	33.11	32.34	26.52	29.91	26.25	53.24	46.27	410.07
1984	126.35	38.80	37.18	62.67	73.69	70.63	50.31	42.09	62.93	27.12	43.99	63.28	31.48	730.52
1985	77.63	36.91	13.23	19.23	37.14	17.76	17.30	21.93	30.87	11.00	17.64	22.30	13.76	336.70
1986	125.32	30.59	5.22	30.32	30.49	12.39	14.90	10.22	11.87	4.07	3.76	7.60	6.23	292.99
Av														
1974-77	88.70	24.73	1.73	15.38	16.03	12.58	10.02	7.20	14.88	12.28	10.26	2.70	5.01	221.48
1978-83	45.49	14.03	4.70	17.82	20.70	20.86	14.60	16.95	14.95	15.58	16.72	20.64	16.92	239.97
1984-46	109.77	35.43	18.54	37.41	47.11	33.59	27.50	24.74	35.22	14.07	21.80	31.06	17.16	453.40

Source: Market Operations Division, National Food Authority, NCR = National Capital Region, # = surplus regions.

Table 9. Ratio of average annual retail rice prices to average annual government ceiling prices in selected cities, 1974-86.

Region City	1 Laoag	4 Calapan	6# Iloilo	8 Tacloban	10 Cag de Oro	11 Davao	12# Cotabato	NCR Manila	Phil
CY 1974	1.49	0.95	0.88	0.93	0.68	–	0.89	0.95	1.06
1975	0.99	0.97	0.98	1.01	0.98	–	0.98	0.95	1.00
1976	0.95	0.92	0.92	0.92	0.96	–	0.93	0.91	0.51
1977	1.00	0.94	0.96	0.98	0.93	–	0.99	0.99	1.00
1978	0.97	0.94	0.94	0.98	0.99	0.96	0.98	1.00	1.00
1979	0.86	0.83	0.85	0.88	0.90	0.87	0.89	0.92	1.00
1980	0.89	0.80	0.86	0.89	0.93	0.92	0.91	0.92	0.95
1981	0.91	0.90	0.86	0.91	0.88	0.90	0.93	0.90	0.97
1982	0.91	–	0.88	0.93	0.96	0.92	0.94	0.94	0.98
1983	0.90	–	0.89	0.89	0.94	0.88	0.92	0.92	0.96
1984	0.98	–	0.97	0.99	0.94	0.97	1.04	0.99	1.05
1985	1.06	–	1.08	1.11	0.92	1.18	1.15	1.08	1.13
1986	1.08	–	1.07	1.13	1.18	1.11	1.06	1.16	1.13
AV									
1974-77	1.11	0.95	0.93	0.96	0.89	–	0.95	0.95	0.89
1978-83	0.91	0.87	0.88	0.91	0.93	0.91	0.93	0.93	0.98
1984–86	1.04		1.04	1.08	1.01	1.09	1.08	1.08	1.11

Source: Average annual retail rice prices were obtained from the Bureau of Agricultural Economics. Average annual government ceiling prices were obtained from the National Food Authority.

Table 10. Ratio of annual average farmgate rough rice prices to annual average government rough rice support prices in selected regions, 1974-86.

Region	1	3#	4	6#	8	10	11	12#	Phil
CY 1974	1.07	1.25	1.11	1.00	1.00	0.76	–	0.96	1.10
1975	0.98	0.95	0.93	0.84	0.87	0.90	–	0.89	0.92
1976	0.93	0.97	0.91	0.84	0.82	0.90	–	0.80	0.91
1977	0.96	1.01	0.91	0.87	0.88	0.88	–	0.85	0.91
1978	0.94	0.95	0.90	0.80	0.90	0.90	0.85	0.85	0.88
1979	0.83	0.83	0.79	0.75	0.78	0.78	0.77	0.76	0.81
1980	0.82	0.79	0.75	0.72	0.78	0.77	0.75	0.80	0.79
1981	0.86	0.88	0.78	0.76	0.82	0.72	0.72	0.77	0.81
1982	0.82	0.84	0.73	0.73	0.74	0.77	0.77	0.81	0.79
1983	0.79	0.78	0.75	0.75	0.74	0.78	0.73	0.79	0.82
1984	1.08	1.03	0.87	0.88	0.80	0.78	0.89	0.92	0.90
1985	0.95	1.06	0.91	0.93	0.91	0.72	0.93	0.95	0.96
1986	0.96	0.89	0.81	0.75	0.72	0.79	0.77	0.77	0.82
Av									
1974-77	0.99	1.04	0.97	0.89	0.90	0.86	–	0.88	0.96
1978-83	0.84	0.85	0.78	0.75	0.79	0.79	0.77	0.79	0.85
1984–86	1.00	0.99	0.86	0.85	0.81	0.76	0.87	0.88	0.89

Source: Average annual farmgate rough rice prices were obtained from the Bureau of Agricultural Economics. Average annual government support prices were obtained from the National Food Authority.

prices. Furthermore, NFA's lack of success was not region-specific. Farm prices rated poorly with respect to support prices in both surplus (Regions 3, 6, 12) and deficit (Regions 1, 4, 6, 19, 11) regions.

The lackluster performance of NFA in the farm sector maybe attributed to several factors. First, budgetary problems constrained NFA procurement to a very small percentage of total production—a mere 4.8% in 1986. Prior to 1986, NFA's rice, wheat, and feed grain import monopoly enabled it to generate funds for its operations. Despite this and in addition to direct government subsidies, operating funds were still insufficient to sustain rough rice procurement activities successfully. After 1986, in line with the Aquino government's new import liberalization policy, NFA's monopoly on wheat and feedgrain imports was lifted. This event increased NFA's dependence on government subsidies to finance its operations, further aggravating its financial position.

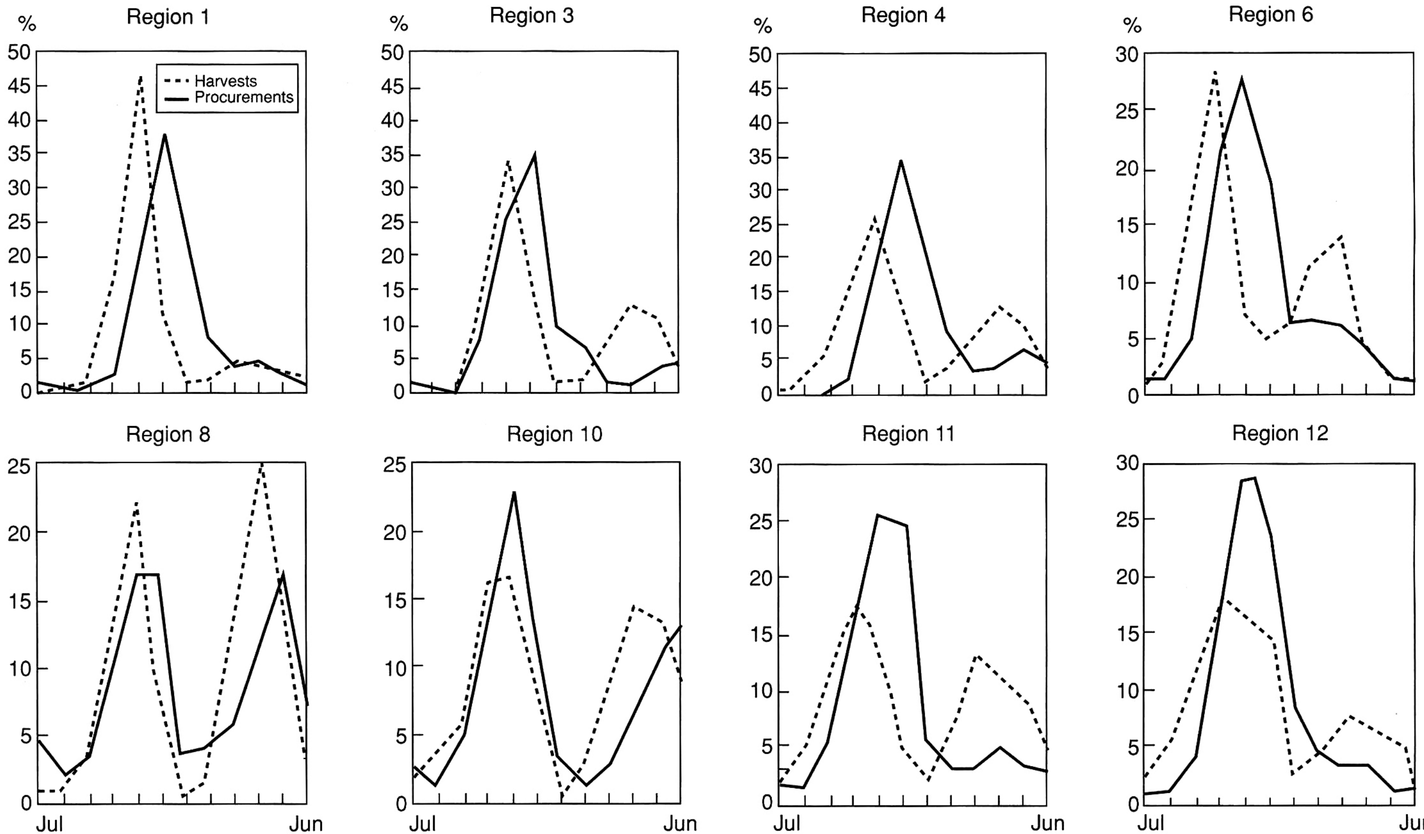
The timing and availability of funds at the procurement centers when harvest purchases have to be made have not been optimal. To achieve maximum impact on farm prices, procurement should occur during peak harvest when supply is at its highest level and rough rice prices are at their lowest. Peak NFA procurement from 1974 to 1986, however, generally occurred 1-2 mo after peak harvest. Figure 2 illustrates the average monthly percentage distribution of rough rice harvests during the crop year (July-June) set against the average monthly percentage distribution of NFA procurement for the period 1980-86.[11] In all eight regions covered by this study, NFA peak procurement occurred after peak harvests. A high-ranking NFA official at one of the regional offices admitted that the delayed procurement was primarily due to budgetary problems. Consequently, farmers who harvested later in the season or had the capacity to store for 1 or 2 mo had a higher chance of selling to NFA. The results of the marketing survey showed that 84% of the farmers in Nueva Ecija and 78% of the farmers in Iloilo did not sell their rough rice output to NFA for reasons such as too many requirements, delayed payment, and late procurement.

Finally, NFA's difficulties increased as it became more successful in defending the ceiling prices. The pressure to keep retail prices from rising above the ceiling price created a price lid which also meant significantly greater purchases were required to keep rough rice prices above the support price. However, NFA's financial constraints meant limitations on its purchasing ability with the resulting inability to simultaneously defend its announced floors.

Testing for market integration

Market integration analysis involves the study of the relationship of prices of homogeneous commodities in two different locations. As defined by Farruk (1970), markets are integrated "when prices in geographically separated markets move together in response to stimuli from changing demand and supply, and other economic conditions.

[11] The monthly percentage distribution of harvests is calculated by (volume of rice output for the month/total production volume for the crop year) x 100.



2. Percentage distribution of monthly NFA procurements vs rough rice harvests.

The accuracy and speed with which prices react and adjust to such stimuli can be taken as an indication of the degree of interrelationship in the mechanism of price formation between markets."

A modified form of Ravallion's (1986) model for testing of market integration is utilized to evaluate the extent of market integration between different levels of the regional rice marketing system in the Philippines. The Ravallion model, a dynamic model of price differentials, assumes the existence of a group of local markets trading with a large central/reference market. According to the model, local prices have an autoregressive distributed lag relationship with central market prices and are at the same time influenced by local conditions.[12] The reduced form of the Ravallion model as applied to each region for the wet, dry, and off-seasons is as follows:

$$PF_{it} = a_{i1} + a_{i2}\, PF_{it-1} + a_{i3}\, DWW_i + a_{i4}\, PW_{it-1} + a_{it}\, NFP_i + e_{it} \qquad (6)$$
$$i = \text{wet, dry, and off-season}$$
$$t = 1, 2, \dots n$$

$$PR_{it} = b_{i1} + b_{i2}\, PR_{it-1} + b_{i3}\, DWW_i + b_{i4}\, PW_{it-1} + u_{it} \qquad (7)$$
$$i = \text{wet, dry, and off-season}$$
$$t = 1, 2, \dots n$$

where PF_t = rice equivalent farm price/kg in month t, PW_t = rice wholesale price/kg in month t, PR_t = rice retail price/kg at time t, DWW = the change in the wholesale price between month t and t-1, NFP = government rough rice procurement in month t as a percentage of annual regional rice production, and e_{it}, u_{it} = error terms.

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[12] The general form of the Ravellion model is presented below

$$\Delta P_{it} = \left[\left(\sum_{j=1}^{n} \alpha_{ij} L^j\right) - L\right] \Delta^i P_t^* + \beta_{io} Pt^* +$$
$$\sum_{j=1}^{n-1} \left(\beta_{io} - 1 + \sum_{k=1}^{j} (\alpha_{in} - \beta_{in})\right) \Delta P^*_{t-j} +$$
$$\left(\sum_{j=1}^{n} \alpha_{ij} + \sum_{j=0}^{n} \beta_{ij} - 1\right) P^*_{t-j} + \delta_j (L) X_i + \varepsilon_{it}$$

where:

P_{it} = price in market i at time t;

P^*_t = reference market price at time t;

X_{it} = vector of seasonal and other influences in market i at time t;

ε_{it} = an error term;

and α_i (L), β_i (L) and δ_i (L) denote polynomials in the lag operator ($L_i p_t = P_{t-i}$), defined as $a_i (L) = 1 - \alpha_{i1} L - \dots - \alpha_{in} L^n$; $\beta_i (L) = \beta_{i0} + \beta_{i1} L + \dots + \beta_{im} L^m$; $\delta_i (L) = \delta_{i0} + \delta_{i1} L + \dots + \delta_{in} L^n$. In the simplest case, where the local and reference market price differences are lagged once (n = m = 1), the general equation can be expressed by:

$$P_{it} = \alpha_i P_{it-1} + \beta_{i0} (P^*_t - P^*_{t-1}) + (\beta_{i0} + \beta_{i1}) P^*_{t-1} + \delta_i X_i + \varepsilon_t$$

Refer to Umali (1990) for the theoretical derivation of the Ravallion market integration model.

This formulation of the Ravallion model with a one month lag for local and reference prices is the appropriate form for testing market integration in Philippine rice markets because 1 mo is adequate time for rough rice to be dried, milled, transported from rural to urban markets, and sold at the wholesale level, or for rice to be distributed from the wholesale to the retail level. It is sufficient time for market prices to adjust to changes in supply and demand.

For the question being addressed in this study, we are concerned with the coefficients a_{i3} and $ß_{i3}$; they measure the extent to which changes in general economic conditions affecting the wholesale price level are being transmitted to the farm and retail markets, respectively, and the extent to which local market participants (farmers and retailers) know the conditions in the wholesale market quickly enough for local prices to be influenced in the same time period. If a_{i3} and $ß_{i3} = 1$, then the wholesale market price changes are fully transmitted to the farm and retail markets in absolute terms, indicating long-run market integration.

Statistical analysis using the Chow test of preliminary runs of the Ravallion model for the farm-wholesale and wholesale-retail levels indicated that a structural change occurred between the periods January 1974-December 1982 and January 1983-June 1986. Thus, these periods are analyzed separately.

Farm-wholesale level results

Tables 11-13 present the results of testing for farm to wholesale market integration for the period 1974-82. All regions displayed weak long-run market integration during the wet, dry, and off-seasons. The coefficients for DWW were all statistically different from 1. And in some cases, the coefficients were not statistically different from zero. Under this low level of market integration, it is likely that information concerning quality preferences is not being transmitted back to growers. Investments in improved quality would not have been stimulated by market signals. The effect of NFA procurement represented by the variable NFP was negligible. During the wet season,

Table 11. Farm-wholesale rice market integration results, wet season, 1974-82.[a]

Variable	Region							
	1	3#	4	6#	8	10	11	12#
C	0.225	0.192	0.267	0.113	0.064	–0.086	0.303	–0.011
	(0.320)	(0.163)	(0.220)	(0.167)	(0.120)	(0.076)	(1.065)	(0.059)
PFt-1	0.351	0.188	0.591[c]	0.601[c]	0.438[c]	0.670[b]	0.272	0.873[b]
	(1.048)	(0.216)	(0.211)	(0.271)	(0.209)	(0.104)	(2.907)	(0.092)
DWW	0.590[b]	0.472[b]	0.340[b]	0.233[b]	0.583[b]	0.353[b]	0.581[b]	0.371[b]
	(0.127)	(0.133)	(0.094)	(0.107)	(0.153)	(0.075)	(0.116)	(0.067)
PWt-1	0.383	0.561[b]	0.192[b]	0.228	0.413[c]	0.272[b]	0.387	0.096
	(0.712)	(0.165)	(0.122)	(0.138)	(0.170)	(0.073)	(1.629)	(0.070)
NFP	0.046	0.007	0.035	0.024	0.051	0.051	0.004	0.022
	(0.054)	(0.019)	(0.033)	(0.037)	(0.069)	(0.018)	(0.013)	(0.013)
R^2	0.88	0.82	0.71	0.74	0.91	0.95	0.91	0.93
DW	1.88	2.15	1.82	2.06	2.13	2.22	1.87	2.10

[a]Standard errors are in parentheses. [b] = 1% significance, [c] = 5% significance, [d] = 10% significance from 0 except DWW where significance is measured from 1.

Table 12. Farm-wholesale rice market integration results, dry season, 1974-82.[a]

Variable	Region							
	1	3#	4	6#	8	10	11	12#
C	–0.001	0.035	0.344	–0.027	0.226	0.251	0.125	–0.091
	(0.109)	(0.232)	(0.105)	(0.120)	(0.179)	(0.193)	(0.837)	(0.156)
Pft-1	0.537[b]	0.230	0.433[c]	0.482[c]	0.341[d]	0.107	0.258	0.349[d]
	(0.164)	(0.751)	(0.160)	(0.232)	(0.205)	(0.208)	(4.313)	(0.181)
DWW	0.060[b]	0.653[d]	0.397[b]	0.360[b]	0.348[b]	0.467[c]	0.671[c]	0.316[b]
	(0.171)	(0.201)	(0.063)	(0.182)	(0.225)	(0.245)	(0.160)	(0.174)
PWt-1	0.402[b]	0.676	0.305	0.430[c]	0.403[b]	0.596[b]	0.530	0.567[b]
	(0.144)	(0.627)	(0.095)	(0.173)	(0.134)	(0.153)	(3.044)	(0.151)
NFP	–0.229	–0.040	0.018	0.005	–0.019	–0.042	0.003	0.004
	(0.281)	(0.042)	(0.049)	(0.045)	(0.045)	(0.043)	(0.041)	(0.065)
R^2	0.88	0.88	0.92	0.92	0.74	0.80	0.93	0.86
DW	1.50	1.94	2.04	2.22	1.60	2.00	1.80	1.98

[a]See Table 11 footnote.

Table 13. Farm-wholesale rice market Integration results, Off-season, 1974-82.[a]

Variable	Region							
	1	3#	4	6#	8	10	11	12#
C	0.054	0.108	0.661[d]	0.142	0.118	0.220[d]	0.339[c]	0.112
	(0.073)	(0.084)	(0.335)	(0.114)	(0.117)	(0.126)	(0.141)	(0.138)
Pft-1	0.580[b]	0.866[b]	–0.103	0.364[c]	0.512[b]	0.505	0.287	0.324
	(0.137)	(0.178)	(0.264)	(0.152)	(0.134)	(0.151)	(0.208)	(0.298)
DWW	0.309[b]	0.382[a]	0.448[c]	0.724[c]	0.183[b]	0.125[b]	0.548[b]	0.344[b]
	(0.102)	(0.165)	(0.299)	(0.121)	(0.169)	(0.192)	(0.127)	(0.109)
PWt-1	0.330[b]	0.069	0.543[c]	0.442[b]	0.334[b]	0.305[b]	0.381[b]	0.471[c]
	(0.116)	(0.139)	(0.251)	(0.133)	(0.091)	(0.106)	(0.134)	(0.200)
NFP	0.001	0.045	0.219	0.033	0.019	–0.059	0.045[c]	0.007
	(0.059)	(0.029)	(0.189)	(0.056)	(0.080)	(0.038)	(0.021)	(0.023)
R^2	0.92	0.89	0.29	0.82	0.79	0.84	0.89	0.86
DW	2.06	1.77	2.06	1.99	1.83	1.83	1.89	1.48

[a]See Table 11 footnote.

when the bulk of rough rice procurement occurs, the coefficients of NFP for all regions were very small and not statistically different from 0. All the coefficients of NFP were similarly small and not statistically different from 0 during the dry season. Only Region 11 during the off-season displayed a statistically significant coefficient (0.045). These results confirm the findings in the previous section which showed that NFA had minimal effect on prices of rough rice.

The 1983-86 period showed improved long-run integration in all regions (Tables 14-16). The improvement in market integration may be attributed partly to the declining levels of government price intervention at the wholesale level, which allowed for freer movement of wholesale and farm prices. The inflationary conditions during this second period may also be influencing the results by creating contemporaneous nomina1 price movement (Timmer 1987). Ten of the 21 coefficients of DWW

Table 14. Farm-wholesale rice market integration results, wet season, 1983-86.[a]

Variable	Region							
	1	3#	4	6#	8	10	11	12#
C	0.808	–0.931[c]	–	–0.002	0.258	1.151[d]	0.349	–0.143
	(0.608)	(0.309)	–	(0.747)	(0.497)	(0.686)	(0.338)	(0.176)
Pft-1	0.528	–0.861[c]	–	–0.396	0.020	–0.456	0.269	0.017
	(0.518)	(0.311)	–	(1.121)	(0.537)	(0.636)	(0.308)	(0.217)
DWW	0.521	0.822	–	0.747	0.787	0.572[b]	0.490[b]	0.659[b]
	(0.423)	(0.136)	–	(0.376)	(0.183)	(0.145)	(0.122)	(0.062)
PWt-1	0.273	1.906[b]	–	1.070	0.631[d]	0.867[c]	0.442[d]	0.786[b]
	(0.463)	(0.329)	–	(0.903)	(0.349)	(0.376)	(0.219)	(0.159)
NFP	–0.110	–0.747[b]	–	–0.357	0.150	–0.149	–0.086	0.041
	(0.966)	(0.162)	–	(0.427)	(0.657)	(0.178)	(0.067)	(0.029)
R^2	0.90	0.99	–	0.89	0.95	0.97	0.96	0.99
DW	1.99	2.55	–	1.89	1.73	2.00	1.70	2.35

[a]See Table 11 footnote.

Table 15. Farm-wholesale rice market integration results, dry season, 1983-86.[a]

Variable	Region							
	1	3#	4	6#	8	10	11	12#
C	0.433[d]	0.361	–	–0.215	0.480[c]	0.435	0.229	–0.091
	(0.235)	(0.304)	–	(0.261)	(0.175)	(0.249)	(0.361)	(0.214)
Pft-1	0.646[c]	0.795[d]	–	0.238	0.059	0.209	0.074	–0.162
	(0.274)	(0.406)	–	(0.570)	(0.324)	(0.301)	(0.294)	(0.433)
DWW	0.691[c]	0.891	–	0.985	0.708[b]	0.745[c]	0.700[c]	0.826[b]
	(0.121)	(0.184)	–	(0.141)	(0.056)	(0.097)	(0.140)	(0.073)
PWt-1	–0.2628	0.094	–	0.954[d]	0.595[c]	0.481	0.623[c]	0.936[b]
	(0.258)	(0.404)	–	(0.465)	(0.216)	(0.200)	(0.210)	(0.343)
NFP	–0.808[c]	–0.031	–	0.636[d]	–0.248[d]	–0.011	0.232	0.132
	(0.341)	(0.325)	–	(0.327)	(0.123)	(0.107)	(0.149)	(0.297)
R^2	0.98	0.97	–	0.98	0.99	0.96	0.94	0.99
DW	1.83	1.87	–	1.46	1.83	2.22	1.92	2.19

[a]See Table 11 footnote.

were not statistically different from 1, indicating that changes in economic conditions at the wholesale markets, including changes in quality preferences, were being fully transmitted back to farm-level markets. The remaining 11 were statistically different from 1, but were relatively high in value ranging from 0.5 to 0.8. NFA paddy procurement continued to exhibit minimal influence on farm prices.

Wholesale-retail level results

At the wholesale-retail level, the coefficients of DWW in all regions and seasons during the period 1974-82 were statistically different from 1, indicating weak long-run market integration (Tables 17-19). The low levels of market integration during this period can be traced, to a large extent, to government price intervention; wholesale prices displayed only slight seasonal behavior as a result of government rice distribution in

Table 16. Farm-wholesale rice market integration results, off-season, 1983-86.[a]

Variable	Region							
	1	3#	4	6#	8	10	11	12#
C	0.192	0.260	–	0.578[c]	–0.076	0.732[b]	0.709[d]	0.296
	(1.493)	(0.241)	–	(0.266)	(0.326)	(0.238)	(0.351)	(0.196)
Pft1	0.379	0.494[c]	–	0.054	0.507[c]	–0.087	–0.517	0.091
	(4.467)	(0.268)	–	(0.387)	(0.213)	(0.360)	(0.670)	(0.366)
DWW	0.811	0.792	–	0.593[c]	0.847	0.542[b]	0.820	0.665[c]
	(0.178)	(0.234)	–	(0.181)	(0.278)	(0.113)	(0.174)	(0.154)
PWt-1	0.527	0.429	–	0.631[c]	0.357[c]	0.652[c]	1.027[c]	0.656[c]
	(3.753)	(0.277)	–	(0.289)	(0.168)	(0.225)	(0.461)	(0.280)
NFP	–0.015	–0.230[c]	–	–0.212	0.69	–0.245	–0.320	–0.006
	(0.064)	(0.118)	–	(0.205)	(0.482)	(0.207)	(0.199)	(0.058)
R^2	0.97	0.97	–	0.92	0.89	0.98	0.96	0.96
DW	1.76	1.52	–	2.06	1.77	2.08	2.28	2.03

[a] See Table 11 footnote.

Table 17. Farm-wholesale rice market integration results, wet season, 1974–82.[a]

Variable	Region							
	1	3#	4	6#	8	10	11	12#
C	–0.019	–0.142	0.005	0.133	0.024	–0.299	0.237	–0.045
	(0.097)	(0.088)	(0.174)	(0.090)	(0.076)	(0.130)	(0.291)	(0.048)
PRt-1	0.363[d]	0.824[b]	0.805[b]	0.399[c]	0.680[b]	0.672[b]	0.604	0.969[b]
	(0.205)	(0.100)	(0.178)	(0.170)	(0.180)	(0.128)	(0.510)	(0.059)
DWW	0.794[c]	0.472[b]	0.637[b]	0.788[b]	0.672[b]	0.864[d]	0.640[b]	0.528[b]
	(0.076)	(0.072)	(0.084)	(0.057)	(0.0871)	(0.077)	(0.098)	(0.046)
PWt-1	0.692[b]	0.278[c]	0.227[b]	0.601[b]	0.343[b]	0.505[c]	0.326	0.064
	(0.221)	(0.125)	(0.179)	(0.173)	(0.177)	(0.181)	(0.437)	(0.063)
R^2	0.90	.98	0.90	0.96	0.97	0.98	.97	0.97
DW	1.99	2.10	1.85	2.03	2.18	1.93	1.69	2.24

[a] See Table 11 footnote.

wholesale markets. More notably, due to the legally enforced retail price ceiling, retail prices remained constant during certain months of the year. The Philippines was under martial rule from 1972 to 1981 and President Ferdinand Marcos empowered the military to close down and revoke the license of retail stores that sold rice above the ceiling price during some months. Government fixing of the retail price contributed greatly to the lack of market integration during the years 1974-82. Furthermore, with all rice being sold at the ceiling price, the quality premium was diluted, and incentives for quality improvement may have been obviated. However, it should be noted that the degree to which changes in wholesale prices were transmitted to real prices (as reflected by the coefficient DWW) was generally greater than the degree to which changes in wholesale prices were transmitted back to farm prices during this period.

Wholesale-retail trade indicated improved long-run market integration during the period 1983-86 (Tables 20-22). The coefficients of DWW were statistically different

Table 18. Farm-wholesale rice market integration results, dry season, 1974–82.[a]

Variable	Region							
	1	3#	4	6#	8	10	11	12#
C	0.036	–0.064	0.307	0.036	0.006	–0.083	0.298	–0.074
	(0.109)	(0.102)	(0.104)	(0.097)	(0.072)	(0.053)	(2.779)	(0.099)
PRt-1	0.539[c]	0.829[b]	0.304	0.631[b]	0.651[b]	0.784[b]	0.592	0.742[b]
	(0.193)	(0.120)	(0.223)	(0.194)	(0.148)	(0.135)	(4.015)	(0.169)
DWW	0.631[c]	0.791[b]	0.743[b]	0.688[c]	0.754[c]	0.694[c]	0.806[c]	0.778[c]
	(0.140)	(0.125)	(0.077)	(0.143)	(0.094)	(0.097)	(0.092)	(0.104)
PWt-1	0.478	0.225	0.603	0.392[d]	0.390[c]	0.278	0.312	0.314
	(0.193)	(0.152)	(0.192)	(0.200)	(0.153)	(0.145)	(3.159)	(0.187)
R^2	0.95	0.97	0.95	0.97	0.98	0.98	0.98	0.97
DW	1.84	2.02	2.01	1.77	2.16	1.92	1.33	1.93

[a]See Table 11 footnote.

Table 19. Farm-wholesale rice market integration results, off-season, 1974–82.[a]

Variable	Region							
	1	3#	4	6#	8	10	11	12#
C	–0.011	–0.025	0.163	0.002	0.078	–0.041	0.038	–0.013
	(0.043)	(0.035)	(0.138)	(0.066)	(0.056)	(0.047)	(0.084)	(0.106)
PRt-1	0.780[b]	0.939[b]	0.779[b]	0.812[b]	0.737[b]	0.814[b]	0.921[b]	0.430[b]
	(0.076)	(0.051)	(0.099)	(0.128)	(0.098)	(0.123)	(0.148)	(0.155)
DWW	0.623[b]	0.401[b]	0.322[b]	0.633[b]	0.575[b]	0.773[c]	0.635[b]	0.520[b]
	(0.049)	(0.057)	(0.046)	(0.066)	(0.078)	(0.099)	(0.116)	(0.077)
Pwt-1	0.241[b]	0.086	0.152[c]	0.209	0.254[b]	0.224	0.074	0.634[b]
	(0.072)	(0.056)	(0.069)	(0.129)	(0.094)	(0.136)	(0.162)	(0.164)
R^2	0.98	0.99	0.90	0.95	0.97	0.98	0.97	0.96
DW	1.89	1.84	1.92	2.06	2.07	2.27	2.15	1.80

[a]See Table 11 footnote.

Table 20. Farm-wholesale rice market integration results, wet season, 1983-88. [a]

Variable	Region							
	1	3#	4	6#	8	10	11	12#
C	0.287	4.515	–	-0.001	–0.609[b]	0.504	0.008	–0.060
	(0.224)	(0.379)	–	(0.292)	(0.118)	(0.447)	(0.115)	(0.167)
PRt-1	0.098	0.536	–	0.562	–0.012	-0.002	–0.088	0.097
	(0.442)	(0.489)	–	(2.523)	(0.180)	(0.528)	(0.472)	(0.306)
DWW	0.937	1.033	–	1.037	1.153[b]	0.898	0.935	1.023
	(0.077)	(0.255)	–	(0.061)	(0.036)	(0.124)	(0.063)	(0.065)
Pwt-1	0.878[d]	0.618	–	0.469	1.268[b]	0.996[d]	1.153[c]	0.994[b]
	(0.426)	(0.532)	–	(2.655)	(0.220)	(0.501)	(0.496)	(0.309)
R^2	0.99	0.98	–	0.99	0.99	0.99	0.99	0.99
DW	1.81	1.96	–	1.31	2.13	1.97	2.35	2.30

[a]See Table 11 footnote.

Table 22. Farm-wholesale rice market integration results, dry season, 1983-86.[a]

Variable	Region							
	1	3#	4	6#	8	10	11	12#
C	0.376[c]	–0.207	–	0.025	0.018	0.170	–0.064	0.061
	(0.169)	(0.283)	–	(0.161)	(0.072)	(0.155)	(0.046)	(0.104)
PRt-1	–0.172	0.288	–	0.765[c]	0.417	0.316	0.247	0.399
	(0.336)	(0.342)	–	(0.260)	(0.414)	(0.332)	(0.349)	(0.346)
DWW	0.961	1.123	–	0.913	1.150[b]	0.934	1.017	1.028
	(0.067)	(0.173)	–	(0.065)	(0.040)	(0.059)	(0.029)	(0.043)
PWt-1	1.145[b]	0.863[d]	–	0.257	0.623	0.693	0.801[c]	0.632
	(0.335)	(0.406)	–	(0.269)	(0.448)	(0.338)	(0.370)	(0.365)
R^2	0.99	0.98	–	0.99	0.99	0.99	0.99	0.99
DW	2.09	1.83	–	2.24	1.98	1.04	1.88	1.73

[a]See Table 11 footnote.

Table 22. Farm-wholesale rice market integration results, off-season, 1983-86.[a]

Variable	Region							
	1	3#	4	6#	8	10	11	12#
C	0.267[c]	–0.042	-	0.081	–0.078	0.423[c]	0.037	0.154
	(0.101)	(0.201)	-	(0.088)	(0.163)	(0.166)	(0.071)	(0.096)
PRt-1	0.161	0.489	-	0.551[c]	0.336	–0.022	–0.170	0.307
	(0.227)	(0.422)	-	(0.244)	(0.848)	(0.288)	(0.337)	(0.217)
DWW	0.894	0.856	-	0.922[d]	1.018	0.939	0.949	0.945
	(0.064)	(0.127)	-	(0.042)	(0.084)	(0.071)	(0.034)	(0.044)
PWt-1	0.822[b]	0.584	-	0.460[d]	0.743	1.023[b]	1.219[b]	0.707[c]
	(0.223)	(0.477)	-	(0.248)	(0.944)	(0.287)	(0.349)	(0.220)
R^2	0.99	0.98	-	0.99	0.99	0.99	0.99	0.99
DW	2.02	1.64	-	2.13	1.63	2.13	1.82	2.07

[a]See Table 11 footnote.

from 1 in only 3 cases: Region 8 during the wet (1.153) and dry (1.150) seasons and Region 6 during the off-season (0.922). These results for Regions 6 and 8, however, indicate a high degree of market integration. The improvement in market integration can be attributed to the decline in government intervention in terms of the reduction of rice distribution at the wholesale level and an end to the enforcement of ceiling prices through threats of store closures. Similarly, inflation may also be influencing the measured degree of market integration. Notably, the degree to which the change in wholesale prices was transmitted toretail prices, as reflected by the coefficient DWW, was generally greater than the degree to which the change in wholesale prices was transmitted back to farm prices. This indicates slightly better, though still imperfect, transmission of price changes at the retail level compared with the farm level.

Overall, the effect of public sector price stabilization activities on regional spatial price efficiency is to weaken the link between the farm and wholesale markets and between the wholesale and retail markets. However, the results of market integration analysis of Philippine rice markets also indicate improving market connection at all levels.

Summary and policy implications

A historical study of the Philippine rice marketing sector provides evidence of increasing competition in the rice retail, wholesale, warehousing, and transport industries, as the number of operators and business units during the period 1974-86 generally increased. The milling sector, though displaying increasing milling capacity for the same period, exhibited a marked decline in number in the late 1970s. This high level of market activity, compounded by the significant weight rice traders place on quality in determining prices of their products, implies that the market ought to be an effective conduit for transmitting quality preferences. However, this transmission can only occur if the retail, wholesale, and farmgate markets are well-integrated. The Philippine government, on the other hand, has been pursuing a price stabilization program where maintaining low consumer prices took precedence over the propping up of farm prices. This policy created a “price lid,” causing downward pressure on farm prices and incomplete transmission of consumer preferences.

The tests for market integration reveal weak links between farm and wholesale and wholesale and retail markets during the period 1974-82. However, a marked improvement in the degree of market integration during the period 1983-86 is in part attributable to declining levels of government intervention in the marketing system.

The incentives for the development and adoption of quality-improving technologies rest on the prompt and accurate transmission of price signals to the farm level. This study reveals that government price intervention is an important determinant of the efficiency of price transmission across markets. The binding price ceiling implies that intervention has dampened price movements relative to those implied by free and integrated markets. Moreover, the government monopoly in the importation of rice restricts the entry of better quality commodities, and the lack of foreign competition removes the incentive to improve local rice processing facilities.

It is the market which ultimately sets the price of rice; it will also be the rice market that will determine the incentives for any farm-level grain quality improvement strategy. Therefore, a clear understanding of the constraints implied by the rice marketing system is essential for the effective formulation and implementation of a grain quality improvement program.

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Rice grain quality in selected international markets

Assessing quality characteristics and price of rice in selected international markets[1]

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As incomes of rice-consuming countries rise and yield constraints are gradually overcome, grain quality becomes increasingly important for both traditional exporters and importers. For the former, grain quality is essential for sustaining traditional markets and for penetrating into high-income and high technology-requirement markets. For the latter, as self-sufficiency draws near, improving grain quality not only improves welfare of local consumers but also provides assurance that emergent surpluses will find a rewarding market.

Monke and Pearson (1987) argue that a substantial price difference between different qualities in the world market implies nonperfect substitution. Hence, technological changes that improve the quality of rice may yield high gross return apart from the positive welfare effects derived by consumers in the producing countries. In particular, improving quality characteristics related to genetic sources or varieties may reduce processing cost and directly raise returns to farmers.

The test of whether quality characteristics related to varieties will yield additional price premium is the main objective of this study which examines the relationship between price and quality characteristics of rice in three selected high-income markets: Hongkong, Bonn, and Rome.

Hongkong is a traditional Asian rice-consuming and-importing country. Bonn and Rome were selected to represent northern and southern European preferences, respectively, within the emerging EEC market. Rice samples were taken from major retail outlets and analyzed for their physicochemical properties at IRRI. The characteristic variables included in the hedonic function were obtained from interviews with traders, millers, and supermarket managers in each market.

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Grain quality characteristics

Rice standards

The most common criteria used by traditional rice growers and exporters to grade their rice involve physical properties such as length of grain, degree of milling, percentage of brokens, proportion of damaged grain, colored grain, moisture level, and impurities. Table 1 provides comparisons of rice standards of various major exporters. It is apparent that only Thai and U.S. rices are of a comparably high standard. Although Pakistan exports a number of grades of rice—for example, IRRI-6, Punjab (15-20%), Sind (15-20%), IRRI-6 (also known as Mehran 69 in the Sind), and Sind (15.20%)—only Basmati rice is considered high-standard rice. However, since Basmati is demanded by a specific ethnic group and is not consumed widely, it is often considered a specialty rice.

Rice standards do not fully explain the immense diversity in prices. For example, according to Thai rice standard, U.S. No. 2 and Thai 100% C are equivalent in quality but Thai 100% C rice received 92% of the CIF Rotterdam price received by U.S. No. 2 in the tight market situation in 1981 and fell to 50-60% of U.S. No. 2 price between 1982 and 1985 (Efferson 1985). Quality criteria, such as cooking qualities, some of which are not incorporated in rice standards, contribute to this price differential.

Cleanliness or absence of impurities is generally included in rice standards. In developed countries such as the U.S. and Australia, where rice growing, processing, and transporting are highly mechanized, the continuous processing and packing system ensures absence of foreign matter. In the Asian exporting countries where the processing, packing, and transporting systems are partly manual, standards on foreign matters are less strictly observed. In Thailand, rice standards are checked for tax purposes because a higher grade rice used to be taxed at a higherrate. Under this system, percentage of brokens and the length of the kernel rather than absence of impurities are considered most important.

Cooking quality

What are the consumers' preferred quality characteristics that are not covered by rice standards? What explains why one kind of rice is preferred to another? People from different regions have different tastes and preferences. The Japanese prefer the soft and relatively sticky short-grained japonica rice. Thais tend to favor well-milled, long-grained indica rice which is soft but flaky when cooked. In many traditional rice markets such as India, Pakistan, and Thailand, fragrant rices fetch the highest prices. In nontraditional markets such as those in the West, fragrant rice is considered spoiled or contaminated (Efferson 1985). Bangladesh, Nigeria, and Liberia are said to prefer parboiled rice while Jordan prefers rice treated with paraffin oil (FAO 1986). What consumers consider good rice depends partly on historical and partly on sociocultural factors. A top-quality rice in one region may be considered a low-quality variety in another region. Therefore, the concept of "good-quality rice" needs to incorporate consumer preference for cooking quality.

It is possible to translate consumer preference for cooking quality into measurable chemical properties. Cooking quality depends on a number of chemical characteris-

Table 1. Comparison of rice standards in selected countries.[a]

Thai grade	Other countries: Brokens (%)	Size of brokens	Milling degree	USA No. 1	USA No. 2 4% max	USA No. 2	USA No. 3 10% max	USA No. 4	USA No. 5 20% max	USA No. 5	Myanmar Emata super 100%	Myanmar Emata super 5%	Myanmar Emata Burma 10%	Myanmar Emata Burma 15%	Myanmar Emata Burma 25%	Myanmar Emata SMS 35%	Pakistan IRRI-6 Punjab 15-20%	Pakistan IRRI-6 Sind 15-20%	Pakistan IRRI-6 Sind 20-25%	Pakistan IRRI-6 Sind 35%	Pakistan IRRI-6 Sind 40-45%	Vietnam Short grain 15%	Vietnam Short grain 20%	Vietnam Short grain 25%
				4%	4%	7%	10%	25%	20%	35%	4%	3-7%	8-12%	13-18%	22-20%	30-40%	15-20%	15-20%	20-25%	35%	40-45%	15%	20%	25%
				Less than 3/4 & small brokens							3/4-1/2	1/2-1/3			1/2-1/4		Less than 3/4 & small brokens							
	%	parts		Well-milled			Reasonably well-milled		Lightly milled		Extra well-milled	Well-milled		Reasonably well-milled			Well-milled		Reasonably well-milled					
100% A	4.0	8-5 (5.2 mm)	Extra well-milled	◒																				
100% B	4.5	8-5 (5.2 mm)			○																			
100% C	5.0	8-5 (5.2 mm)				◒																		
	3-7	7.5-3.5 (4.6 mm)	Well-milled				○				○													
10%	8-12	7-3.5 (4.6 mm)						◒				◒												
15%	13-17	6.3-3 (4.0 mm)	Reasonably well-milled						◓				◒				◓					◓		
20%	18-23	6-3 & C1 (3.8 mm)												◒				◓					◓	
25% super	23-28	5-3 & C1 (3.2 mm)								◓									◓					◓
25%	23-28	5-3 & C1 (3.2 mm)	Ordinarily well-drilled and/or reasonably well-drilled												◒					◓				
35%	33-40	5-3 & C1 (3.2 mm)																			◓			
45%	42-50	5-3 & C1 (3.2 mm)														○								

[a] ◓ Better than Thai grade.
○ The same as Thai grade.
◒ Lower than Thai grade.

tics—apparent amylose content, gelatinization temperature, gel consistency, grain elongation, and aroma. These properties will be examined more closely in the following subsections.

Amylose content. A major determinant of eating and cooking quality, amylose content directly affects water absorption and volume expansion during cooking as rices with high amylose content bring about high volume expansion (not necessarily elongation) and high degree of flakiness. Tenderness and stickiness of cooked rice inversely correlate with amylose content. When cooked, rices with high amylose content are relatively dry, separate, and less tender. They also become hard upon cooling. Low-amylose (10-20%) rices—e.g., all the japonica varieties—tend to be moist and sticky when cooked.

The amylose content of the U.S. long-grained rices ranges from 23 to 26%; they are considered intermediate- to high-amylose varieties. The amylose content of Thai rices ranges from a low 12% to a high 31%. Basmati rices tend to have higher amylose content than Thai fragrant rices—i.e., 22.7% for Basmati 370 and 23% for Basmati 6129, respectively, and less than 20% for Khao Dawk Mali 105.

Gelatinization temperature. The temperature at which the starch granules begin to swell irreversibly in hot water is the gelatinization temperature. The alkali test is used to measure gelatinization temperature. For example, alkali spreading values of 1-2 reflect high gelatinization temperature (>74 °C); 3, high-intermediate; 4-5, intermediate (70-74 °C); and 6-7, low (<70 °C). This property is expected to be increasingly important if quick cooking is desired (e.g., in the production of instant or minute rice).

The breeding strategies of IRRI, the Philippine Department of Agriculture, and the Thailand Ministry of Agriculture and Cooperatives focus on intermediate gelatinization temperature. Most recommended Thai varieties have low gelatinization temperature. U.S. long-grained rices generally have intermediate gelatinization temperature, while the medium- and short-grained varieties have low gelatinization temperatures.

Gel consistency. Rices with similar amylose contents can be differentiated according to tenderness as measured by gel consistency. Given the same amylose group, cooked rice with softer gel consistency is more tender.

The method used by Cagampang et al (1973) to measure gel consistency classifies rices into three groups: hard (26-40 mm), medium (41-60 mm), and soft (61-100 mm).

Grain elongation, In South Asia and the Middle East, grain elongation without girth expansion is considered a desirable quality. Basmati rices of India and Pakistan expand 100% upon cooking. Thai rices generally expand both lengthwise and girthwise upon cooking.

Aroma. Some traditional varieties of rice are highly aromatic; the chemical creating the flavor is identified as 2-acetyl-1-pyrroline which is found in the volatile oil component of cooked rice (Buttery et al 1983). Aromatic rices fetch high prices in some international markets such as South Asia, the Middle East, and Thailand. The relatively well-known aromatic varieties include Basmati rice from India and Pakistan and Khao Dawk Mali from Thailand.

Sources of and returns to rice quality improvement

Traditional criteria for grading rice involve physical appearance. As rice is marketed in high-income markets, requirements such as absence of foreign matter, longer shelf life, and attractive packaging have emerged as new quality criteria. In addition, because high-yielding varieties produce grains with greater chalkiness, translucency and whiteness have been reemphasized as significant criteria, An earlier study of the author on rice quality in Thailand has identified sources of quality improvements and losses (Kaosa-ard 1985). Table 2 summarizes traditional and emerging criteria as classified by sources of quality improvements and losses.

Varietal improvement can enhance quality in the long run, but often processing is used to meet a desired quality standard. For example, a sorter can help delete colored grain. Mechanical equipment is used to separate brokens from head rice. Consequently, it can be expected that returns to processing constitute a large proportion of market prices. Varietal improvement in chemical properties, on the other hand, may give returns to farmers rather than to processors.

Cooking quality preferences of consumers in countries where rice is not a traditional staple (e.g., Europe, Africa, and the Americas) have not been studied. To date, knowledge has been based on observed transactions in the international markets. The willingness of consumers to pay for chemical properties will give a first approximation of preferred cooking qualities. In high-income, modern urban markets, factors (like packaging) and services which accompany a particular sales outlet could also affect consumers' willingness to pay for a product.

In the following discussion, the term "rice standard" refers to measures using traditional criteria and the term "rice quality" includes cooking quality. While it is possible to have an international comparison of standards, high or low quality must be discussed with respect to a particular market.

Conceptual framework

The instrument used to relate market price and quality characteristics of rice in this study is the hedonic regression which states a general relationship as follows (see Unnevehr 1992):

$$P_i = P\,(X_{il}, \ldots\ldots, X_{ij}, \varepsilon_{xi})$$

where P_i = observed price of commodity i, X_{ij} = characteristic j in commodity i, and e_{xi} = disturbance term.

This hedonic function is not automatically a demand or a supply function. As Rosen (1974) had shown, the hedonic price curve represents equilibria of the consumer's bid curve and the supplier's offer curve and suggested a two-stage least square if a demand or a supply structure is to be reflected.

There is no a priori rule regarding the inclusion of quality characteristics (Tabor 1988), but the characteristics included should be observable and economically relevant to consumers. Therefore, the use of expert information to specify what should be in the inclusion list is necessary.

In the present study, both linear and logarithmic $P_i = \overset{\pi}{_k} X_i^{Pk}$) models are used. The linear specification is generally acceptable if the characteristics measured are objective, continuous, and not lumpy in nature. These properties are well met by rice, the commodity in this study. The inclusion of the characteristics for each market depends on information obtained from interviews.

Table 2. Traditional and emerging quality criteria and sources of quality improvement.

Quality criterion	Sources of quality improvement (loss)						
	Variety	Site or site and genotype interaction	Preharvest management	Postharvest handling	Processing	Others	Short-run solution
Traditional							
% brokens	*	*	*	*	*	* (Environment)	Processing
Whiteness	*	*	-	-	*	-	Processing
Shape	*	-	-	-	-	-	-
Age	*	-	-	-	-	-	-
Aroma	*	*	-	-	-	* (Storage)	-
Emerging							
Physical appearance							
Foreign matter	-	-	-	*	*	* (Storage)	Processing
Translucency	*	*	*	-	-	-	Processing
Color	*	-	*	*	*	* (Storage)	Processing
Chemical properties							
Apparent amylose content	*	-	-	-	-	-	-
Gelatinization temperature	*	-	-	-	-	-	-
Gel consistency	*	-	-	-	-	-	-
Texture of cooked rice	*	-	-	-	-	-	-
Shelf life	-	-	-	-	*	*	Processing
Elongation	*	-	-	-	-	-	-
Marketing (packaging)	-	-	-	-	*	*	Processing

* Source of quality improvement.

Assessing quality characteristics in the Hongkong rice market

While Hongkong has imported almost all of its rice since 1965, the volume of rice imports into Hongkong has been constant at about 360,000 t/yr despite the increase in population. Hongkong's three major suppliers of rice in 1986 were Thailand (50%), China (33%), and Australia (17%).

Consumer preference

Consumption of rice in per capita terms is estimated at 70 kg/yr. However, a large proportion is consumed by foreign visitors and tourists. Hongkong consumers prefer long, slender, well-milled, and soft-textured rice. Thai rice is well-known in Hongkong for its flavor and, more recently, fragrance. Thai rice supplied to Hongkong is generally of superior standard (i.e., more carefully selected and milled) than rice supplied elsewhere.

Rice exported from China to Hongkong is mostly 10% long-grained rice called "See Mew". The high-amylose Chinese rice is particularly suitable for fried rice being served in restaurants. Australian rice is preferred for its softness. The long-grained "lnga" variety constitutes 75% of total Australian supplies, while the short-grained Calrose variety provides 15%; the remainder consists of rice brokens for processing. American rice is less preferred, owing to its higher cost and unsuitable taste and texture.

As incomes rise steadily over time, more and more Hongkong consumers shift from higher to lower amylose rices. Hongkong traders therefore blend rice of different origins to achieve the desired cooking quality. Moreover, since the Australian and Thai rices are harvested at different times, the two are said to be complementary—i.e., a fresh-season crop from Thailand may be blended with a last-season crop from Australia (and vice versa) to maintain the desired cooking quality.

A total of 93 samples were collected from 3 retailers (10 samples), 3 supermarkets (40 samples), and 3 wholesalers (43 samples). They were collected and shipped to IRRI in December 1987.

Grain characteristics

Table 3 indicates physicochemical characteristics of the rice samples collected from Hongkong which tend to have soft texture; 20% amylose, on average; and medium (50-60 mm) gel consistency. On the basis of conventional standards, they are mostly high-quality rices exhibiting more than 95% head rice with less than 1% chalky and damaged grains. Juliano et al (1992) presents more information regarding physicochemical properties.

One of the most striking quality differences observed in rices from various origins is in amylose content. On the average, it is highest for Chinese (24.7%) and lowest for Thai rice (17.8%). Fragrant rice from Thailand has an amylose content as low as 14%. Thai and Australian rices sold in Hongkong have very soft gel. It should be noted that actual amylose contents of rices from all origins are much lower than what traders believe them to be.

Table 3. Physicochemical characteristics of 93 Hongkong rice samples, November 1987.

Origin	Mean	Standard deviation	Minimum	Maximum
Length (mm)	6.41	0.79	4.79	8.25
Width (mm)	2.07	0.32	1.76	2.92
Length-width ratio	3.12	0.47	1.67	3.72
Head rice (%)	95.60	4.43	78.40	99.80
Kett whiteness (%)	42.91	1.55	39.40	46.60
Chroma meter L* value	74.60	0.71	72.60	76.20
Chalky grains (%)	0.34	0.32	0.03	2.00
Damaged grains (%)	0.28	0.23	0.00	1.02
Alkali spreading value	6.43	0.76	3.00	7.00
Apparent amylose (%)	19.96	4.19	13.90	27.70
Gel consistency[a] (mm)	53.63	19.44	26.00	91.00
Gel consistency[b] (mm)	67.32	21.58	28.00	100.00

[a] 100 mg test. [b] 90 mg test.

Table 4. Mean price of rice (HK$/kg) in Hongkong markets, by distribution outlet, November 1987.[a]

Origin	Sample (no.)	Mean	Standard deviation	Minimum	Maximum
Retailers	10	4.55	0.33	3.97	4.96
Wholesalers	43	3.33	0.42	2.58	4.40
Supermarkets	40	4.90	0.51	3.78	5.68
All samples	93	4.13	0.88	2.58	5.68

[a] HK$7.76 = US$1.00.

Price variation

A preliminary survey indicated and data from samples confirmed that prices differ substantially according to type of outlet (i.e., wholesale, retail, and supermarkets) (Table 4). Compared with supermarkets, retail shops on average offer rice at lower prices, but this price is higher than those offered by the wholesaler. Within the same supermarket chain, the price of rice of the same brands could differ but prices of the same brands in two competing supermarkets in the same location could be similar. Therefore, the variation of prices at the supermarket level depends on or correlates with its distribution. In other words, a well-distributed brand may have a wider price dispersion. This finding suggests a weighting procedure in the regression analysis.

Pure Chinese rice, a hard-texture type, fetches the lowest price while bagged rice of mixed origins is the most expensive (Table 5).

Impact of market and quality characteristics on prices

Interviews with Hongkong traders, wholesalers, and distributors identified percentage of head rice, length, milling degree, and soft texture to be important quality variables. Two sets of regression were run on Hongkong samples. The first two observations used 68 (instead of 93) samples because some supermarket samples were of the same brand and packing. The mean values of prices and characteristics of these samples were

Table 5. Price of rice (HK$/kg) in Hongkong markets. by origin, November 1987.[a]

Origin	Sample (no.)	Mean	Standard deviation	Minimum	Maximum
China	24	3.30	0.58	2.58	4.63
Thailand	34	4.03	0.82	3.22	5.32
Australia	14	4.92	0.51	4.10	5.52
United States	6	4.38	0.56	3.55	5.12
Mixed origins	12	4.94	0.42	4.26	5.68
Unidentified origins	3	4.57	0.15	4.45	4.90
All samples	93	4.13	0.88	2.58	5.68

[a] HK$7.764 = US$1.00.

Table 6. Impact of quality and marketing attributes on prices of rice in Hongkong markets (all samples), November 1987.

Attribute	Linear model			Log model		
	Coefficient	S.E.	t	Coefficient	S.E.	t
Constant	HK$1.847	0.334	5.519	0.226	0.131	1.727
Length (mm)	0.177	0.801	2.212	0.225	0.104	2.172
Gel consistency[a] (mm)	0.009	0.002	4.083	0.148	0.034	4.258
Retailers	1.289	0.112	11.505	0.338	0.029	11.506
Supermarkets	1.500	0.093	16.142	0.367	0.024	15.087
Adjusted R^2		0.8529			0.846	
F value		98.083			93.071	
Degrees of freedom			(4,63)			(4,63)

[a] 90 mg flour.

therefore used. A set of dummy variables representing sales outlet was also added to this equation. Soft texture was approximated by gel consistency. Both linear and logarithmic models were tried. Both equations were weighted by the inverse of the square root of the market share of each observation. Preliminary results suggested that milling degree was not statistically significant and was dropped from the equation. Head rice percentage and length of rice tended to correlate and head rice was dropped from the equation to avoid multicollinearity problems.

The best-fit equations are presented in Table 6. The linear model seems to provide a marginally higher R^2. It is suggested that a marketing margin of retail prices over wholesale prices was HK$1.50 for supermarket samples and HK$l.29 for rice from small retail shops, An increase of 1 mm in rice length would result in a price increment of 18 ¢/kg while a 1-mm increase in gel consistency (softer gel) would increase price by 1 ¢. Together, these variables explained about 85% of price variation in the

Table 7. Impact of quality characterlstics on retail prlces of rice in Hongkong supermarkets, November 1987.

Characteristic	Linear model			Log model		
	Coefficient	S.E.	t	Coefficient	S.E.	t
Gel consistency[a] (mm)	HK$0.17	–0.004	3.84	0.190	0.061	3.102
Head rice (%)	0.058	0.013	4.42	1.147	0.266	4.316
Apparent amylose (%)	0.089	0.024	3.64	0.334	0.107	3.132
Constant	–3.426	1.353	–2.53	–5.406	1.220	–4.432
Adjusted Ra		0.757			0.727	
F value		18.699			16.136	
Degrees of freedom			(3, 14)			(3, 14)

[a] 90 mg rice flour.

Hongkong market. The logarithmic model suggests that price elasticity of length was 0.225%; that of gel consistency was 0.148%.

The second set of regression comprises only observations obtained from supermarkets (Table 7). At the Supermarket level, the quality characteristics suggested by supermarket managers and importers are statistically significant—Hongkong consumers prefer long-grained, fluffy, but soft rice. The premium from the increase in head rice percentage and soft gel consistency (a measurement of tenderness) at the supermarket level are 6 and 9 c/kg, respectively, and return to 1% increase in amylose content raises price by 9 c. Together, these attributes explain 76% of price variation at the supermarket level. The log model suggests a higher price elasticity with respect to head rice than to amylose or gel consistency. It can be concluded that in this high-income, traditional, rice-consuming market, cooking quality parameters are important considerations.

Price and quality characteristics of rice in the European Community

Prior to the accession of Spain and Portugal, production of rough rice in the European Community (EC) (FAO 1987b) averaged 1.2 million t, almost entirely of japonica varieties. Almost 90% of this output is produced in Italy. When the output of Spain and Portugal is included, total rice output is estimated to increase to 1.9 million t, with 60% produced in Italy; 24% in Spain; and 16% in France, Greece, and Portugal (FAO 1987a).

Consumption of milled rice in the EC (FAO 1987b) averaged about 940,000 t in the early 1980s, increasing at an annual rate of 3.4% from 700,000 t in the mid-1970s. The growth is more rapid for the indica type—annual per capita consumption is highest in Greece (5 kg) and Italy (4.8 kg) and lowest in the Federal Republic of Germany (2 kg).

The rice markets in the EC can be divided into two submarkets: the Northern and the Southern European market, each having a distinct set of preferences. The Northern EC consumers (those in Northern France, Germany, Switzerland, and the Benelux countries) prefer the relatively dry cooking indica rice while those in Southern France, Spain, and Italy prefer the round and medium-grained japonica type.

A structural imbalance—i.e., production of japonica despite the preference for indica—has resulted in a net import of about 600,000-700,000 t of milled rice equivalent from nonmember countries, mainly the U.S., Thailand and, to a lesser extent, Surinam. Because Portugal is a net importer, the accession of Spain and Portugal increased imports by 100,000 t. The surplus japonica varieties were exported to the Middle East and Eastern Mediterranean countries with an increasing volume under food aid programs. In 1986, about 500,000 t of rice were exported by the EC under such programs.

The rice market in the Federal Republic of Germany

As mentioned earlier, annual per capita consumption in the Federal Republic of Germany is about 2 kg. The country imports approximately 170,000 t of rice and exports between 30,000 and 40,000 t annually. The three major suppliers are the U.S., Thailand, and Surinam.

The total value of retail sales is around 300 million deutsche mark (DM) every year. Of the rice marketed in the Federal Republic of Germany, 15% are japonica varieties (mostly used for desserts). The remaining are indica varieties imported mainly from the U.S. and Thailand. In the indica market, the combined market share of two American firms which produce high-quality rice is about 30%. These firms also pack their rice in high-quality packing materials. The largest market share, about 55%, is held by large chain stores which sell lesser quality rice. The remaining 15% is shared by two millers who produce medium-quality products.

By local regulation, rice distributors must specify the percentage of brokens on the containers. There are three standards—the spitzen (not more than 5% brokens), standard (not more than 15% brokens), and household (not more than 25% brokens). In the market segment supplied by discount or chain stores, 50% of these rices are of spitzen quality, 10% are of standard quality, and the remaining 40% are of household quality. The high- and medium-quality producers generally distribute spitzen-quality rice. There are a few producers who market 100% whole kernel rice but their market share is negligible.

Characteristics of samples. Rice sold in Bonn market is packed mostly in 500-g lots. “Boil in Bag,” one of the more popular types of packing, refers to the packing of rice in a perforated plastic bag in which rice can be boiled until cooked. This type of packing facilitates both cooking and cleaning activities.

Consumer preference. German consumers prefer rice which cooks easily. Length of kernels and degree of milling, desired qualities for East Asian consumers, are not considered important characteristics in Germany where consumers are thought to be more interested in flaky rice with relatively hard texture. Some traders feel that such a preference has been fostered by advertisements of a US. brand which suggest that good rice “never sticks.” Others claim that German consumers do not care about the “taste” of rice since they are more interested in price. Interviews with traders also suggest that customers have little knowledge about the local grading system (i.e., percentage of brokens). They only know vaguely that whole kernel and spitzen are of superior quality. German customers are said to be more conscious of price than of quality.

Physicochemical characteristics of German rice samples. Table 8 shows the physicochemical characteristics of the collected samples of long-grained rice. In general, rice sold in Germany has a much lower percentage of head rice, higher amylose (23% on average), and slightly harder gel consistency than the Hongkong samples. Even the amylose content of the short-grained samples is higherthan that of Hongkong's indica rice samples. For samples coming from the EC, Chroma meter L*, a*, and b* values (which indicate shades of color) are also provided. L* indicates whiteness; a negative value of a* indicates green while a positive value indicates red; and b* suggests a yellow tone. Raw rice generally had higher whiteness (Chroma meter L* values) and lower Chroma meter a* and b* values than parboiled rice. The physicochemical characteristics of German and Italian rice samples are discussed in another chapter.

Price variation. Prices of packaged rice in Germany vary according to grade, processing level, grain type, packing type, and lot size (Table 9). Whole grain and spitzen-quality rice fetch much higher prices than standard and household rice. Both whole grain and spitzen rice are generally branded products while standard and household rice usually bear the name of the discounters. Packing types also appear to have significant impact on prices. Precooked and parboiled rice derive 60-230% higher margin than does regular rice.

Impact of grain quality on prices. The independent variables specified for the hedonic functions of the German samples include processing (brown, regular, parboiled, or precooked), packing type (double vs single packing), amylose content, and gel consistency. The observations were weighted by the inverse of the square root of market share by brand (Table 10). Both linear and logarithmic functions were tried with the log equation providing a better fit.

Table 8. Physicochemical characteristics of 82 long-grained rice samples from Bonn, Germany, June 1988.

Variable	Mean	Standard deviation	Median	Minimum	Maximum
Length (mm)	7.37	0.85	7.24	1.23	8.53
Width (mm)	2.24	0.10	2.23	2.01	2.70
Length-width ratio	3.33	0.22	3.26	2.95	3.98
Head rice (%)	88.51	19.27	94.65	2.80	99.20
Chalky grains[a] (%)	3.39	2.09	2.86	0.56	8.94
Damaged grains (%)	4.37	3.30	3.65	0.00	14.78
Translucency[b] (%)	75.27	20.13	82.00	20.00	99.00
Kett whiteness (%)	30.19	9.26	35.03	22.00	44.50
Chroma meter L* value	56.28	26.39	65.45	1.50	77.10
Chroma meter a* value	–0.16	1.16	–0.35	–2.70	4.00
Chroma meter b* value	19.65	4.64	17.40	13.00	28.80
Alkali spreading value	5.84	1.06	6.20	1.00	7.00
Apparent amylose (%)	23.42	1.47	23.35	17.20	28.60
Gel consistency, 100 mg (mm)	47.43	14.77	43.00	30.00	98.00
Gel consistency, 90 mg (mm)	65.44	15.20	62.00	33.00	98.00
Protein (%)	7.91	0.46	8.00	6.80	9.00

[a]n = 45. The others had 0% chalky grains. [b]n = 41. The others had 100% translucency.

Table 9. Prices of 106 German rice samples (deutsche mark/500 g), June 1988.[a]

Variable	n	Mean	Standard deviation	Median	Minimum	Maximum
Grade						
Whole grain	2	2.84	1.48	2.84	1.79	3.89
Spitzen (max 5% brokens)	81	2.61	1.20	1.99	1.22	5.98
Standard (max 15% brokens)	6	1.41	0.31	1.39	1.09	1.89
Household (max 25% brokens)	14	1.60	0.46	1.58	0.99	2.98
Brokens	3	1.32	0.57	0.99	0.99	1.98
Processing type						
Milled, raw	59	1.81	0.68	1.59	0.99	4.58
Parboiled (A)	34	2.90	0.98	3.22	1.29	4.58
Precooked (B)	6	3.65	1.22	3.08	2.78	5.98
Brown, raw	4	1.76	0.20	1.79	1.49	1.98
Parboiled, precooked	3	5.98	0.00	5.98	5.98	5.98
Grain type						
Short grain	20	1.87	0.82	1.49	1.25	3.98
Long grain	86	2.55	1.22	1.99	0.99	5.98
Packing type						
Single plastic bag	43	1.63	0.26	1.69	1.09	1.99
Plastic bag in box	5	3.18	0.47	2.98	2.78	3.98
Boil-in-bag	43	2.91	1.24	2.99	0.99	5.98
Aluminum bag in box	1	3.89	–	–	–	–
Grain in box	13	2.69	1.65	1.99	0.99	5.98
Single paper bag	1	2.15	–	–	–	–
Lot size						
250 g	23	3.28	1.62	2.98	1.58	5.98
500 g	72	2.20	0.92	1.84	0.99	4.49
1000 g	11	1.67	0.29	1.62	1.22	2.15

[a] DM1.75 = US$1.00.

Table 10. Impact of quality characteristics on retail prices of rice in Bonn (Germany) supermarkets, June 1988.[a]

	Linear model			Log model		
Characteristic	Coefficient	S.E.	t	Coefficient	S.E.	t
Constant	DM 0.474	0.504	0.941	0.609	0.281	-2.462
Head rice (%)	0.011	0.006	2.020	0.246	0.063	3.936
Lot size[b]	0.561	0.271	2.075	ns	ns	ns
Double packing	0.624	0.219	2.852	0.366	0.073	5.051
Brown rice	0.800	0.211	3.788	0.339	0.076	4.413
Parboiled rice	0.189	0.388	0.488	0.128	0.144	0.889
Adjusted R^2		0.416			0.4884	
F value		11.112			12.297	
Degree of freedom			(5. 66)			(5, 66)

[a] Weighted by the inverse of the square root of the market share of each brand. [b] Not statistically significant.

On the basis of the linear model, factors found to influence prices in Bonn supermarkets are lot size, packing type, and degree of processing. Double packing would fetch DM 0.62 over and above single packing. Smaller lot size (500 g) gets DM 0.56 higher premium. Regular rice obtains DM 0.80 less than brown rice because in these samples all brown rices happen to be whole kernels. Parboiled or precooked rice obtains DM 0.19 more than the regular rice. Percentage of head rice is found to be the only quality characteristic that is statistically significant but its impact is small. A 1% increase in head rice would yield DM 0.011 more. The log model predicts that a 1% increase in head rice will increase prices by 0.25%. Cooking qualities specified for this model (i.e., amylose and gel consistency) do not turn out to be important factors.

The rice market in Italy

Italy, the largest producer and exporter of rice in the EC, produces slightly more than 1 million t of rice and while it exports about 700,000 t annually, it also imports small amounts. The rice grown in Italy are japonica varieties, the preferred varieties in Southern Europe including the south of France, Spain, and Portugal. The surplus output of Italy enters the North European countries as "milk rice" for desserts and the remaining output has to find markets outside the Northern European region, mainly in Jordan and Lebanon. Italian millers also import brown rice for further milling and processing for the EC market.

Rice is sold in large supermarket chain stores, suburban small supermarkets, and special food stores (alimentari) and food markets. Rice sold in all outlets are mostly packed in transparent plastic bags which are generally less fancy than those in Germany. The variety and milling degree (i.e., unmilled, milled, overmilled) are generally specified. They consist of 7 brown rices (3 raw, 4 parboiled) and 98 milled rices: 17 parboiledand 81 raw (9 undermilled, 34 overmilled, and 38 regularly milled).

Consumer preference. Interviews with rice experts, local millers, and packers revealed that preferences of Italian consumers are different from those of Northern European consumers as they are accustomed to the homegrown japonica varieties. Italian consumers, it is claimed, have a good knowledge of delicious varieties. In contrast with consumers in other regions, they prefer more chalky varieties. Hence, nonchalky rice is usually exported. The slender shape which is more preferred in the Far East market is not considered a superior characteristic in Italy.

Price. Prices of Italian rices differ according to market outlet, grain type, lot size, and packing (Table 11). Indica rices are imported and are subject to high levies; hence, they command higher market prices. Locally produced rice is packed in plastic bags or contained in thin cardboard boxes.

Physicochemical characteristics of Italian rice. Table 12 provides information on the physicochemical characteristics of short-grained Italian rice. Japonica varieties sold in Italian market tend to have higher amylose and harder gel than the indica varieties sold in the Hongkong market.

Impact of quality characteristics on prices. Quality characteristics specified by traders as important quality attributes in Italy (i.e., chalkiness and cooking qualities like amylose and gel consistency) were included in the regression along with market outlet, and grain and packing type which were entered as dummy variables. Since market

Table 11. Prices of 105 rice samples (lira/kg) from Rome (Italy) markets, May 1988. [a]

Variable	n	Mean	Standard deviation	Median	Minimum	Maximum
Outlet type						
Alimentari	15	3957	125	3600	2050	6100
Supermarket	67	2121	527	1990	1180	4060
Small supermarket	16	2200	555	2020	1490	3580
Food market	7	1843	190	1900	1500	2100
Grain type						
Indica	10	4080	159	4280	1900	6100
Japonica	95	2197	605	2040	1180	4500
Lot size						
500 g	21	3195	112	2850	1900	6100
1000 g	84	2172	750	1970	1180	5600
Packing type						
Single plastic bag	49	2147	876	1890	1180	5600
Plastic bag in box	4	4005	576	3820	3580	4800
Aluminum bag in box	1	6100	–	–	–	–
Grain in box	49	2378	706	2290	1340	6000
Vacuum packing	2	2840	198	2840	2700	2980

[a] Lira 1,258.70 = US$1.00.

Table 12. Physicochemical characteristics of 95 Japonica rice samples sold in Rome (Italy) markets, May 1988.

Variable	Mean	Standard deviation	Minimum	Maximum
Length (mm)	6.36	0.67	4.86	7.29
Width (mm)	3.06	0.23	2.62	3.88
Length-width ratio	2.09	0.24	1.57	2.45
Head rice (%)	97.14	1.44	92.40	99.70
Chalky grains [a] (%)	4.47	6.32	0.00	34.06
Damaged grains (%)	3.28	2.47	0.28	15.20
Translucency [b] (%)	78.54	11.96	41.00	98.00
Kett whiteness (%)	39.76	20.82	12.00	53.00
Chroma meter L* value	73.21	6.32	53.60	79.60
Chroma meter a* value	–0.83	1.23	–2.20	3.80
Chroma meter b* value	15.66	4.71	11.10	28.20
Alkali spreading value	6.95	0.36	4.01	7.02
Apparent amylose (%)	19.52	2.27	16.00	26.00
Gel consistency, 100 mg (mm)	53.93	12.25	28.00	81.00
Gel consistency, 90 mg (mm)	69.38	13.78	30.00	95.00
Protein (%)	6.92	0.67	5.50	8.80

[a] n = 79. [b] = 67; others had 100% values.

shares of each brand cannot be obtained, the regressions were not weighted but had been corrected for heteroscedasticity problem.

All variables specified have the expected sign: the more chalky, the higher the price; double packing fetches 1443 lira higher than single packing; japonica varieties command 654 lira less than indica variety (for 1-kg pack); rice in a special food store

Table 13. Weighted regression of quality and marketing attributes on price of Rome (Italy) rice samples, May 1988.

Attribute	Linear model			Log model		
	Coefficient	S.E.	t	Coefficient	S.E.	t
Constant	2700.20	403.28	6.70	8.29	0.41	20.15
Alimentari	1415.39	288.57	4.90	0.59	0.12	4.71
Supermarkets	425.37	243.59	1.75	0.18	0.11	1.69
Japonica	–653.55	284.63	–2.30	0.22	0.13	–1.75
Double packing	1443.10	358.80	4.02	0.39	0.19	2.02
Chalky grains (%)	11.60	9.17	1.27	0.02	0.20	1.12
Gel consistency[a] (mm)	–9.90	4.38	–2.26	–0.18	0.10	–1.75
Adjusted R^2	0.77	0.52				
F value	47.47	15.19				
Degrees of freedom			(6, 76)			(6, 76)

[a]100 mg rice flour.

(alimentari) and supermarket are 1415 and 425 lira higher, respectively, than that in the food market (Table 13). The nonlinear model suggests that price elasticity of chalkiness (in absolute value) is lower than that of gel consistency. A 1% increase in chalkiness yields an additional price premium of 0.02% and an increase in softness (gel consistency) by 1 mm reduces price by 0.18%. As in other international markets, marketing variables (such as distributional channel, packing type) asserted high price premiums. The Italian consumers favor harder textured rice.

Conclusions

The present study suggests that marketing variables (outlet, packaging, lot size) have high implicit values in all high-income markets investigated. In traditional rice-consuming markets such as Hongkong and Italy, cooking characteristics tend to be significant. In the Federal Republic of Germany, only marketing variables show significant implicit prices. In the traditionally rice-consuming economies such as Hongkong and Italy, quality characteristics turn out to be important considerations. In Hongkong, indica rice is preferred and higher prices are paid for relatively long grain, higher percentage of head rice, flaky but soft-textured rice. In Rome, japonica rice is preferred and in contrast to East Asian consumers, Italians prefer chalky grains and relatively harder gel. In both markets, the type of outlets is an important factor influencing prices. In Bonn, a traditionally nonrice-consuming market, only one physical quality (percentage of head rice) is statistically important. In this market, the level of processing, lot size, and packing types are important considerations.

Two explanations may be offered for the fact that chemical properties are not significant in the German market. First, the range of cooking characteristics may be too narrow for consumer evaluation, an explanation given to a similar phenomenon found in Indonesia (Tabor 1988). This situation could occur if traders prescreen quality characteristics and select a specific narrow range to meet a certain specification. In the case of the German market, traders may have tailored their orders to match the

Table 14. Comparison of major cooking (chemical) properties of rice sold in 3 international markets. [a]

Property	Hongkong (n = 68)	Bonn, FRG (n = 72)	Rome, Italy (n = 105)
Amylose (%)			
Mean	20.25	22.84	19.73
Standard deviation	4.40	1.75	2.43
Minimum	13.90	17.20	15.80
Maximum	27.10	26.00	26.00
Range	13.20	8.80	10.20
Coefficient of variation (%)	21.46	7.66	12.31
Gel consistency[b] (mm)			
Mean	66.74[b]	56.81[b]	69.38
Standard deviation	22.61	15.38	13.78
Minimum	28.00	31.00	30.00
Maximum	100.00	99.00	95.00
Range	72.00	68.00	65.00
Coefficient of variation (%)	33.88	27.07	23.27

[a] The statistics presented are calculated from the samples used in the regression (reduced samples). [b] 90 mg rice flour/2.00 ml 0.2 N KOH.

specification of a famous American brand. Secondly, traditional nonrice eaters such as the German consumers have not yet acquired the ability to distinguish the cooking characteristics of rice or have not established a specific preference for cooking quality. Evidence in Table 14 tends to support the first explanation if one compares the chemical properties of the German samples with those of the Hongkong samples. The range and coefficients of variation of amylose content of the German samples are the lowest. However, when gel consistency is considered, the same statistics are lowest in the Italian samples, and yet this variable is statistically significant in the Italian hedonic regression.

This study has several implications for a traditional exporter like Thailand, which obviously has the advantage in supplying traditional Asian markets like Hongkong because of the Thai varieties' cooking quality. On the other hand, the U.S. has an advantage in supplying an emerging nontraditional market like Germany because U.S. rice producers have a domestic market focused on physical quality and attractive packaging. To enable Thailand to compete in the Northern European market, Thai exporters need to develop aggressive marketing strategies to advertise the cooking quality of Thai rice and to improve its packaging.

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Grain quality characteristics of export rices in selected markets[1]

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The physicochemical properties of brown and milled rices in international trade have not been systematically studied. Only 4% of the world's rice enters the international market (Efferson 1985), with Thailand and the U.S. as principal rice exporters. Market samples in some countries have been classified on the basis of U.S. rice grades (Riverburgh 1961) and on cooking and eating qualities (Simpson et al 1965). The world rice market also has been studied in terms of behavior, structure (Siamwalla and Haykin 1983), and market quality (Efferson 1985). Rice quality in major exporting countries—Thailand (Bhattacharya 1984, Attaviriyasook 1985), U.S. (Webb et al 1985), Australia (Blakeney 1979), China (Fang 1985)—and in all rice-producing countries (Juliano and Pascual 1980, Juliano 1985) has been reviewed. The properties of Italian rice varieties have also been reviewed (De Rege et al 1966, Baldi et al 1981).

This study focuses on grain characteristics of rice exported from Bangkok, rice in the retail markets of a rice-consuming, but mainly rice-importing country (Hongkong), and of nontraditional rice-consuming countries in the European Community (Bonn, Germany, representing northern Europe, and Rome, Italy, representing southern Europe) (Kaosa-ard and Juliano 1992). The role of rice in Hongkong is reviewed (Bruton 1987); annual rice consumption is about 70 kg per capita. Annual rice consumption is about 2 kg per capita in Germany and 4.8 kg per capita in Italy (Kaosa-ard and Juliano 1991).

Materials and methods

Samples of milled rice and brown rice (50 g each) were obtained from retail markets in Hongkong in November 1987, in Bonn in June 1988, and in Rome in May 1988. Retail prices and packaging were noted. Export rices from Bangkok were obtained in

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May 1986 through SGS Far East Ltd., Bangkok. Mean export prices during July 1986 also were obtained from SGS. Retail prices were converted into U.S. dollars using the prevailing rate at the time of sampling.

Grains with >50% chalky area and damaged grains were removed manually from each sample. (Damaged grains are those that are distinctly discolored or damaged by water, insects, heat, or other means.) Mean length and width of 10 grains per sample were analyzed using a photoenlarger (10X) and length-width (L-W) ratios were calculated. Head rice was measured using a Satake Testing Rice Grader TRG 05A with a cylinder indented to remove brokens <3/4 of whole-grain length. Translucency was analyzed using a Riken-Sanno rice meter (brown rice model). Whiteness was measured with a Kett Model C-3 whiteness meter and with a Minolta Chroma meter Model CR-110 on L*a*b* mode with granular material attachment. Five grams of brown rice per sample were milled for 0.5-1 min in a Kett Pearlest small-scale polisher for analysis of alkali spreading value (Little et al 1958), amylose content (AC), and gel consistency (GC)

Five grams of each milled rice sample was ground in a Udy cyclone mill with 60-mesh sieve and analyzed for colorimetric apparent AC (Juliano et al 1981), GC of 100 mg and 90 mg flour/2 ml 0.2 N KOH (Cagampang et al 1973), and crude protein by microKjeldahl method (Juliano and Pascual 1980). Gel consistency values for 90 mg are reported (instead of 100 mg) because we observed that many market samples with medium GC gave hard values at 100 mg but not at 90 mg.

To assess the aroma of Hongkong rices, 20-30 grains were cooked in a boiling water bath for 10 min in 20 ml water in covered 50-ml test tubes and cooled. Aroma was rated as strong, moderate, slight, or none (IRRI 1971).

Grain length was classified as extra long (>7.50 mm), long (6.61-7.50 mm), medium (5.51-6.60 mm), and short (<5.50 mm) (Khush et al 1979). Grain shape (length-width ratio) was classified as slender (>3.00), medium (2.01-3.00), and bold (1.01-2.00). Final starch gelatinization temperature (GT), indexed by alkali spreading value, was classified as low (6-7), intermediate (4-5, high-intermediate (3), and high (2) (Little et al 1958). Apparent AC was classified as waxy (0-2%), low (10-20%), intermediate (20.1-25.0%), and high (>25.0%). Gel consistency was classified as soft (61-100 mm), medium (41-60 mm), and hard (27-40 mm).

Results and discussion

Variety classification

Thai export prices. Most samples were long with hard, slender grains, except for glutinous (waxy) rices (Table 1). Thai Basmati had a higher export price than fragrant rices (Jasmine, Khao Dawk Mali), which in turn had a higher export price than nonaromatic rices. Nonglutinous (nonwaxy) rice bad a slighty lower price than glutinous rice. Brokens were cheaper than head rice.

Alkali spreading values showed a predominance of intermediate-GT rices among the nonaromatic milled rices; mainly low-GT rices were prevalent among fragrant and glutinous rices. Thai Basmati showed intermediate GT, intermediate AC, and hard GC. The nonaromatic nonwaxy milled rices had intermediate to high AC, the fragrant rices

Table 1. Classification of selected properties of 73 Thai export raw rices exported from Bangkok, May 1986.

Sample	Mean price (US$/t)	Sample (no.)	Length [a]		L-W ratio [b]		Alkali spreading value [c]			Apparent amylose content [d]				Gel consistency [e]			Crude protein (% wet basis)	
			L	M	S	M	L	I	HI	Wx	L	I	H	S	M	H	Range	Mean
White rice 100%	220	10	10	0	10	0	1	8	1	0	1	3	6	0	2	8	6.2-7.1	6.6
White rice 5%	205	5	5	0	5	0	1	4	0	0	0	5	0	0	0	5	6.5-7.1	6.9
White rice 10%	206	5	2	3	3	2	0	5	0	0	0	0	5	1	0	4	6.0-7.0	6.5
White rice 25%	180	5	1	4	3	2	1	4	0	0	0	2	3	0	0	5	5.9-6.6	6.2
White rice brokens																		
A-1 superspecial	155	3	–	–	–	–	2	1	0	0	0	0	3	0	0	3	6.3-6.4	6.3
White rice brokens																		
A-1 special	115	7	–	–	–	–	0	7	0	0	0	4	3	0	1	6	5.5-6.4	6.2
Fragrant rice 100%	290	9	9	0	9	0	9	0	0	0	8	1	0	4	5	0	6.1-7.0	6.4
Fragrant brokens A-1	123	7	–	–	–	–	4	3	0	0	5	1	1	1	4	2	5.8-6.6	6.2
Thai Basmati	700	1	1	0	1	0	0	1	0	0	0	1	0	0	0	1		7.7
Glutinous rice 10%	240	6	2	4	4	2	6	0	0	6	0	0	0	6	0	0	5.8-6.7	6.3
Glutinous rice short																		
grains 10%	240	5	1	4	1	4	5	0	0	5	0	0	0	5	0	0	5.8-6.2	6.0
Glutinous brokens	180	2					2	0	0	2	0	0	0	2	0	0	5.5-5.5	5.5
Total/mean	209	65	31	15	36	10	31	33	1	13	14	17	21	19	12	34	5.5-7.1	6.4
Brown rice																		
Brown rice 100%	175	5	3	2	3	2	0	5	0	0	0	4	1	0	3	2	6.7-7.1	6.9
Thai Basmati	465	1	0	1	1	0	0	1	0	0	1	0	0	0	0	1	–	7.6
Black glutinous	205	1	0	1	0	1	1	0	0	1	0	0	0	1	0	0	–	8.0
Mixed, red and white	175	1	1	0	1	0	0	1	0	0	0	1	0	0	0	1	–	6.8
Total/mean	215	8	4	4	5	3	1	7	0	1	1	5	1	1	3	4	6.7-8.0	7.1

[a] L = long (6.61·7.50 mm) and M = medium (5.51-6.60 mm). [b] S = slender (>3.00) and M = medium (2.01.3.00) [c] Gelatinization temperature type: L = low (6.7). I = interrnediate (4-5), and HI = high-intermediate (3). *d* Wx = waxy (02.0%). L = low (10.1-20.0%), I = Intermediate (20.1-25.0%), and H = high (>25.0%). [d] S = soft (61-100 mm). M = medium (41-60 mm), and H = hard (27-40 mm).

Table 2. Classification of selected propem of 25 Thai export parboiled rices exported from Bangkok, May 1986.

Sample	Mean price (US$/t)	Sample (no.)	Length[a]		L-W ratio[b]		Alkali spreading value[c]		Apparent amylose content[d]		Gel consistency[e]			Crude protein (% wet basis)	
			L	M	S	M	L	I	I	H	S	M	H	Range	Mean
Milked rice															
Parboiled 100%	195	8	8	0	7	1	5	3	4	4	5	2	1	6.4-7.1	6.8
Parboiled 5%	185	8	8	0	7	1	4	4	2	6	2	3	3	6.0-7.2	6.4
Parboiled 10%	180	1	1	0	1	0	1	0	1	0	0	0	1	–	6.7
Parboiled 15%	175	1	1	0	1	0	1	0	1	0	0	0	1	–	6.2
Parboiled 35%	163	1	1	0	1	0	0	1	1	0	0	0	1	–	6.5
Total/mean	187	19	19	0	17	2	11	8	9	10	7	5	7	6.0-7.2	6.6
Brokens															
Parboiled A-1 special	125	2	–	–	–	–	2	0	1	1	0	1	1	6.5-6.6	6.6
Brown rice															
Parboiled	185	4	4	0	3	1	4	0	4	0	4	0	0	7.0-7.5	7.3

[a]L = long(6.61-7.50 mm) and M = medium (5.51-6.60 mm). [b]S = slender (>3.00) and M = medium (2.01-3.00). [c]Gelatinization temperature type: L = low(6.7) and I = intermediate (4.5). [d]I = intermediate (20.1-25.0%) and H = high (>25.0%). [e]S = soft (61-100 mm), M = medium (41-60 mm), and H = hard (27-40 mm).

had mainly low AC. Gel consistency of nonwaxy raw milled rice was mainly hard, except for fragrant rice with medium to soft values. Glutinous rices were relatively pure with the specified <2% AC and soft GC. Nonwaxy nonaromatic rice results suggest that no specific variety type is used for export.

Protein content of Thai retail market rices (mean 7.45%) was lower than that reported by Unnevehr et al (1985b) when Thai rice imported into Indonesia had 6.9% protein.

Parboiled rices exported from Bangkok were lower priced than raw rice and were exclusively long-grained and either slender- or medium-shaped (Table 2). The medium-shaped grains had L-W ratios of 2.9-3.0, indicating that they were almost slender. Gelatinization temperature based on alkali spreading value was either low or intermediate, AC was either intermediate or high. Gel consistency of parboiled rice showed variable values but tended to be softer than those reported for raw rice (Biswas and Juliano 1988). Protein content was also lower than that reported by Unnevehr et al (1985b). The intermediate GT reaction from alkali spreading value of some parboiled rices suggested that parboiling temperatures may have been close to 100 °C or at low steam pressure. Gelatinization temperature became low for all rices parboiled at 120 °C regardless of the alkali reaction of the raw grain (Biswas and Juliano 1988).

Hongkong imported rices. Thailand, China, Australia, and the USA were the major sources of imported rice in Hongkong (Table 3). Chinese rice was least expensive, with mainly short, medium-shaped grains, low GT, and high AC (Fang 1985). Thai rices had mainly long, slender grains, low GT, low AC, and soft GC, reflecting fragrant or aromatic rices (Table 1). Their retail prices were, as expected, higher than the wholesale export prices of Bangkok. Australian rices had both long and medium grains, low GT, low or intermediate AC, and soft GC, typical of the two grain types grown (Blakeney 1979). American samples had long and medium grains with low GT, variable AC, and soft GC.

Varieties were often mixed in Hongkong to obtain the desired quality (Kaosa-ard and Juliano 1991). Mixed samples had mainly long, slender grains, low GT, low to intermediate AC, and soft to medium GC. Unidentified samples were one long- and two medium-grained milled rices with low GT, low or high AC, and variable GC. Chinese rices had the highest crude protein. The protein content of imported Thai rice was similar to that of exported fragrant Thai rice in Table 1.

Sensory evaluation (IRRI 1971) of aroma level of the 93 cooked rice samples found the highest level for low-AC samples and the lowest for high-AC samples (Table 4). Results were consistent with the aromatic rices being mainly Thai fragrant rices (jasmine rice) (Kaosa-ard and Juliano 1991) with low AC (Juliano et al 1964, Unnevehr et al 1985 a,b). Thailand was the major source of rice samples in the study, followed by China (Table 3).

Rices in Rome markets. Rices were mainly milled, but seven brown rices were included in the study (Table 5). Twenty percent were parboiled, mainly the 11 samples of Ribe. Italian varieties of raw milled rice predominated—19 Arborio, 15 Ribe, 10 Roma, 9 Originario, 8 Padano, and 6 San Andrea samples. Varieties were long to medium but relatively wide or coarse, resulting in a medium shape classification.

Table 3. Classification of selected properties of 93 milled rices in Hongkong retail markets, Nov 1987.

Source	Price (US$/kg)		Sample (no.)	Length[a]			L-W ratio[b]			Alkali spreading value[c]			Apparent amylose content[d]			Gel consistency[e]			Crude protein (% wet basis)	
	Range	Mean		L	M	S	S	M	B	L	I	HI	L	I	H	S	M	H	Range	Mean
China	0.33-0.60	0.43	24	0	8	16	2	20	2	22	2	0	0	5	19	2	7	15	16.39.5	7.6
Thailand	0.41-0.69	0.52	34	34	0	0	34	0	0	29	3	2	22	9	3	30	4	0	6.1-6.9	6.6
Australia	0.53-0.71	0.63	14	8	6	0	8	4	2	14	0	0	7	7	0	13	1	0	6.0-6.5	6.2
USA	0.46-0.66	0.56	6	5	1	0	5	1	0	5	1	0	1	3	2	5	0	1	6.2-7.4	6.6
Mixed	0.55-0.73	0.64	12	12	0	0	12	0	0	12	0	0	7	5	0	8	4	0	5.9-7.1	6.7
Unidentified	0.57-0.61	0.59	3	1	2	0	1	2	0	3	0	0	1	0	2	1	1	1	6.6-7.0	6.8
Mean/total	0.33-0.73	0.53	93	60	17	16	62	27	4	85	6	2	38	29	26	59	17	17	5.9-9.5	6.8

[a]L = long (6.61-7.50 mm), M = medium (5.51-6.60 mm), and S = short (<5.50 mm). [b]S = slender (>3.00). M = medium (2.01-3.00), and B = bold (1.01-2.00). [c]Gelatinization temperature type: L = low (6.7), I = intermediate (4-5), HI = high-intemediate (3), and H = high (2). [d]L = low (10.1-20.0%), I = Intermediate (20.1-25.0%), and H = high (>25.0%). [e]S = soft (61-100 mm), M = medium (41-60 mm), and H = hard (27-40 mm).

Retail prices were higher than those in Hongkong markets (Table 3). Italian rice tended to be cheaper than imported rice. Raw rice was cheaper than parboiled rice, but Carnaroli raw rice had a higher retail price (US$2.57 and $3.58/kg) than even parboiled rices. Carnaroli had intermediate AC (Baldi et al 1981) and hard GC. All Italian rices had low GT, low to intermediate AC, and mostly soft GC, as reported earlier (Baldi et al 1981, De Rege et al 1966, Juliano and Pascual 1980).

The AC range for all varieties was within the 5% level except for Padano (6.6%) and Originario (6.0%). These values were larger than those reported for French varieties grown in different locations, showing a 5.3% range in starch AC (Morrison and Nasir Azudin 1987). Imports were mainly long-grained rices from Thailand, the U.S., and Indonesia, and short-grained rices from China. These rices had mainly intermediate AC, soft GC, and low GT.

Protein content was 7.1-8.6% in brown rice and 5.5-8.8% in milled rice, the highest being in U.S. parboiled rice (Table 4).

Rices in Bonn markets. Classification was mainly by grain type because brand names were used instead of variety names in the imported rice samples from the Bonn markets. Extra long, slender grain samples were as important as long, slender grains either in both raw milled and brown rices (Table 6). Superlong rices (>7.5 mm) were characteristic of Surinam varieties and were not seen in the American (Webb et al 1985) and Thai long-grained varieties (Attaviriyasook 1985, Raosa-ard and Juliano 1991). They had mainly intermediate GT, but some had low GT and intermediate AC. Others had high AC. Gel consistency was medium to soft. Short-grained milled rice had mainly low GT, low to intermediate AC, and soft GC.

Parboiled rices were mainly long-grained, whereas precooked rices were either long- or short-grained. Parboiled rices had low GT, intermediate AC, and soft GC, typical of U.S. long-grained rices. Precooked rices had properties similar to those of raw rices. Protein content was higher in brown rice than in milled rice, with the short-grained milled rice having a lower protein content.

Physical properties

Brown rice. Because of similarities in physical properties, brown rice samples are discussed according to rice type. All raw and parboiled brown rice samples had high head rice yield (Table 7). All physical properties were similar; chalky grains were no

Table 4. Relationship between aroma level of cooked rice and apparent amylose content of 93 nonwaxy milled rices from Hongkong retail markets.

Aroma level of cooked rice	Apparent amylose content type			Total
	Low	Intermediate	High	
Strong	6	1	0	7
Moderate	5	4	0	9
Slight	19	11	16	46
None	9	12	10	31
Total	39	28	26	93

Table 5. Classification of selected properties of 84 raw and 21 parboiled rices in retail markets in Rome, Italy, May 1988.

Variety and form	Price (US$/kg)		Sample (no.)	Length[a]			L-W ratio[b]			Alkali spreading value[c]		Apparent amylose content[d]			Gel consistency[e]			Crude protein (% wet basis)	
	Range	Mean		L	M	S	S	M	B	L	I	L	I	H	S	M	H	Range	Mean
Brown rice																			
Italian, raw	2.15-2.62	2.38	2	1	1	0	0	2	0	2	0	2	0	0	2	0	0	7.1-7.3	7.2
Imported, raw	–	2.22	1	1	0	0	0	1	0	1	0	1	0	0	1	0	0	–	7.4
Italian, parboiled	2.37-2.84	2.69	3	2	1	0	0	3	0	3	0	3	0	0	1	2	0	7.3-7.6	7.4
Imported, parboiled	–	4.85	1	1	0	0	1	0	0	1	0	0	1	0	1	0	0	–	8.6
Milled rice																			
Italian, raw	0.94-3.58	1.61	76	34	27	15	0	52	24	76	0	54	19	3	49	23	4	5.5-8.8	6.9
Imported, raw	1.51-4.45	3.08	5	4	0	1	4	0	1	2	2	1	3	0	2	3	0	5.7-7.1	6.6
Italian, parboiled	1.67-3.02	2.18	13	6	7	0	1	12	0	13	0	13	0	0	13	0	0	5.9-7.3	6.8
Imported, parboiled	1.51-4.77	3.00	4	4	0	0	4	0	0	4	0	0	4	0	4	0	0	6.8-8.6	7.5

[a] L = long (6.61-7.50 mm), M = medium (5.51-6.60 mm), and S = short (<5.50 mm). [b] S = slender (>3.00), M = medium (2.01-3.00), and B = bold (1.01-2.00). [c] Gelatinization temperature type: L = low (6.7) and I = intermediate (4-5). [d] L = low (10.1-20.0%), I = intermediate (20.1-25.0%), and H = high (>25.0%). [e] S = soft (61-100 mm), M = medium (41-60 mm), and H = hard (27-40 mm).

Table 6. Classification of selected properties of 64 raw and 42 processed rices in retail markets in Bonn, Germany, Jun 1988.

Variety and form	Price (US$/kg)		Sample (no.)	Length[a]				L-W ratio[b]		Alkali spreading value[c]		Apparent amylose content[d]			Gel consistency[e]			Crude protein (% wet basis)	
	Range	Mean		EL	L	M	S	S	B	L	I	L	I	H	S	M	H	Range	Mean
Raw																			
Brown rice, long	1.70-2.56	2.00	4	2	2	0	0	4	0	3	1	0	4	0	0	4	0	8.6-9.0	8.8
Milled rice, long	1.13-5.22	2.31	42	20	22	0	0	42	0	10	32	0	37	5	11	29	2	6.8-8.7	7.8
Milled rice, short	1.42-2.04	1.63	15	0	0	1	14	0	15	15	0	5	10	0	11	3	1	5.4-7.3	6.2
Brokens, long	1.13	1.13	3	0	3	0	0	3	0	2	1	0	3	0	0	3	0	6.9-8.2	7.6
Mean/total	1.13-5.22	2.08	60	20	25	1	14	45	15	27	33	5	50	5	22	35	3	5.48.7	7.4
Processed																			
Brown rice, parboiled, long	3.75-4.43	4.17	3	0	3	0	0	3	0	3	0	0	3	0	3	0	0	8.0-8.6	8.3
Milled rice, parboiled, long	1.47-6.81	3.41	32	4	28	0	0	32	0	32	0	0	32	0	29	3	0	7.1-8.5	8.0
Milled, precooked, long	6.81	6.81	2	2	0	0	0	2	0	2	0	0	2	0	2	0	0	8.3-8.7	8.5
Milled, precooked, short	3.17-4.53	3.62	5	0	0	0	5	0	0	5	0	2	3	0	5	0	0	5.8-6.0	5.9
Mean/total	1.47-6.81	3.61	39	6	28	0	5	34	5	39	0	2	37	0	36	3	0	5.8-8.7	7.7

[a]EL = extra long (>7.50 mm), L = long (6.61-7.50 mm), M = medium (5.51-6.60 mm), and S = short (<5.50 mm). [b]S = slender (>3.00), M = medium (2.01-3.00), and B = bold (1.01-2.00). [c]Gelatinization temperature type: L = low (6.7), I = intermediate (4-5), HI = high-intermediate (3), and H = high intermediate (3). [d]L = low (10.1-20.0%), I = intermediate (20.1-25.0%), and H = high (>25.0%). [e]S = soft (61-100 mm), M = medium (41-60 mm), and H = hard (27-40 mm).

more than 3%. Bonn raw rices had up to 9.6% damaged grains. In contrast, parboiled brown rices had no chalky grains but still had damaged grains. The Rome samples had more damaged parboiled rices than raw rices. Parboiling increased grain translucency and Chroma meter a* and b* values. Parboiling reduced Kett whiteness and Chroma meter L* values.

Black glutinous brown rice had only 2% translucency, 7% Kett whiteness, a Chroma meter L* value of 40, and the lowest Chroma meter b* value of 8. A mixture of red and nonpigmented brown rice exported from Bangkok had 22% translucency, 15% whiteness, Chroma meter L* value of 57, Chroma meter a* value of 3, and Chroma meter b* value of 15. Pigments reduced brown rice translucency, Kett whiteness, and Chroma meter L* and b* values.

Milled rice. Head rice yield of milled rice varied more than that of brown rice (Table 7). Chalky and damaged grains were also more variable in the Rome and Bonn samples than in the Hongkong samples. Translucency was high for nonwaxy grains and low for waxy grains exported from Bangkok. Waxy rice had higher Kett whiteness and Chroma meter L* values than nonwaxy rice. Raw milled rice had higher translucency, Kett whiteness, and Chroma meter L* values, but lower Chroma meter a* and b* values compared with raw brown rice. Imported and local samples in Rome had similar properties.

Parboiled milled rice had better head rice than raw milled rice. Parboiled milled rice had no chalky grains, but it had damaged grains (Table 7). Translucency was superior to that of raw rice, but whiteness and Chroma meter L* values were lower. Chroma meter a* and b* values were higher. Results were similar to those observed in brown rices.

Compared with raw rice, precooked long- and short-grained rices in Bonn had higher head rice; fewer chalky and damaged grains; and more variable translucency, higher whiteness, and Chroma meter L* values (Table 7). Chroma meter a* and b* values were similar to those of raw rice.

Rices classified as brokens contained some head rice but tended to have lower translucency. Brokens had a similar—but narrower—range of whiteness and Chroma meter values as raw rice.

Conclusions

Specific rice quality types were distinctly preferred for each export market and for particular food preparations. Export nonwaxy rices from Thailand were mainly long-grained rices with intermediate or low GT and high to intermediate AC for raw and parboiled nonaromatic rices. Raw fragrant rices had low GT and low AC. Waxy (glutinous) rices had either long or medium grains and low GT.

Aromatic rices (Khao Dawk Mali and Basmati) had higher prices than nonaromatic rices. Thai rices imported in Hongkong were mainly fragrant. Most of the Hongkong rices had low to intermediate AC and low GT except those imported from China, which had high AC and short grains.

Raw and parboiled rices in Rome retail markets ranged from long to short and were mainly medium- to bold-shaped grain varieties from Italy which had low GT and low

Table 7. Physical attributes of raw and parboiled, processed brown and milled nonpigmented rices exported from Bangkok, and rices sold in retail markets in Hongkong, Rome, and Bonn.

Rice type and source	Sample (no.)	Head rice (%)	Chalky grains (%)	Damaged grains (%)	Translucency (%)	Whiteness (%)	Chroma meter		
							L*	a*	b*
Brown, raw									
Bangkok	6	92-97	–	–	30-50	19-24	61-67	1-3	19-20
Rome	3	96-98	0-2.3	0	36-42	18-23	59-64	2	20
Bonn	4	95-96	1.4-3.0	1.8-9.6	32-40	21-22	63-64	1-2	13-18
Brown, parboiled									
Bangkok	4	97-98	–	–	69-72	13-15	55-58	3-4	22-24
Rome	4	98-100	0	4.2-14.2	74-88	12-14	54-55	3-4	23-24
Bonn	3	94-98	0	1.8-5.0	74-100	12-14	55-57	3-4	24
Milled, raw									
Bangkok 100-25%	35	58-92	–	–	70-100	36-44	72-76	-2-1	11-14
Bangkok (waxy) 10%	11	46-98	–	–	30-38	48-56	80-83	-1-	11-16
Hongkong	93	78-100	0-2.0	0-1.0	64-100	39-47	73-76	-3—1	11-16
Rome, local	76	92-99	0-34.1	0.3-15.2	51-100	38-53	73-80	-2-0	11-15
Rome, imported	5	95-100	0.6-2.5	0.4-2.6	76-100	34-46	70-77	-2-0	13-14
Bonn	57	37-98	0.6-8.9	0-9.7	45-100	34-50	72-79	-2-1	13-18
Milled, parboiled									
Bangkok 100-35%	19	65-98	–	–	96-100	17-25	63-68	-2-1	19-26
Rome, local	13	96-99	0	1.0-5.4	100	18-22	61-65	0-2	24-28
Rome, imported	4	97-98	0	1.0-7.3	100	18-22	60-65	0-2	25-27
Bonn	34	88-99	0	0-11.6	100	15-30	58-72	-1-3	23-26
Milled, precooked									
Bonn	7	93-98	0-2.3	0-3.6	30-32, 100	44-54	76-82	-3—2	13-15
Brokens									
Bangkok, raw	17	0-37	–	–	44-91	36-46	74-79	-1-1	13-16
Bangkok (waxy)	2	0	–	–	20-22	54-55	83-84	-1	12
Bangkok, parboiled	2	0-4	–	–	82	21-24	64-65	0-1	20-22
Bonn	3	0	3.0-8.0	1.5-14.8	20-50	40-42	74-76	-1	15-16

to intermediate AC. In contrast, raw and precooked milled rice in retail markets in Bonn had extra long to long, slender grains, intermediate to low GT, and intermediate to high AC; they also had short, bold grains, low GT, and intermediate to low AC. Parboiled rices were mainly the long-grained type.

Brown rice was represented in all markets except Hongkong. Mean protein content of milled rice was below 7% in all markets except Bonn. Physical properties of the various waxy or nonwaxy varieties within the same rice type—brown raw, brown parboiled, milled raw, and milled parboiled—were similar. Head rice yields were high in export rices.

Aroma (low to intermediate AC), long grain, and high percent head rice were some of the important considerations for export prices of Thai rice. Kaosa-ard and Juliano (1991) found that quality characteristics were important considerations in the traditionally rice-consuming economies such as Hongkong and Italy. Long grain, high head rice, and soft GC were observed in the Hongkong samples. The Rome samples had high percent chalky grains and harder GC. In the traditionally nonrice-consuming market of Bonn, only high percent head rice was significantly related toprice. Processing level, lot size, and packaging type were the important price considerations (Kaosa-ard and Juliano 1991).

Similar studies in other rice-consuming countries would provide benchmark information on grain qualities preferred by consumers; that would assist rice breeding programs. Characterization of Pakistani export rices would be useful to supplement data on Thai export rices.

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Notes

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Appendices

APPENDIX 1

Operations manual for domestic grain quality assessment studies

Analytical framework

The analytical framework for this study is based on the theory of consumer demand for characteristics of goods, as developed by Ladd and Suvannunt (1976). Consumer demand for goods is determined by the utility gained from the consumption of that good. The utility of a good may be viewed as a function of its characteristics. Hence, the utility a consumer derives from the purchase of a good depends on the total amount of product characteristics purchased. For example, consumers demand rice for its taste and nutritional value, and the utility obtained is the sum of utilities obtained from the different characteristics of rice.

From this perspective, it can be shown that:

$$P_r = \sum_{j=1}^{m} X_{rj} P_{rj} + u$$

where P_r = market price of rice, X_{rj} = quantity of characteristic j in one unit of rice, P_{rj} = implicit value of characteristic j, and u = random error term.

The price consumers pay for rice is equal to the sum of the value of the product's characteristics (Ladd and Suvannunt 1976).

If the characteristics that define grain quality can be measured, the implicit value of these characteristics can be estimated by least squares regression of observed market price on measures of quality. The independent variables (X_{rj}s) should explain the variance in rice price while the estimated coefficient (P_{rj}) measures the implicit value of each characteristic.

Measures of quality characteristics have been developed as follows:

■ Physical characteristics

—Whiteness (% of pure white) and brightness (for parboiled rice)
—Brokens (% grains)
—Shape (ratio, length/width)
—Chalkiness (proportion of grain)
—Translucency (%)

- Chemical characteristics
  - —Amylose (%)
  - —Gel consistency (mm)
  - —Alkali spreading value (gelatinization temperature index)
  - —Aroma (0-1 dummy)

Hypotheses

Several hypotheses have been advanced:

1. That at a specific time and location, observed price variation in rice is due to variation in quality characteristics of rice;
2. That implicit prices of characteristics gained from the model will yield information that can be used to identify those areas of research and extension that would be most effective in upgrading the quality of rice;
3. That implicit values of characteristics may differ across regions and between rural and urban markets, reflecting varying patterns of consumer preference and ability to pay for grain quality.

Methodology

Retail markets for milled rice

The methodology for the study is outlined using the Philippines as an example. Considerations taken into account varied across countries. For example, the need to examine preference for parboiled rice in Bangladesh may require a different approach to the collection of samples. The main approach of the methodology is to capture regional, rural, and urban consumer preferences using the representative case study method.

Site selection. The number of retail market data collection sites should be determined, maximizing the coverage of the data within the constraints imposed by 1) the need to collect the data within as short a time period as possible to minimize price variance due to factors other than quality, 2) laboratory resources, and 3) manpower and transport.

In the case of the Philippines, seven sites were chosen on the basis of regional spread, urban and rural municipal population estimates (1983, major rice-consuming and -producing areas of the country, and distances of rural markets from urban centers.

The centers chosen were the following:

- Manila as a major retail urban consumption center in Luzon;
- Cebu City as a similar center in the Visayas;
- Davao City representing the same in Mindanao;
- Talugtug, Nueva Ecija, as a major retail rural producing center in Luzon;
- Lambunao, Iloilo, as a similar center in the Visayas; and
- Pikit, North Cotabato, representing the same in Mindanao.

In all rural cases, alternative sites were also chosen in the event that first choices are found to be inappropriate.

In all cases, except Manila, the main market was used. In the case of Manila, two markets (Paco and Quiapo) were taken from the four main retail markets in Greater Manila to retain proportionality on population grounds.

The sites were selected following this procedure: The major surplus (rice-producing) and deficit (rice-consuming) provinces in each of the three main groups of islands in the Philippines—namely, Luzon, Visayas, and Mindanao—were identified using 5-yr average surplus-deficit data. Aside from being a natural classification tool, this device, together with regional spread, was an attempt to control the impact of other market factors such as transport costs. After identifying the provinces, the major urban center based on 1985 population estimates was taken in each case to determine the urban data collection center. For the choice of rural market (bearing in mind the requirement of a sufficiently large market so that the full range of consumer preferences of the population is represented), the municipality with the highest proportion of rural to urban inhabitants was chosen and the major market center within that area was identified. An additional criterion was that the rural site should be at least 30 km away from a major urban center.

Sampling. In all cases (except Manila where two markets were taken), the main market was selected. To obtain grain samples, rice retailers in each market were randomly selected and a minimum of 100 g of rice sample of each variety and grade was bought for laboratory analysis of characteristics. The random sample of retailers was sometimes taken from municipal listings of retailers within close proximity of the market area. Where no list existed or was deemed inaccurate, a random sample on the basis of on-the-spot preliminary enumeration of retailers was taken. In the absence of prior information about the number of retailers and number of varieties/grades offered, the following guidelines for sampling were adopted: if the market had 10 or less retailers, we took the total into the sample; if there were more than 10, we took enough retailers to give a total number of rice samples of more than 50 (the number of retailers sampled depending on an on-the-spot assessment of the average number of varieties and grades being offered for sale). These guidelines, in the case of the Philippines, provided sufficient degrees of freedom for data analysis.

Data to be collected. For each physical sample collected, the price per local weight measure, the designated name (in the Philippines, this is variety plus grade), the retailer's name and number, and the names and locations of suppliers were written in a data entry sheet. An identification code of samples describing the market, retailer, and sample number was developed and marked onto the sample container.

Time of data collection. It is important that data be collected within as short a time as possible to minimize price variability arising from seasonal and other factors. For the Philippine study, estimated data collection time was 27 days. A second consideration was the seasonal timing of data collection. The choice of season should ideally coincide with the main harvest period for rice. Two rounds of data collection were done in the Philippines—the first corresponding to the dry season harvest in April and the second covering the wet season harvest in November.

Data analysis. Data were analyzed using a scatter diagram examination, a correlation matrix developed for price and quality characteristics, and regression analysis.

Assessment of rough rice quality

Methodology. Using the selected sites in the retail rice quality study, a sample of mills was selected from each area stratified by type and capacity of mill. From selected mills, the following data were collected: price of rough rice by variety and by entry/exitpoint of the mill; source of rough rice by occupation and by distance from the mill; location of milled rice purchasers; occupation of purchasers (e.g., whether retailers or wholesalers). To separate milling and postharvest field handling influences, the following procedures were adopted for assessing rough rice quality.

1. Quality measurements of “check” samples (e.g., those obtained from IRRI experimental plots representing as far as possible “perfect” handling and “perfect” milling) were taken for each variety to be tested. These measurements represented the benchmark against which field handling and private milling quality influences were measured.

2. Field samples from the mills, representing “imperfect” handling and “imperfect” milling, were obtained for all main varieties found at the mill. For each batch of rough rice to be assessed, two types of samples were prepared—a sample premill to be run through the IRRI laboratory mill and a sample postmill (field mill) to be brought back to the laboratory for quality assessment. The first sample (premill) was analyzed at the laboratory to measure characteristics determined before milling (e.g., percentage of foreign matter) and to assess potential milling recovery and quality from the field sample. The conjunction of the premill sample yielded the overall measurements of imperfect handling and imperfect milling.

3. Measurements from steps 1 and 2 indicated total quality losses due to both handling and milling.

4. A comparison of the results of the field sample of rough rice milled through the laboratory mill with results from step 1 (benchmark) indicated quality losses due to “imperfect handling.”

5. Subtracting the results of step 4 from the results of step 3 gave quality losses due to “imperfect milling.”

6. These procedures were taken for all the major varieties found in the mills and were appropriately classified by variety (where possible), with type and capacity. The procedures were replicated twice for each mill to obtain an even spread of rough rice sample from the batch.

7. The following quality measurements were made:

- moisture content (premill);
- length-width ratio (pre- and postmill);
- percentage of discolored grains, damaged and infested grains (postmill);
- percentage of foreign matter (premill);
- percentage of total rice outturn (postmill);
- percentage of head rice outturn (postmill);
- percentage of cracked grains (premill);
- percentage of cracked grains (postmill); and
- percentage of immature grains (postmill).

All measurements were made at the Grain Quality Laboratory except moisture content readings which were done in the field.

Limitutions to methodology and justification for use. Several limitations to these procedures may be identified.

1. The individual influences of the various stages (harvesting, threshing, drying, transportation, etc.) in postharvest handling could not be determined separately.

2. Moisture content was not a reflection of field moisture content at the harvest stage but only of that at the milling stage after drying.

3. It was at best an approximation of farmers' practices and was obviously less controlled than if samples were taken directly from farmers' fields.

4. Rice data did not reflect accurate farmgate prices but included marketing cost of intermediate inputs.

However, the methodology yielded estimates of overall quality characteristics of rough rice and this was divisible into overall postharvest handling and milling effects on quality. Further work may be done to consider in more detail the different stages of postharvest handling and to conduct more detailed price and marketing analyses as resources permit. At this stage in the work concerning milled rice and rough rice quality, it was most important to obtain indications of the economic effects of postharvest handling, milling, and varietal differences on quality, as until then, only the end product at the retail level had been examined.

Interpretation. Interpretation was directed toward comparing implicit prices of rough rice and retail rice (within the limitations imposed by results deriving from different samples: albeit from the same area and, therefore, theoretically from the same map of consumer preferences linked with production in that area, depending on the extent to which retail rice had its source from local areas in rural and urban markets).

A second line of interpretation can be directed toward assessing the important areas for quality-improving intervention and a third toward assessing the incentives for quality improvement by studying the relationship between potential returns and costs of improvement. Finally, economic constraints on quality improvement should be outlined from the preceding stages and suggestions (policy or otherwise) should be made for easing these constraints.

Procedures for measuring milled rice characteristics as used by the IRRI Cereal Chemistry Department

Whiteness is measured using the Kett Whiteness Meter, an optical instrument. The scale ranges from 0 to l00%, with 100% indicating pure white magnesium oxide powder.

Translucency is measured with a Brown Rice Translucency Rice Meter with a scale ranging from 0 to 100%.

Chalkiness is measured using a visual rating of the chalky proportion ofthe grain. The scale is 1-9: 1 = less than 10% chalkiness; 5 = 10-20% chalkiness; 9 = more than 20% chalkiness. Chalkiness is inversely related to translucency.

Percent head rice is measured by sizing grain and weighing unbroken grain (75% intact) in a 100-g subsample.

Length and width are measured in millimeters using 10 whole grains under a 10X photoenlarger.

Amylose content percentage is measured using a simplified iodine colorimetric procedure.

Gelatinization temperature is measured by the alkali spreading value. This is the extent of disintegration of milled rice soaked in 1.7% potassium hydroxide (KOH) solution for 23 h at 30 °C. A high rating indicates more disintegration and a low gelatinization temperature.

Gel consistency is measured by the length of cold milled rice paste in a test tube held in a horizontal position (unreplicated 80, 90, and 100 mg flour in 0.2 N KOH). A higher number indicates softer gel consistency. The average of 90 and 100 mg data is reported.

Foreign matter/damaged grains percentage is measured through physical separation of dockage and damaged grains of a 50-g subsample.

APPENDIX 2B

Procedures for laboratory analysis of rough rice samples

Three 250-g samples are obtained from the 1-kg sample collected from the field.

The moisture content of the samples is measured using the Steinlite Moisture Meter.

The percentage of cracked grains is determined using the rough rice Crack Detector.

Using a 10X photoenlarger, 20 rough rice grains from each replicate are measured to obtain the average length and width of rough rice.

Immature grains are selected/picked out and weighed. The percentage of immature grains is then computed.

Dockage (stones, weed seeds, and other foreign matter) are picked out. Samples are further cleaned using the Bates Aspirator which removes light foreign matter by an air blast. The total dockage percentage is then computed.

To obtain the weight of brown rice, samples are dehulled using the Satake Laboratory Sheller.

The McGill Laboratory Mill is used in milling the samples. The final weight of milled rice is measured.

Milling degree is computed based on the amount of bran removed from the brown rice.

Milling recovery is computed based on the weight of milled rice recovered as a percentage of the weight of the original rough rice sample.

Using a grain sizer, brokens and whole grains are separated and weighed accordingly. The percentage of each to total milling recovery is computed.

Chalkiness is measured using the *Standard evaluation system for rice* scale. A visual rating of the chalky proportion of the grain is used in the measurement. The scale is 1-9: 1 = less than 10% chalkiness; 5 = 10-20% chalkiness; and 9 = >20% chalkiness.

Whiteness is measured using the Kett's Whiteness Meter. The scale is from 0 to 100%, with 100% indicating pure white magnesium oxide powder.

Yellow and fermented grains are picked out and weighed. The percentage of yellow/fermented grains to total milled rice sample is computed.

Using a 10X photoenlarger, 20 milled rice samples from each replicate are measured to obtain the average length and width of milled rice.

APPENDIX 3

Glossary of rice quality terms[1]

Compiled by B.O. Juliano

Aged rice — rice that is kept at least 4 mo after harvest. Expands more on cooking and less sticky than cooked, freshly harvested rice.

Alkali spreading value — a measure of degree of dispersion of head milled rice in 1.7% KOH after 23 h at 30°C (IRRI, Bangladesh) or at room temperature (Indonesia, Malaysia, Thailand). Gelatinization temperature classification: low, 6-7; intermediate, 4-5; intermediate/high, 3; and high, 1-2.

Bangladesh uses duplicate 6 raw grains in 10 ml 1.7% KOH, not applicable to parboiled rice (see degree of parboiling); Indonesia and IRRI use duplicate 6 raw grains in 10 ml 1.7% KOH; Malaysia uses unreplicated 10 grains in 15 ml 1.7% ROH; while Thailand uses duplicate 10 grains in 24 ml 1.7% KOH.

Amylose content — see apparent amylose content.

Apparent amylose content — colorimetric assay of iodine-amylose complex at 620 nm using amylose standard (Bangladesh, Malaysia) or amylose/waxy rice (Indonesia, Thailand, IRRI). Amylose is the linear fraction of starch. Apparent amylose is used since at amylose concentration of more than 25%, amylopectin shows increased iodine binding instead of amylose. Classification: waxy 0.2%, low amylose 10-20%, intermediate amylose 20-25%, and high amylose 25-34%.

Appearance (Bangladesh) — visual measure using a 1 (poor)-5 (excellent) scale combining whiteness, brightness, color, presence of brokens, etc.

Aroma (Thailand) — milled rice (2 g) is soaked in 2 ml 10% NaCl for 30 min in a culture tube with stopper and aroma is assessed by a trained person.

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[1]Reprinted with permission in part from *Grain postharvest research and development: priorities for the nineties.* Proceedings of the 12th ASEAN Seminar on Grain Postharvest Technology, 29-31 August 1989, Surabaya, Indonesia. J. O. Naewbanij, ed. (1991) ASEAN Grain Postharvest Programme, Bangkok. p. 266-267.

Black grain (Bangladesh) — completely black milled rice in 150-g sample and expressed as number per 100 g.

Breadth — see width.

Brewer grains (Indonesia) — grains <1/5 the length of whole milled grain.

Brokens — grains which are less than 2/3 (Indonesia), 3/4 (IRRI), or 4/5 (Bangladesh, Malaysia, and Thailand) the length of whole milled grain. Sample weight is 150 g (Bangladesh), 100 g (Indonesia, Malaysia), or 50 g (IRRI, Thailand). Thailand further classifies brokens into big brokens (0.5-0.8 the length of whole grain), brokens 0.25-0.5, and small brokens <0.25. Malaysia also classifies brokens into big brokens (0.5 -0.8 the length of whole grain) and brokens 0.2-0.5.

Brown rice — husked or cargo rice or rice caryopsis. Rough rice from which the hull (husk) has been removed.

Bulk density (g/liter) (Indonesia) — net weight of grain in the official 1-liter Baume container to nearest whole gram weight.

Chalkiness — based on the IRRI scoring system of 0-5 (Indonesia and Thailand): 0 = no chalkiness, 5 = >80% chalky. Later revised by IRRI to 1-9 where 0 = none, 1 = small (<l0%), 5 = medium (11-20%), and 9 = large (>20% of kernel area) (Bangladesh). IRRI measures translucency using the Riken-Sanno Rice Meter calibrated for brown rice.

Chalky grains — nonwaxy grains with>50% chalkiness (>l0% in Malaysia). Include immature grains (except Thailand). Sample weight—100 g in Indonesia, 50 g in Malaysia, Thailand, and IRRI—expressed as weight %. Head rice is used in Malaysia and Thailand.

Contrasting grains (%) (Bangladesh) — 150-g sample classified on the basis of minor or contrasting grain length and expressed as weight % of the sample.

Cooking time — five g of rice are boiled for 10 min in 135 ml distilled water; 10 grains are collected every min until 9 of the 10 grains are without white core. The time needed to cook 9 of the 10 grains is called minimum cooking time (Bangladesh, Indonesia, and Thailand).

Damaged grains — distinctly discolored or damaged by water, insects, heat, or any other means (include yellow grains). Sample weight: 50 g (Malaysia, Thailand, and IRRI), 100 g (Indonesia), or 150 g (Bangladesh). Head rice is used in Malaysia. Values are expressed as weight % (in number per 100 g in Bangladesh).

Defatted grains — rice flour (40 mesh) of undermilled or brown rice (IRRI) is defatted with refluxing 95% ethanol or 85% methanol for 18 h to remove fat which interferes with apparent amylose assay.

Degree of milling — percent efficiency of bran removal from brown rice during milling; done visually with well-milled rice as 100% milled (Indonesia, Bangladesh). Thailand classifies milled rice into ordinary, reasonably well-, well-, and extra well-milled.

Degree of parboiling by alkali spreading value — 6 grains were soaked for 12 h in 10 ml 1.0% KOH at 30°C, and scored using the scale of Little et al (1958).

Elongation ratio — ratio of grain length of 10 cooked rice grains to that of raw rice grains, preferably presoaked in water 30 min before cooking for 10 min (Thailand). Cooking time uses predetermined period with 15 whole grains measured (Bangladesh).

Empty grains (chaff) — removed from 50 g rough rice by winnowing.

Equilibrium water content (EWC) — milled parboiled rice (2 g) of known moisture (12%) is soaked for 23 h at 28-30 °C, blotted, and reweighed (Bangladesh).

Foreign matter-milled rice — all matter other than milled rice, such as brown rice, rough rice, or seeds.

Foreign matter-rough rice — all matter other than rough rice (IRRI); nonrice material only (Indonesia, Thailand). Sample weight is 50 g (Indonesia, IRRI).

Gelatinization temperature — temperature wherein at least 90% of the starch granules swell irreversibly in hot water with loss of crystallinity and birefringence. Final gelatinization temperature is classified as low (55-69.5 °C), intermediate (70-74 °C), and high (74-80 °C). It is measured by the alkali spreading value.

Gel consistency — length of gel of 100 mg rice flour in 2 ml 0.2 N KOH in 13- × 100-mm test tubes after 1 h in horizontal position. Indonesia and Thailand read after 30 min standing. Two replicates of 100 mg (except IRRI) with one each of 90 mg and 100 mg flour to correct for undermilled and aged samples are used as needed.

Glutinous (waxy) rice — grains with opaque endosperm containing mainly amylopectin in starch and <2% amylose in milled rice. Use 50-g sample to determine percent nonglutinous (translucent) rice.

100-grain weight (Bangladesh) — the mean weight of three subsamples of 100 grains.

Green grains — see immature grains.

Head rice — grains with at least 2/3 (Indonesia), 3/4 (IRRI), or 4/5 (Bangladesh, Thailand, and Malaysia) the length of whole milled grain; the opposite of brokens. Sample weight: 100 g in Indonesia and Malaysia, 50 g in IRRI and Thailand, and 150 g in Bangladesh. Grain with broken eye is considered broken in Bangladesh. Expressed as % of total milled rice or as % of rough rice weight.

Imbibition ratio (Bangladesh) — see volume expansion ratio.

Immature grains — grains with still greenish caryopsis or brown rice; called opaque grains in Indonesia. Estimated on the basis of 50 g head rice (Malaysia), 50 g (Thailand and IRRI), or 100 g (Indonesia).

"Kepulanan" (Indonesia) — cooked rice with smooth texture measured by sensory evaluation.

Length and width (breadth) — determined on 10 (Bangladesh, Thailand, and IRRI), or 25 (Indonesia, Malaysia) whole grains with or without photoenlarger. Contrasting length (mixture) refers to presence of grains other than the predominating length. Determined on 200 grains (Thailand), 50-g samples (Malaysia and IRRI), and 150-g samples (Bangladesh).

Milled rice — rice obtained after milling with all or part of the bran and germ from brown rice removed.

Milling recovery rate — total milled rice yield as a percentage of rough rice yield.

Moisture — measured using a Kett Moisture Meter and expressed on a wet basis (Bangladesh, Thailand, and IRRI). About 12% (Malaysia).

Nonglutinous rice (nonwaxy) — rice containing >2% amylose in milled rice. Normally translucent endosperm.

Opaque grains — see immature grains.

Parboiled rice (Bangladesh) — processed rice product where the rough rice is soaked, steamed, and finally dried as a form of accelerated aging.

Protein, crude — determined by microKjeldahl N method and converted to protein by multiplying by 5.95 (Indonesia, IRRI, Thailand, and Bangladesh).

Rough rice — paddy or rice retaining its hull (husk) after threshing.

Translucency — the opposite of chalkiness; measured with a Riken-Sanno Rice Meter which measures transmitted light through a fixed volume of rice grains, one model for brown rice, another for milled rice (IRRI only has the brown rice model). Visual score (Bangladesh and Indonesia) using IRRI system 0-5.

Volume expansion ratio (Bangladesh) — milled rice (5 g) is boiled in excess water for a predetermined cooking time. Volume of raw and cooked rice is determined by water displacement.

Water absorption (Indonesia) — 8 g milled rice cooked for 30 min with 135 ml tap water in 300 ml beaker, decanted for 5 min, and weighed. Based on weight of cooked and raw rice.

Weight/length (Bangladesh) — grain weight in mg divided by grain length in mm.

Whiteness — measured with a Kett Whiteness Meter Model C-3 (Malaysia, IRRI), C-300 (Thailand), or C-100 (Indonesia) using light reflected by the surface of the rice grain. Use pure white MgO powder as basis (100%) or barium oxide standard (87%). Whiteness is also measured with a Minolta Chromameter Model CR-110 on L*a*b* mode, where L* is a measure of whiteness; a*, a measure of redness; and b*, a measure of yellowness (IRRI). Visual score (Bangladesh).

Width — the widest part of the intact grain in mm (see Length and width [breadth]).

Yellow grains — damaged grains discolored by stackburning or heat. Measured on 50-g sample (IRRI and Thailand), 50-g head rice (Malaysia), or 100-g sample (Indonesia).