Hedonic Model Estimation: Application to Consumer Demand for Rice Grain Quality

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ABSTRACT

A study using the hedonic pricing model was conducted to evaluate consumer preferences for rice quality. Consumers were categorized by location (urban vs. rural) and income classes – low, medium, and high. Physical and chemical characteristics considered important determinants of rice price were whiteness, translucency, grain length, foreign matter content, head rice recovery, apparent amylose content and alkali spreading value.

Both urban and rural consumers were price responsive to changes in quality characteristics. Cooking and eating qualities like texture and softness of cooked rice were found to exert the biggest influence

on the price paid by both groups. However, urban consumers attached higher implicit values to quality characteristics than rural consumers.

Differences in characteristics preferred were also noted among income classes. As income level rose consumers become more discriminating and their willingness to pay for rice becomes increasingly dependent on more quality characteristics.

The findings indicate that rice consumers attach economic significance to quality considerations, however, this demand for quality varies widely among different consumers. The study, therefore has strong implications for rice research on breeding, cultivation and postharvest systems to produce qualities that better satisfy consumer needs.

INTRODUCTION

Rice occupies a unique position in the economic and political life of the Philippines because of its importance in traditional dietary habits and its dominance in peasant agriculture. Rice and rice products contribute 56.2% of staple calories, 42.9% of total protein and 29.8% of total iron in the average Filipino diet (8). It accounts for 70% of the total calories and protein intake for the lowest quantile of all income-earning households in the country.

Rice farming is the main occupation of many Filipinos and nearly 40% of the effective crop area is devoted to rice accounting for about half the output of food crops. Philippine rice production grew at an average annual rate of 4.5% from 1976 to 1981. Improved rice technology increased production to the point that national self sufficiency targets had been reached in the late 70s.

However, the late 80s witnessed the scarcity of rice available in the domestic market. This was aggravated by the very little attention given to consumer preferences for rice quality. The government monopoly in international trade prevents world quality premiums from being reflected in domestic market by giving no incentives to private millers to meet world quality standards within the private trade (11). While consumers quickly signalled their preference for some quality attributes, there has been no precise estimate to quantify the value of these characteristics. Studies of consumer preferences for rice have been conducted in the Philippines but most utilized laboratory and

taste panels (5). Quality determination, therefore remains highly dependent on personal observation and induction from grades and prices observed in the market.

Using the hedonic pricing model permits assessment of rice grain characteristics valued by consumers. The implicit prices for characteristics derived from hedonic estimation help highlight areas for future research, extension and policy initiatives. Unnevehr's work has clearly suggested a number of avenues for future grain quality improvement (Unnevehr, 1985). Plant breeders and postharvest technologists can target attributes which are economically viable in breeding improvement research and postharvest technology development, respectively. For the social scientists, the results provide an agenda for public policy research in rice marketing, technology assessment, and research prioritization.

Objectives

The study was designed to estimate implicit prices for characteristics that define rice grain quality at the consumers' level.

Specifically, it aimed to:

1. determine the effects of consumer status and purchasing capacity on the demand for rice quality;
2. determine the variation in demand for rice quality between urban and rural areas and among income groups; and
3. examine implications for future rice grain quality improvement activities.

METHODOLOGY

The Hedonic Model

The conceptual basis for estimating consumer demand for rice quality is Lancaster's (10) model of consumption theory which regards properties of the good and not the good itself as the direct objects of utility. Using this concept, Ladd and Suvannunt (1976) developed the consumer goods characteristics model (CGCM) which describes the price of a good as a linear summation of the implicit value of its attributes. The model remains consistent with the basic assumption of demand theory that consumers maximize utility subject to a budget constraint (Appendix A).

For rice, the CGCM can be expressed mathematically as:

$$P_r = \sum_{j=1}^{m} X_{rj} P_{rj} \qquad (1)$$

where: P_r = price of rice; X_{rj} = quantity of rice grain characteristic j, that is, percent of whiteness, translucency, head rice recovery, foreign matter content, amylose content, millimiters of grain length; and alkali spreading value (Appendix A)

P_{rj} = implicit price of characteristic j.

The relationship in equation 1 referred to as the pure hedonic model assumes 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 have a significant amount of residual variation. This is expected in markets where consumers have different preferences or different incomes and nonhomothetic indifference maps (Cowling and Reyner, 1970; Lucas, 1975). A theoretical framework was thus adopted from Rosen (1974) which assumes that the price of rice is not only a linear summation of the implicit values of its attributes but merges the effects of varying consumer tastes. Mathematically, the model referred to as the extended hedonic model is expressed as:

$$P_r = f(X_{rj}, a) \qquad (2)$$

where a is a vector of consumer traits consisting of age, educational attainment, monthly per capita income and a location dummy.

The first partial derivative of price P_r with respect to any characteristic, $\varepsilon P_r / \varepsilon X_{rj} = b_{rj}$, reveals the consumers' implicit bid for the underlying attribute, X_{rj}.

In principle, Rosen's modelling strategy has been applied in other countries to numerous industrial and agricultural products (Rosen, 1974). In the Philippines, the first attempt to apply this technique is made on rice. Data on income and taste variables are available to allow parametization of taste across different rice consumer groups. The vector of consumer traits therefore, represents exogenous shift variables.

The hedonic model in equation 2 was specified in logarithmic form[3]. Lucas (1975) expounded that if the analysis revolves around intrinsic physical properties typically measurable

on a cardinal scale, then the consumption technology is additive and homogenous of degree one. If the working model is confined to a CGCM type of analysis, additivity is 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 pinpoint the nature of preferences between different groups of consumers was 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.

Ordinary least squares (OLS) was used to estimate the relationships for each location and income group. The Chow test was applied to determine if the estimated price and quality relationships differed significantly between rural and urban consumers (Chao, 1960; Fisher, 1970). A similar analysis combining all data sets and using dummy variables was also conducted with urban and rural data.

Data

Variations in consumer preferences resulting from urbanization was captured by selecting four markets each in Nueva Ecija province and in Manila to represent contrasting rural and urban areas, respectively (Fig. 1). The total number of regular consumers buying rice in each selected market was determined from 2 weeks of direct observation and interview of retailers. A list of these consumers together with their monthly incomes formed the population of rice consumers in the market. Using a stratified ramdom sampling procedure, 150 consumers from urban Manila and 146 consumers from rural Nueva Ecija were considered in the study. Sampling by income group generated 99 low-income consumers, 89 medium-income and 108 high-income. Based on the food consumption survey of FNRI, respondents earning less than P400 per capita per month were considered low-income consumers; those with a per capita income (PCI) of P400 to P800 per month comprised the medium-income group and those earning more than P800 per month were high earners.

Each respondent was personally interviewed while purchasing rice in the market to ensure simultaneous collection of 100-gram rice samples. The samples were analyzed for physi-

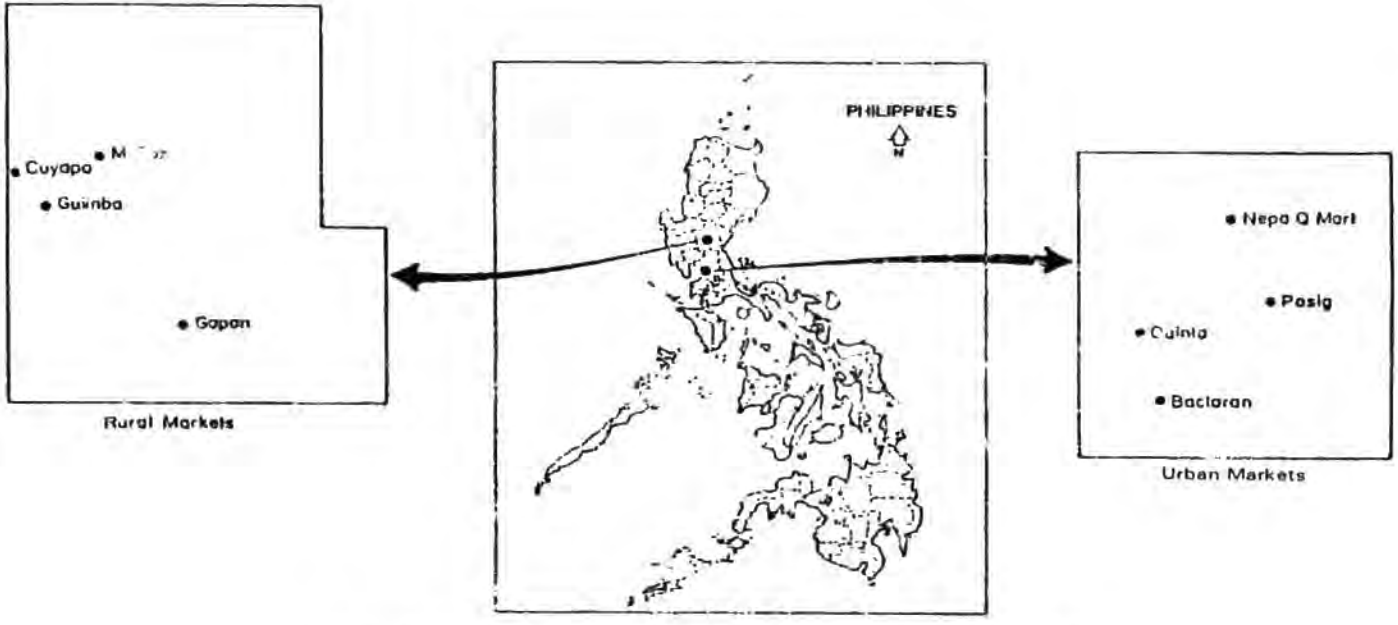

Fig. 1. Locations of rural and urban consumer markets, Nueva Ecija and Manila, Philippines.

cal and chemical characteristics at the Cereal Chemistry Laboratory of the International Rice Research Institute (Appendix C).

DISCUSSION OF RESULTS

The Filipino Rice Consumer

Urban and rural consumers. A survey of 150 urban and 146 rural consumers in Manila and Nueva Ecija, respectively showed marked differences in social traits and economic status (Table 1). Urban consumers spent more time in school than their rural counterpart. Likewise, the average monthly per capita income or urban consumers was substantially higher than rural households.

Table 1. Selected characteristics of rice consumer groups, Manila and Nueva Ecija, Philippines, 1987.

CHARACTERISTIC	CONSUMER GROUP					
	Location			Income Group		
	Urban	Rural	Diff.	Low	Medium	High
Average age	37	40	3*	37[a]	39[b]	40[b]
No. of years schooling	11	9	2**	8[b]	10[b]	12[a]
Occupation						
White-collar job	45(30)	36(25)		1(1)	14(16)	49(45)
Blue-collar job	52(35	54(37)		33(33)	41(46)	32(30)
Unemployed	53(35)	56(38)		65(65)	34(38)	27(25)
Average per capita income (P/mo)	1136	595	541**	250[c]	576[b]	679[a]

** - Significant at 1% level.
* - Significant at 5% level

Note: Means followed by the same letter are not significantly different at the 5% level using DMRT. Figures in parentheses are percentages of respondents reporting.

Rice consumption patterns vary between the two groups of consumers . Monthly per capita rice consumption of 8 kg. by rural consumers is higher than the 7 kg. consumed by urban consumers (Table 2). However, urban households spent more for rice than rural households. The increase in expenditure was due to the demand for high-quality rice in urban markets. In the Philippines, different grades are sold in urban markets with substantial price differentials observed between low and high-

quality rice at any given time. On the average, about seven varieties/grades were found in urban markets while five choices were available in rural markets. A P1.00/kg difference in average price was observed between urban and rural rice.

Table 2. Per capita consumption, expenses and average price paid for rice by different consumer groups, Manila and Nueva Ecija, Philippines, 1987.

CONSUMER GROUP	RICE CONSUMPTION (kg/mo)	RICE EXPENSES		AVE. PRICE (P/kg)
		Amount (P/mo)	% of Total Household Expenditure	
Location				
Urban	7.00	53	8	7.00
Rural	8.00	49	14	6.00
Income Group				
Low	8.25	51	19	6.00
Medium	8.00	50	11	6.25
High	7.25	51	7	7.25

Consumers by income group. Regrouping urban and rural consumers by income level showed distinct differences among consumers. The nature of occupation varied, with the high-income group engaged in white-collar employment and the medium-and low-income consumers involved in blue-collar and farm jobs. A majority of high income earners were from urban areas while low-income consumers were mostly rural residents.

Regardless of whether purchased in urban or rural markets, average rice consumption decreased as income rose. A difference of 1 kg per month per person was observed in the quantity consumed by low- and high-income consumers. The rate of substitution away from rice also increased with income level. Examination of expenditure items other than rice for high-income consumers revealed that bread, noodles, root crops and other rice substitutes contributed heavily to the family's monthly food budget. This observation reinforced the findings of Aragon (1972) that as income rises, increase in consumption of rice and rice products is only moderate in contrast with substantial increase in the consumption of wheat products. In addition, research done by Belarmino (1983) also confirmed that as income increases, the rise in per capita use of rice and rice products was negligible, as opposed to a significant increase in

use of wheat and wheat products. Cross-price elasticities between rice and wheat were negative and increased in magnitude with income.

Despite increased rice consumption with increasing income, monthly per capita expense for rice did not differ significantly among the three groups. This implies that as purchasing power increases, consumers demand not only quantity but quality as well. This finding is substantiated by the higher prices paid as income levels rose. The substitution of high-quality grain reflects the application of the law of dietary quality on a staple food like rice. This is also consistent with the findings of Shah (1983) which states that as income expands, the pent-up demand for variety and quality manifests itself powerfully. At a certain stage, variety and quality increase with income and both fall relative to the expansion of income producing the Engle curve effect.

HEDONIC RELATIONSHIPS AND IMPLICIT PRICES

Urban and rural consumers. Significant determinants of price among urban consumers were grain length, foreign matter content, head rice recovery, amylose content, and alkali spreading value (Table 3). A one percent increase in grain length decreased price by 0.25%. Consumers were willing to pay P0.33 for each millimeter decrease in grain length (Table 4). The inverse relationship was inconsistent with expectation and might result from purchase of higher priced-, short-grained traditional varieties. The presence of IR42, a short-grained modern variety that enjoys a premium in the market because it resembles traditional varieties, partly accounted for this relationship. A negative relationship was observed between rice price and foreign matter content. A percentage reduction in foreign matter increased price by 0.04% or P0.10 for urban consumers.

Head rice recovery was directly related with price. A one percent increase in head rice caused a 0.13 % increment in price equivalent to P0.01 among urban consumers.

Amylose content exerts a strong influence on taste and cooking qualities of rice. Generally, Filipinos prefer rice with low intermediate amylose content. Price is expected to be negatively related with this characteristic. Among urban consumers, a one percent decline in amylose content increased price by 0.31% or P0.08/kg

Table 3. Estimated implicit price function by location, Manila and Nueva Ecija, Philippines, 1987[a]

CHARACTERISTIC	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)	(0.46)	(0.59)
Length	-0.25**	-0.02	-0.13
	(-2.90)	(-0.20)	(-1.82)
Foreign matter	-0.04**	-0.02**	-0.03**
	(-3.14)	(-3.53)	(-4.20)
Head rice recovery	0.13*	0.09*	0.15*
	(2.19)	(2.37)	(3.92)
Amylose content	-0.31**	0.31**	-0.06
	(1.36)	(1.76)	(1.90)
Alkali spreading value	0.18**	0.09**	0.14
	(4.39)	(3.25)	(4.97)
Consumer Traits			
Age	0.05	0.04*	0.03
	(1.81)	(2.22)	(1.80)
Education	0.02	0.04	0.04
	(0.65)	(1.76)	(1.48)
Income	0.08**	0.002	0.05
	(0.65)	(1.76)	(1.48)
Location			0.05**
			(6.20)
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 1% level.
* Significant at 5% level.

Alkali spreading value measures the temperature and the time required for cooking. A one percent rise in alkali spreading value increased price by 0.18% implying that urban consumers prefer rice with lower cooking temperature and shorter cooking time. This result was expected considering that urban homemakers were employed either as white-collar or blue-collar workers and place a premium on their time. Similarly, because urban

consumers pay more for rice with lower amylose content, this rice likely has less expansion and cooks faster. For urban consumers, alkali spreading value costs P0.25 per unit.

Table 4. Mean implicit prices (P/unit) of characteristics paid by urban and rural consumers, Manila and Nueva Ecija, Philippines, 1987.

CHARACTERISTICS	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	0.01	-0.02	-0.06
Head rice recovery	-0.08	0.01	0.02
Amylose content	-0.08	0.08	0.16
Alkali spreading value	0.25	0.12	0.38

Rural consumers, in contrast, were price responsive to changes in whiteness, foreign matter content, head rice recovery, amylose content, and alkali spreading value (Table 3 and 4). A one percent increase in whiteness caused price to increase by 0.17% and commanded an implicit price of P0.03. Likewise, price increased by 0.09% for every one percent increment in head rice recovery. Rural consumers preferred rice with fewer brokens and attached an implicit value of P0.01 to head rice recovery.

Foreign matter was an undesirable characteristic decreasing price by 0.02% for each additional percentage in rice. Rural consumers paid P0.02 for each percent of impurities removed from rice.

Contrary to expectations, rural rice price increased by 0.31% for every one percent increase in amylose content. It should be noted that 66% of the rice samples had intermediate amylose content so that a positive relationship generally existed within this range. Moreover, because higher amylose rice has greater expansion when cooked, rural consumers were willing to sacrifice moistness and softness for more expansion to feed an entire family with less rice. Because of this tradeoff, an implicit price of P0.08 was attached to amylose content.

Preference for fast-cooking rice was also manifested by rural consumers. A one percent increment in alkali spreading

value increased price by 0.09%. Rural consumers paid P0.12 per unit of this characteristic.

Among the consumer traits hypothesized to affect the price of rice, per capita income was significant for urban consumers. As income increased by one percent, price increased by 0.08%. This suggests that the recognized desire for rice of better grade is translated into effective demand with increases in purchasing power. For rural consumers, however income level was insignificant. More than 70% of rural consumers had low per capita income. Likewise 93% of the samples purchased were low-value rice with prices ranging from P5.50 to P6.50 per kilogram. 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 high priced traditional varieties.

Age and educational attainment of the homemaker were not significant factors influencing the willingness of urban consumers to pay a certain price for rice. However, in rural areas older and highly educated homemakers purchased higher-priced varieties.

Comparison of rural and urban hedonic relationships showed the applicability of the hedonic model to both urban and rural data sets as determined by a test of equality of coefficients of urban and rural regressions. The Chow test showed that the two estimated relationships were significantly different making it incorrect to assume equal coefficients. The effects of quality characteristics on rice price were not the same across urban and rural locations. The study of Aragon (1972) lends evidence that rice varieties or grades varied not only by income but also by location.

Consumers by income group. The decision of low-income consumers to buy a specific rice grade was significantly affected by amylose content and foreign matter content (Table 5). Amylose content was positively associated with price. A one percent increase in amylose content caused a 0.31% rise in price and was valued particularly by the low-income consumers at P0.08 (Table 6). The direct relationship was expected because this group prefers rice that guarantees greater volume expansion, thus allowing 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 each percent decrease in this characteristics. Low-income consumers considered foreign matters an unfavorable characteris-

Table 5. Implicit price function by income group, Manila and Nueva Ecija, Philippines, 1987.[a]

CHARACTERISTICS	INCOME GROUP		
	Low	Medium	High
Rice Characteristics			
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 recovery	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-value.
**Significant at 1% level.
*Significant at 5% level.

tics and were willing to pay P0.03 for each percent reduction in foreign matter. Other characteristics such as whiteness, translucency, head rice recovery, and alkali spreading value had positive but insignificant effects on price paid by low-income consumers.

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 each percent increase in grain length. Medium-

Table 6. Mean implicit prices (P/unit) of characteristics paid by different income groups, Manila and Nueva Ecija, Philippines, 1987.

CHARACTERISTICS	INCOME GROUP		
	Low	Medium	High
Whiteness	0.01	0.01	-0.03
Translucency	0.001	0.001	0.002
Length	0.16	-0.23	-0.44
Foreign matter content	-0.03	-0.03	-0.14
Head rice recovery	0.01	0.01	0.02
Amylose content	0.08	0.02	-0.17
Alkali spreading value	0.07	0.15	0.39

income consumers paid P0.23 for each millimeter reduction in grain length. The inverse relationship between price and grain length was inconsistent with apriori expectations because of the presence of IR42, a short-grained modern variety which commanded a higher price in the market.

An inverse relationship was also noted between price and foreign matter content. A one percent increase in foreign matter decreased price by 0.16%. Medium-income consumers paid P0.03 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 one unit increase in alkali spreading value increased price 0.11% and cost P0.15 for the medium-income group. This group preferred rice which requires shorter cooking time.

Prices paid by high-income consumers depended heavily on quality characteristics. Included were grain length, foreign matter content, head rice recovery, amylose content, and alkali spreading value. Grain length exhibited a significant negative relationship with price. A one percent increase in length reduced price by 0.32%. High-income consumers paid P0.44 for each millimeter reduction in length. The inconsistent negative effect was due to the purchase of high-priced traditional varieties which were relatively shorter than ordinary varieties.

Foreign matter was inversely related with price causing it to decline by 0.04% for every one percent increase in this characteristics. Among the three consumer groups, the high-income class paid the highest implicit price of P0.14 for each percent reduction in foreign matter.

High-income consumers also expressed preference for higher head rice recovery. A one percent increase in this characteristic caused a significant 0.02% increase in price. The cost of a one percent of head rice was P0.02 for high-income consumers.

The effect of amylose content on price was strongest for high-income consumers. A one percent increase in amylose content significantly decreased price by 0.61%. The inverse relationship was due to the presence of high-priced traditional varieties with intermediate amylose content. An implicit price of P0.17 was paid for each percent decrease in amylose content.

The highest value of P0.39 was attached to a unit of alkali spreading value by high-income consumers. This group would incur a 0.28% increase in price for each percent increase in alkali spreading value. This preference for fast-cooking rice could be attributed to the time-bound nature of this group composed mostly of white-collar, urban residents.

Among the consumer traits hypothesized to affect rice price only location was significant. The coefficient of the location dummy showed that the intercept of the regression for urban consumers was higher than for rural consumers for all income groups. This implies that consumers buying rice in urban markets paid higher prices than those purchasing rice in rural markets.

Comparison of hedonic relationships by income group revealed that consumers were more willing to pay for quality characteristics as income level rose. Increasing F-ratios imply improvement of fit of the regression models with increasing income. The sizable and significant t-statistics calculated for each individual coefficient in the high-income regression shows that the effect of each quality attribute on rice was strongest for the high-income group. These results support Efferson's (6) claim that the higher the 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.

CONCLUSIONS

A hedonic pricing model was used to determine the relationship among rice prices, quality characteristics and consumer traits. Comparison of preferences expressed by rural and

urban households and by consumers of different income groups was also made.

Physical and chemical characteristics of rice considered to significantly affect the purchasing decisions of consumers were whiteness, translucency, grain length, foreign matter content, head rice recovery, amylose content and alkali spreading value.

Results showed that both urban and rural consumers were price responsive to changes in quality characteristics. Among the attributes, cooking and eating qualities like texture and softness of cooked rice were found to exert the biggest influence on the price paid by both groups. However, the magnitude of the regression coefficients indicated that all characteristics except for whiteness exerted stronger influence in urban than in rural rice price. Consequently, urban consumers attached higher implicit prices to these characteristics than rural consumers. The Chow test further confirmed the significant difference in the estimated price and quality relationships between urban and rural consumers.

Differences in characteristics preferred were also noted among income classes. As income level rose, consumers became more discriminating and their willingness to pay for rice were increasingly dependent on quality characteristics. Likewise, within income groups, prices paid by consumers varied depending on whether purchase was made in urban or rural markets.

The findings reveal that consumers attach economic importance to rice quality. The study also confirms that preferences for rice quality vary among distinct consumer groups. The study has strong implications for rice research on breeding improvement, cultivation and postharvest systems to produce qualities that better satisfy consumer needs.

SUGGESTED RESEARCH AREAS

The study has integrated price-quality relationships with a demand model for rice. It provides a number of results which are useful in identifying areas for rice grain quality improvement. The study however, has its inherent limitations. Only two major sites were included, a rural producing area and an urban consuming area. Because locational differences are affected not only by degree of urbanization, it would be worthwhile to examine more specifically defined locations to accurately capture preference variations resulting from cultural or

ethnic classes, religion and additional socioeconomic characteristics.

Likewise, because both observed and implicit prices of embodied attributes may be affected by aggregate demand and supply conditions, the implied value of an embodied quality attribute may not remain the same across marketing seasons. The hedonic estimation technique must also be adjusted for temporal differences in markets. Periodic surveys should also be institutionalized to monitor consumer demand and preference patterns.

The hedonic model was able to identify rice characteristics relevant to consumers. But it was not successful in relating consumers' perceptions of rice quality characteristics purchased to the actual characteristics intrinsic in the rice itself. A similar study extended to include a taste test using the rice samples bought by consumers could bridge the gap between actual and perceived characteristics. Results from laboratory taste panels could be used of rice.

The study can be extended to include an estimation of the benefits and costs accruing from altering product characteristics to improve quality. Standard welfare measures such as the changes in consumer surplus can be calcualted to measure the benefits gained from such improvements. A related study would be to compare the distributional impact of altering grain characteristics. An important issue is the extent to which benefits from quality improvement are distributed among different classes of consumers. A second issue is the extent to which benefits from quality improvement are transmitted through the marketing system to the trade community and ultimately to the farmers.

Government policies and the nature of the marketing system have major effects on quality determination. Therefore, a focus on the particular components of the marketing system and the policies which have a direct impact on the price formation for different qualities of rice would also be a useful research topic. Specifically, the following institutional and policy directions are recommended:

1. Assess methods and mechanisms for improving the transmission of quality incentives to farmers through the marketing system;
2. Examine the degree to which imperfections in the credit market may inhibit farmers from adopting improved postharvest technologies;

3. Evaluate the degree to which government intervention in the rice market has produced distortions in pricing and misallocation of resources.
4. Evaluate institutional mechanisms of organizing farmers allowing them to realize scale economies in processing, trading storage and financial operations.

The research agenda for rice quality are multidisciplinary. Biological scientists would focus on identification of characteristics economically viable for breeding and improvement. For postharvest technologists, the list would include prioritization and development of technologies which clearly recognize the quality requirements of each market. They could focus on development/redesign of technologies which produce marginal but significant quality improvements and remain cost effective at current wage and capital costs. For the social scientists, the agenda include pricing policy and marketing, technology assessment and returns to investments in rice research.

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The consumer is assumed to maximize equation (2) subject to the budget constraint:

$$\sum_{j=1}^{n} P_i q_i = E \qquad (4$$

where P_i is the market price of product i and E is total income.

The consumer selects the values of q_i that maximize the Lagrangian:

$$L = U\ (X_{01}, X_{02}, \ldots, X_{0m}) - \lambda\ (p_i\ q_i - E) \qquad (5)$$

Because the X_{0j}'s are functions of the q_i's, the constrained maximum of U is:

$$\lambda L/\lambda q_i = (\lambda U/\lambda X_{0j})\ (\lambda X_{0j}/\lambda q_i - \lambda P_i = 0 \qquad (6)$$

The marginal utility of income, λ, is equal to $\varepsilon U/\varepsilon E$. With this substitution and solving for pi, equation (6) becomes:

$$P_i = (\lambda X_{0j}/\lambda q_{i)}\ [(\lambda U/\lambda X_{0j}]/\lambda U/\lambda E)] \qquad (7)$$

The marginal yield of the j^{th} product characteristic by the i^{th} product is $\lambda X_{0j}/\lambda q_i$. The marginal utility of income of $\lambda U/\lambda E$. Therefore, the ratio in brackets is the marginal rate of substitution between income and the j^{th} product characteristic. Because expenditure is assumed to equal income, the bracketed term is also the marginal implicit price of the j^{th} characteristic. Equation (7) states that the price paid by the consumer equals the sum of the marginal values of the product characteristics. Each value is equal to the quantity of the characteristic obtained from a marginal unit of the product multiplied by the marginal implicit price of the characteristic. Because yield of most product characteristic is constant for each unit of a product, $\lambda X_{0j}/\lambda q_i = X_{ij}$ is assumed constant.

Furthermore, if the marginal implicit price is also assumed constant, then it can be represented by P_{ij}. Therefore, equation (7) for a particular product such as rice becomes:

$$P_r = E\ X_{rj}\ P_{rj} \qquad (8)$$

where: P_r = price of rice;

X_{rj} = quantity of characteristic j

APPENDIX B
CHARACTERISTICS OF MILLED RICE AND THEIR EXPECTED RELATIONSHIP WITH PRICE

CHARACTERISTIC	MEASURE	EXPECTED RELATIONSHIP
Physical		
Whiteness	% of pure white	+
Head rice recovery	% of unbroken grain	+
Shape	length (mm)/width(mm)	+
Translucency	% not chalky	+
Foreign matter content	% of sample	-
Chemical		
Apparent amylose content	%	-
Gel consistency	mm	+
Alkali spreading value		-

APPENDIX C.
PROCEDURES FOR MEASURING MILLED RICE CHARACTERISTICS

1. Whiteness was measured using the KETT whiteness meter, an optical instrument. The scale ranges from 0 to 100, with 100 indicating pure white magnesium oxide powder.
2. Translucency was measured with a Translucency Rice Meter with 0-100% scale.
3. Chalkiness was measured using a visual rating of the chalky proportion of the grain. The scale is 1-9, with 1 = less than 10% chalkiness, 5 = 10 - 20%, 9 = more than 20% chalkiness. Chalkiness is inversely related to translucency.
4. Head rice recovery was measured by grain sizing and weighing unbroken grain (75% intact) in a 100 mg subsample.
5. Length and width were measured in millimeters using ten whole grains under a photoenlarger.
6. Apparent amylose content percentage was measured using a simplified iodine colorimetric procedure.

7. Gelatinization temperature was measured by the alkali spreading value. This is the extent of disintegration of milled rice soaked in a 1.7% potassium hydroxide solution for 23 hours at 30°C. A high rating indicates more disintegration and a low gelatinization temperature.
8. Gel consistency was measured by the length of cold milled rice paste in a test tube held in a horizontal position (unreplicated 80, 90 and 100 mg., 12 ml, 0.2 N KOH). A higher number indicates softer gel consistency. The average of 90 and 100 mg data is reported.
9. Foreign matter content/damaged grains percentage was measured through physical separation of dockage and damaged grains of a 25 mg subsample.