What drives consumer demand for rice fragrance? Evidence from South and Southeast Asia

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Abstract

Purpose – The purpose of this paper is to analyze geographic heterogeneity of consumer preferences for intrinsic quality attributes of rice in South and Southeast Asia and the drivers of demand for these attributes, with a particular focus on rice fragrance and the role of gender.

Design/methodology/approach – Stated-preference surveys were conducted with 4,231 urban and rural consumers in 37 cities across seven countries (Bangladesh, India, Cambodia, Indonesia, the Philippines, Thailand, and Vietnam) during 2013–2014 and analyzed through a rank-ordered logistic regression with incomplete ranking choice data.

Findings – Preferences for rice attributes are found to be significantly heterogeneous among consumers in South and Southeast Asia. Urban Thai consumers tend to prioritize appearance and cooking characteristics over taste and nutritional benefits, relative to all other surveyed consumers. In contrast with South Asian consumers, Southeast Asian consumers have largely adopted Thai preferences for rice texture and fragrance, a trend that was earlier coined "*Jasminization*." We find that demand for rice fragrance is mainly driven by women, educated consumers, large families, families spending a lower share of their food expenditures on rice, and consumers in Southeast Asia (particularly the Philippines and Cambodia).

Originality/value – Little is known about geographic heterogeneity, drivers, and the role of gender in demand for rice fragrance. This paper fills these knowledge gaps. Our findings suggest that the more women are empowered in grocery decision-making, the more demand for aromatic rice is expected to rise. These insights can assist market-driven and gender-responsive rice breeding programs in simultaneously enhancing rice farmers' livelihoods *and* gender equity.

Keywords Product attributes, Consumer attitudes, Gender, Rice, South Asia, Southeast Asia

Paper type Research paper

1. Introduction

Fragrant or aromatic rice is commonly differentiated by its appearance, aroma, and taste (Chaudhary *et al.*, 2003; Giraud, 2013). Grains are typically slender and almost double in

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length after cooking. It has a soft and fluffy texture, with a pleasant fragrance and appealing taste (Singh *et al.*, 2018). These attributes are present in many aromatic rice varieties produced around the world. However, among the different aromatic rice varieties, Indian Basmati and Thai Jasmine are the most traded in the international market (Pachauri *et al.*, 2010). For example, all exports of these two varieties by India and Thailand serve approximately two-thirds of the world fragrant rice market (Table I).

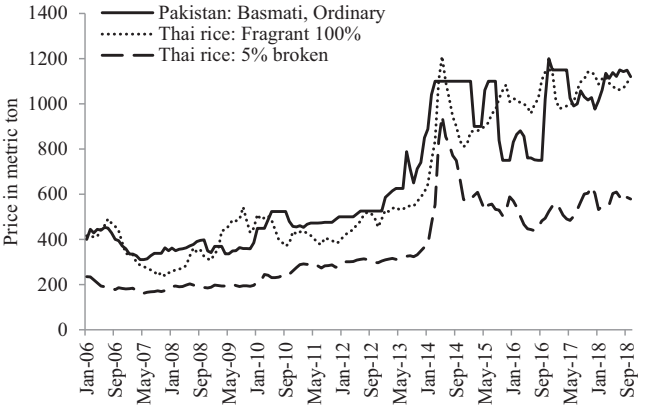
Although annual volumes of fragrant rice exports have dramatically increased from 5.9 million tons in 2008–2010 to 8.7 million tons in 2015–2017, the market share has remained stable at around 20 percent of the rice traded globally during this period (Table I). Because of the presence of the aforementioned quality attributes, the market price of fragrant rice is more than double the price of nonfragrant rice (Figure 1). Since February 2014, the price gap between fragrant and nonfragrant rice seems to be on the rise, which may indicate that a demand shift for fragrant rice is happening in the international market. Local demand for fragrant rice is also increasing, and several studies have linked this to increasing urban demand for rice with superior quality (Minten *et al.*, 2013; Demont and Ndour, 2015; Bradbury *et al.*, 2016; Diagne *et al.*, 2017).

Consumer demand for rice fragrance is increasing in many Asian countries (Peng *et al.*, 2009; Golam *et al.*, 2011; Hanis *et al.*, 2012; Calingación *et al.*, 2014; Custodio *et al.*, 2016; Lau *et al.*, 2017), a trend that was coined the term "*Jasminization*" (Custodio *et al.*, 2016). Particularly in Southeast Asia (i.e. the Philippines, Indonesia, Vietnam, Thailand, and Cambodia), convergence of consumer preferences toward rice with long-slender grains with aroma was evident since the 1980s (Unnevehr, 1986; Abansi *et al.*, 1992, Damardjati and Oka, 1992; Sriswasdilek *et al.*, 1992; Calingación *et al.*, 2014). This trend could be attributed to various factors, including globalization, urbanization, and income growth. Globalization and trade liberalization are important drivers fueling the demand for fragrant rice (Chaudhary, 2003; Marothia *et al.*, 2007). Leading exporters of fragrant rice such as Thailand and India have major influence in popularizing quality attributes embedded in their export products and hence shaping preferences for rice attributes in importing countries such as the Philippines and Indonesia (Custodio *et al.*, 2016). Because of Western influence, taste and lifestyle of Asian populations have been changing, so have their dietary habits and preferences for food (Huang and Bouis, 2001; Pingali, 2007; Reardon *et al.*, 2014). Rapid urbanization levels in both South and Southeast Asia have also induced changes in consumers' taste and lifestyle (Dawe *et al.*, 2014). The demand for aromatic rice is expected to

Major fragrant rice exporting countries	2008–2010		2015–2017		% Change	
	Total export	Fragrant export	Total export	Fragrant export	Total export	Fragrant export
India	2,322	1,787	9,730	3,870	+319%	+117%
Pakistan	3,537	1,046	3,859	553	+9%	−47%
Cambodia	113	113	587	334	+420%	+196%
Thailand	9,418	2,780	10,444	2,430	+11%	−13%
Vietnam	5,798	222	6,588	1,501	+14%	+576%
Sub-total	21,189	5,948	31,209	8,689	+47%	+46%
Global rice export	29,531		43,688		++48%	
Share of fragrant rice export (% of global rice export)		20%		20%		

Table I.
Fragrant rice export market (1000 tons)

Source(s): Production, Supply and Distribution Online (PS&D), USDA Foreign Agriculture Service (FAS); indiastat.com; Rice Exporters Association of Pakistan; Thailand Foreign Agricultural Trade Statistics, and different country-level Grain Reports by USDA FAS



Note(s): "Fragrant 100%" refers to head rice of 100 percent unbroken rice kernels."5% broken" indicates a rice blend with head rice of 95 percent unbroken rice kernels and 5 percent broken kernels
Source(s): FAO GIEWS FPMA Tool, available at: http://www.fao.org/giews/food-prices/tool/public/#/dataset/international

Figure 1.
Comparison of international price of fragrant and nonfragrant rice, 2006–2018

rise more rapidly under increasing levels of urbanization[1]. Finally, per capita income of many Asian countries has been increasing during the last decade. Even though per capita rice consumption in many Asian countries is decreasing steadily[2], as incomes rise, consumer preferences for rice in South and Southeast Asia tend to shift toward superior quality attributes, such as fine grain texture and aroma (Custodio *et al.*, 2016; Mottaleb and Mishra, 2016; Mottaleb *et al.*, 2017).

Despite evidence for increasing demand for rice fragrance, little is known about geographic heterogeneity, drivers, and the role of gender in demand for rice fragrance. First, even though several studies observed that consumer preferences for rice attributes diverge significantly across geographies (Calingación *et al.*, 2014; Demont and Ndour, 2015; Cuevas *et al.*, 2016; Custodio *et al.*, 2016; Custodio *et al.*, 2019; Demont *et al.*, 2017; Bairagi *et al.*, 2019), little is known about the heterogeneity of consumer demand for rice attributes such as fragrance in South and Southeast Asia. Understanding the heterogeneity of consumer preferences is crucial for varietal development programs to incorporate regional and national specificities for grain quality attributes and increase access of rice farmers to urban and rural markets to improve their livelihoods. While most rice breeding programs have primarily focused on yield-enhancing traits such as agronomic and stress-tolerance traits, several studies advocate for the inclusion of consumer-preferred rice attributes in rice breeding (Cuevas *et al.*, 2016; Custodio *et al.*, 2016; Demont and Ndour, 2015; Demont *et al.*, 2017; Mottaleb *et al.*, 2017). Secondly, since there is an important time lag between the development of product profiles in rice breeding and the release and adoption of new varieties, it is vital to understand demand trends and capture future demand for rice attributes. To anticipate future demand, the factors that affect demand need to be identified. Finally, for sustainability reasons there is an increasing need to ensure that varietal development is gender-responsive and accounts for both men's and women's preferences. Therefore, this paper fills these knowledge gaps by identifying consumer preferences for intrinsic[3] quality attributes of rice in seven South and Southeast Asian countries and the factors that affect demand for these attributes. We focus in particular on geographical and gender segmentation of demand for rice fragrance, which enables rice breeding programs to develop targeted variety replacement strategies at regional and national levels that are both more demand-driven *and* gender-responsive.

The rest of the article is organized as follows: Section 2 discusses the sampling technique and data collection methods. Section 3 explains the empirical models to investigate consumer preferences for rice attributes. Section 4 reports the findings drawn from the survey data and econometric analysis and provides an in-depth discussion. Finally, conclusions are drawn in the last section.

2. Sampling technique and data collection

The stated-preference survey was conducted in seven countries through a multi-stage stratified sampling technique (see Figure 2). The selection of regions and countries was determined by funding. The implementation of fieldwork was done in phases and reached a total of 24 cities and 13 rural districts in seven countries. We started with the major cities in South and Southeast Asia to capture the geographic heterogeneity of rice attribute preferences from the urban consumption zones. In the first phase, we purposively selected the main cities in the Philippines, Indonesia, Thailand, Vietnam, Cambodia, South and Eastern India, and Bangladesh. In the second phase of fieldwork, we increased the number of cities in Eastern India and included rural districts both in Bangladesh and in Eastern India (West Bengal and Odisha) (Table II). Inclusion of rural districts was decided to provide comparison of preferences by urbanity. The urban cities were selected according to population size and the rural cities were selected conditional on the importance of rice production in the respective region. The selection of the regions and states in India was mainly based on the breeding priority areas of the International Rice Research Institute (IRRI) in South Asia.

After selection of the cities, each city was divided into strata (i.e. north, south, east, west, and center). In each stratum, a number of primary sampling units (PSUs) were randomly selected, and in each PSU, a starting point was identified (i.e. prominent social establishment such as school and government office). The first house to screen was then approached from the starting point following the right-hand rule. After every successful interview, three houses were skipped before approaching the next house to screen. This systematic sampling approach was continued until the targeted number of households was completed for that PSU.

In each identified household, the respondent from that household was selected for interview based on the three main criteria: (i) involvement in preparation and cooking of meals for the household (fully or partly), (ii) involvement in grocery shopping decision-making, and (iii) having consumed rice at least once in the past six months. If several members in a household met these three criteria, the qualified member with the most recent birthday was selected. Finally, a total of 5,168 respondents were interviewed using a structured questionnaire, in which the main question was respondents' top three preferred rice attributes. Additionally, respondents' rice purchase, consumption, price per kilogram they pay for the rice they typically buy, and other socioeconomic characteristics, were included in the questionnaire. The surveys were conducted during 2013–2014. The questionnaires were translated into local languages. During questionnaire development, the questionnaires were translated to local dialects. Back-translation (i.e. from local dialect to English) of the local versions of the questionnaire was done to ensure that the context was captured.

3. Empirical models

3.1 Choice-based model: rank-ordered logistic (ROL) regression

We designed a survey questionnaire in which respondents are spontaneously asked to rank their three most-preferred rice attributes. For example, if a respondent's first most-preferred attribute is aroma, then aroma = 1; if appearance and nutritional benefits, respectively, are the second and third most-preferred attributes, appearance = 2 and

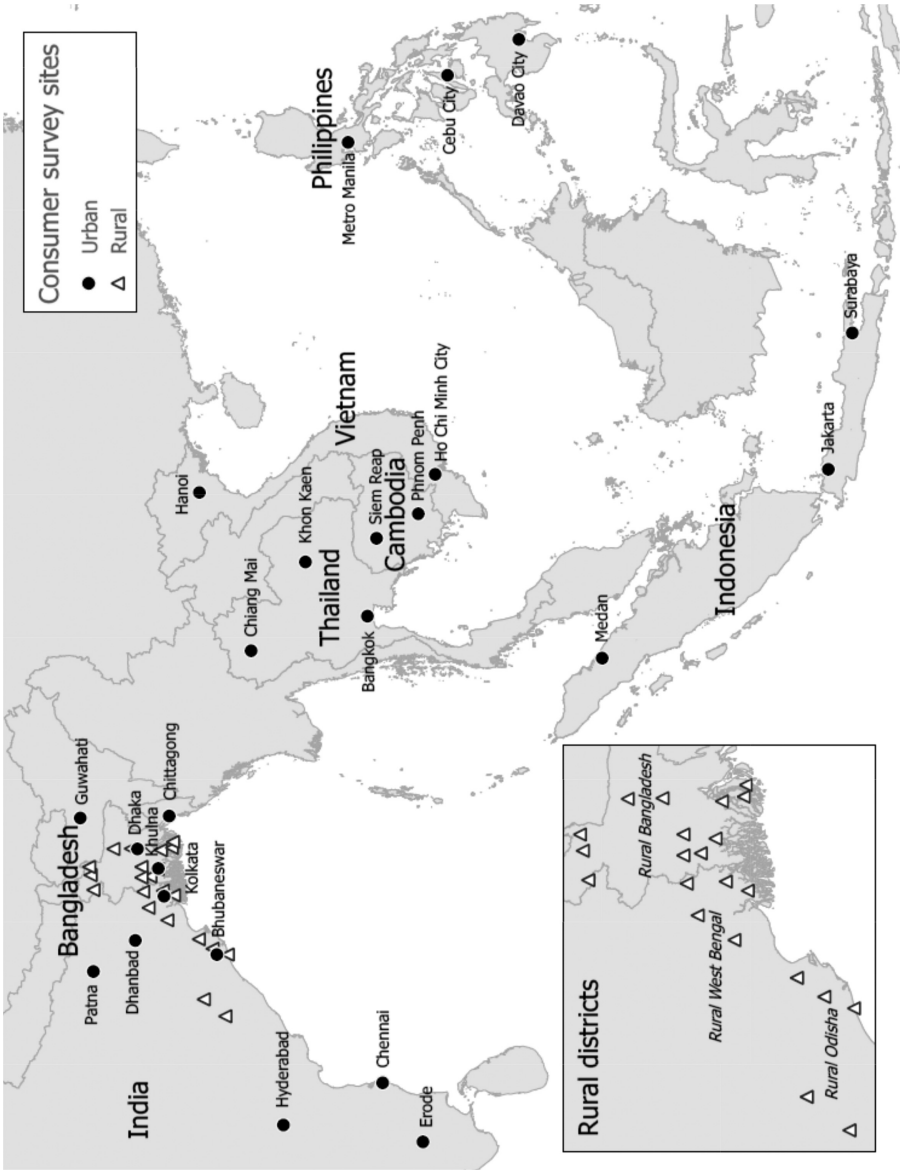


Figure 2.
Map of sampled urban and rural cities in South and Southeast Asian countries

Region	Country	Rural/urban[b]	Number of cities	Households surveyed Freq.	%	Samples used in this study[a] Freq.	%
South Asia	Bangladesh	Urban	3	499	9.7	337	8.0
		Rural	4	600	15.5	569	13.5
	India	East	4	801	12.0	580	13.7
		South	4	619	9.7	445	10.5
		Rural[c]	9	499	6.8	413	9.8
Southeast Asia	Indonesia	Urban	3	500	9.7	427	10.1
	Cambodia	Urban	2	350	9.7	289	6.8
	The Philippines	Urban	3	500	5.8	403	9.5
	Thailand	Urban	3	500	9.7	480	11.3
	Vietnam	Urban	2	300	11.6	288	6.8
Total			37	5168	100	4231	100

Source(s): Authors' computation from consumers' rice preference surveys in seven countries in South and Southeast Asia (2013–2014), International Rice Research Institute (IRRI)

Note(s): [a] A total of 937 samples were excluded because of missing information and outliers

[b] *Locations:* Bangladesh Urban: Dhaka, Chittagong, Khulna; Bangladesh Rural: Khulna, Barisal, Rangpur, Dhaka; India East (urban): Kolkata, Guwahati, Bhubaneswar, Patna, Dhanbad; India South (urban): Chennai, Erode, Hyderabad; India Rural: 24 Parganas, Nadia, Midnapur, Bardhaman, Cuttack, Puri, Bhadra, Kalahandi, Sonepur; Indonesia: Jakarta, Surabaya, Medan; Cambodia: Phnom Penh, Siem Reap; Philippines: National capital region, Cebu, Davao; Thailand: Greater Bangkok, Chiang Mai, Khon Kaen; Vietnam: Ho Chi Minh City, Hanoi

[c] India Rural refers to four rural districts in West Bengal and five rural districts in Odisha

Table II. Sampling distribution of stated-preference survey in South and Southeast Asia

nutritional benefits = 3. To model such choice-based data, we encountered the following three problems. First, in our data, we find a total of 104 rice attributes ranked as either the first most-preferred or second or third most-preferred choices. It is very difficult to analyze the choices by each attribute because the sample size under the majority of the attributes is small. Thus, we aggregated all the choices into six groups: taste, texture, aroma, appearance, nutritional benefits, and cooking characteristics (Table III). Second, since only the top three attributes were recorded, respondents' fourth, fifth, and so forth preferred attributes were unknown, which is a classic example of an incomplete choice ranking problem. Third, ties in ranking were not considered and whether consumers were indifferent between the top three and others was also unknown. Therefore, under such circumstances, a standard model to use is the rank-ordered logit (ROL) model, first introduced in the economics literature by Beggs *et al.* (1981) and further developed by Hausman and Ruud (1987). We used this model to investigate the probability of a rice attribute being selected and the factors that influence consumers' preferences for selecting that attribute, which is described further.

Suppose a representative respondent i prefers the alternative rice attributes j from a set of alternatives, where $i = 1, 2, \ldots, N$ and $j = 1, 2 \ldots, J$. Each respondent i gives to rice attributes j a rank r_{ij} that takes any integer value from 1 to j, where 1 represents the first most-preferred choice and J the least-preferred choice. If a respondent's rank of choices is $r_{ij} = j_1 > j_2 > j_3$, the utility of j_1 for that person is greater than all other alternative choices. Therefore, in a setting of a random utility framework, a respondent's level of utility for each attribute j, U_{ij}, can be written as:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \tag{1}$$

where the first term of Eqn 1 is a deterministic component and can be explained by a set of explanatory variables, $\boldsymbol{X}$,

Category of rice attributes		Attributes of rice
Appearance	Size of uncooked rice	Short, medium, long
	Shape of uncooked rice	Bold, medium, slender
	Homogeneous grain	Uniform size and shape
	Color of cooked and uncooked rice	White, yellowish, brown, red, black
Aroma		Jasmine, popcorn-like, *pandan*-like, rice-cake-like, vanilla-like, fruit-like, ginger-like, sweet, and unspecified aroma
Cooking characteristics (CC)		No need for excessive amount of water, easy to cook as it takes short time, volume expansion (volume increases after cooking)
Nutritional benefits (NB)		Non-fattening, "whole grain" (unpolished), high-fiber, vitamins, and calcium
Taste		Good taste, tasteful, delicious
Texture	Cooked rice	Rough, smooth, chewy, sticky, non-sticky, firm, soft, slippery, loose, and mushy

Source(s): Consumers' rice preference surveys in seven countries in South and Southeast Asia (2013–2014)

Table III. Description of rice attributes elicited from the stated-preference survey in South and Southeast Asia

$$V_{ij} = X_i^{'}\beta_j \tag{2}$$

where β is a vector of parameters related to X to be estimated. The last component in Eqn 1 is a random error term, which is assumed to be independent and identically distributed with a Type-I extreme value distribution.

Although the level of utility U_{ij} is unobserved, it is possible to observe consumer choices of rice attributes. A complete set of rankings of rice attributes from a consumer indicates a complete ordering of the underlying utilities, $U_{ir_{ij}} > \ldots > U_{ir_{ij}}$. Choices are considered as a sequence assuming that consumers start by assigning first-most importance to an attribute among a set of J attributes. When the first choice is made, consumers choose the second-most important among *J–1* attributes, and so on. Therefore, the observed ranking orders of the J attributes are exploded into *J–1* independent observations. Note that the ranking of least-preferred alternatives is assigned with probability 1.

The ROL model can be realized as a series of conditional logit (CL) models, and thus, the probability of a complete ranking is the product of separate CL probabilities, one for each attribute ranked. For example, in case the ranking orders provided by an individual consist of aroma (ar), appearance (ap), and nutritional benefits (nb), the probability of rank ordering can be computed as:

$$\begin{aligned}\Pr(r_1 = \mathrm{ar}, r_2 = \mathrm{ap}, r_3 = \mathrm{nb}|\boldsymbol{X}) = \Pr(r_1 = \mathrm{ar}|\boldsymbol{X}) \times \Pr(r_2 = \mathrm{ap}|\boldsymbol{X}, r_1 = ar) \\ \times \Pr(r_3 = \mathrm{nb}|\boldsymbol{X}, r_1 = \mathrm{ar}, r_2 = \mathrm{ap})\end{aligned} \tag{3}$$

Eqn 3 indicates that the probability of the specific rank orderings is the product of (i) the probability of aroma being chosen from a choice set that includes four alternatives since the product contains only *J–1* probabilities, (ii) the probability of appearance being chosen from a choice set that excludes aroma, and (iii) the probability of nutritional benefits being chosen from a choice set that excludes both aroma and appearance. The likelihood function for the ranking of a single response, say aroma, can be written as:

$$\Pr(r_1 = \mathrm{ar}|\boldsymbol{X}) = \frac{\exp\left(x_k\beta_{\mathrm{ar}|b}\right)}{\sum_{j=1}^{J}\exp\left(x_k\beta_{j|b}\right)} \quad (4)$$

Here b is the base case, the least-preferred one, which is determined once the first three are known. To fit the ROL model, the data matrix is reshaped into the long format. Since we retained a total of 4,231 respondents (see Section 4) and six attributes, the new long format data matrix consisted of 25,386 (=4,231 × 6) observations. We used STATA software to estimate this model, and the results are presented in Tables IV, V, VI and discussed in Section 4.

3.2 Sampling weights

Even though a random sampling method was used to select the household, the resulting sample could overrepresent one preferred attribute and underrepresent another relative to the population distribution of choices on rice attributes. This is called an endogenous sampling problem. If this is not accounted for, parameter estimates from the choice model could be inconsistent (Solon *et al.*, 2013). Therefore, we incorporate sampling weights in the regression to investigate how explanatory variables of interest affect the probability of one rice attribute being chosen over another.

To calculate sampling weights, we used population size by cities by socioeconomic classes (SECs), the definitions of which vary for each country (i.e. based on income in Vietnam and Thailand and based on multiple indicators in the Philippines, India, and Bangladesh), and the proportions vary by city even within a country. Mathematically, weights are calculated as $w_{\mathrm{mn}} = \frac{s^p_{\mathrm{mn}}}{s^s_{\mathrm{mn}}}$, where w_{mn} is the weight for the m-th city and the n-th socioeconomic class; s^p_{mn} is the share of population in the m-th city and the n-th socioeconomic class; and s^s_{mn} is the share of population in the m-th city and the n-th socioeconomic class that was surveyed. In other words, this relationship defines a probability of being sampled from a population.

4. Results and discussion

4.1 Descriptive statistics

Even though a total of 5,168 respondents were interviewed, due to missing information and outliers, we restricted the sample to 4,231 observations[4]. Table IV presents the descriptive statistics of the socioeconomic variables used in this study. We find that the majority of the respondents surveyed are women, that is, 81–98 percent of the samples in each country. Recall that the criterion to select a sample respondent was involvement in cooking meals and grocery shopping. The presence of a higher percentage of women in the sample indicates a higher involvement of women in cooking and preparing meals in the household and in household grocery shopping decisions. We also find that female consumers in Southeast Asia are more empowered in terms of grocery shopping decisions (83–95 percent) than South Asian consumers (Bangladesh and India) (61–73 percent).

The mean age of the sample respondents is 37 years. The highest shares of unschooled populations are found among Bangladeshi, Indian, and Cambodian consumers. On the other hand, the consumer samples from Thailand, the Philippines, and India feature the highest shares of tertiary education (university or postgraduate degree). The major occupation of the respondents is housewife, with the highest share in Bangladesh and India and the lowest in Thailand and Vietnam. Internet access is found to be in the range of 6–43

percent and is lowest in South Asia (India and Bangladesh) and highest in the Philippines and Thailand.

The average household size is between 3.6 and 5.1 in the surveyed cities. Annual per capita income is found to be highest in Thailand, followed by Indonesia, the Philippines, Vietnam, Cambodia, India, and Bangladesh. We also find that consumers in Bangladesh consume the highest quantity of rice (120 kg/capita/year) among the surveyed countries, followed by the Philippines, Cambodia, India, Vietnam, Indonesia, and Thailand. Moreover, they spend 14–31 percent of their total food expenditures on rice. Consumers' revealed willingness to pay for rice is lower in South Asia (Bangladesh and India) than in Southeast Asia, which might be due to differences in income levels and concomitant demand for rice quality and the different policy instruments used by governments to control domestic rice prices. Finally, on average, urban Filipino consumers purchase rice more frequently (at least once a week) than consumers in the other surveyed countries.

4.2 Ranking of consumer preferences for rice attributes

Preference rankings were computed in terms of shares across choices and across countries and regions (Table V)[5]. The highest preference ranking (=1) is found for appearance, followed by texture and other attributes. On average, half of the total sample respondents ranked appearance as their first most-preferred attribute. Country-specific results show that appearance is the most-preferred rice attribute for Bangladesh and India, whereas texture is the most-preferred attribute for Thailand, Vietnam, Cambodia, the Philippines, and Indonesia. Differences in regional preferences for these attributes are also found. We find that the least-preferred choices were nutritional benefits and cooking characteristics. However, urban consumers in Thailand ranked nutritional benefits as their second most-preferred attribute. We also find a substantial consumer segment in Indonesia, Cambodia, the Philippines, and Vietnam (26–37 percent) that ranked aroma as their second most-preferred attribute.

Finally, we performed a statistical test to examine whether the preference ranking of the attributes is statistically different. To determine the overall statistical significance of product preferences, several widely used statistical tests are available, such as the Friedman test and the Anderson test (Rayner and Best, 1990; Carabante *et al.*, 2016). However, we used the Skillings–Mack (SM) test, which is a generalization of the Friedman test and a distribution-free method (Skillings and Mack, 1981; Chatfield and Mander, 2009), because of the nature of our data being incomplete preference ranking data. Here, the null hypothesis is that the mean ranks for each attribute are not different. The estimated SM test statistics is found to be 2,357, with a p-value of 0.000. This implies that we reject the null hypothesis and conclude that the mean ranks of each rice attribute are indeed statistically different.

4.3 Determinants of consumer preferences for rice attributes

The ROL model enables identifying the determinants of consumer preferences for rice attributes; the estimated coefficients are reported in Table VI. The signs of these coefficients indicate the direction of the relationship between the determinants and the consumers' preferred choices over rice attributes (taste, texture, aroma, appearance, nutritional benefits, and cooking characteristics). The coefficients can be interpreted in terms of probability of a rice attribute being more/less preferred by consumers. We included several determinants that cover respondents' individual characteristics (age, gender, education, and employment), household consumption patterns (income, quantity of rice consumption, rice price, rice budget share, and rice purchasing frequency), and women's empowerment in grocery decision-making (Tables V–VI). Moreover, to capture the location specificities of preferences, nine location dummy variables were included[6]. Thailand is set as the reference case because

Table IV.
Socioeconomic profiles of sample respondents

Variables	Definition of the variables	Average or percentage of total frequency						
		Bangladesh	India	Indonesia	Cambodia	Philippines	Thailand	Vietnam
Sample size		982	1579	427	292	423	480	289
Gender								
Female	= 1 if female, 0 = otherwise	97.3	81.7	93.0	98.0	86.8	88.3	97.2
Male	= 1 if male, 0 = otherwise	2.8	18.3	7.0	2.1	13.2	11.7	2.8
Education								
No schooling	= 1 if respondents had no schooling, 0 = otherwise	10.5	7.7	0.2	10.6	0.7	3.5	0.7
Primary schooling	= 1 if respondents had primary or below level of schooling, 0 = otherwise	23.1	12.4	12.9	36.0	12.8	18.3	6.6
Secondary schooling	= 1 if respondents had junior/middle, senior/high school education, and technical or vocational training, 0 = otherwise	55.6	60.7	80.8	41.4	64.3	50.2	78.2
Higher studies	= 1 if respondents had university or postgraduate-level education, 0 = otherwise	10.8	19.2	6.1	12.0	22.2	27.9	14.5
Occupation								
Employed	= 1 if respondent is a full-time or part-time employee, 0 = otherwise	6.4	22.0	25.8	39.0	30.7	67.5	43.9
Housewife	= 1 if respondent is a housewife, 0 = otherwise	88.0	72.4	70.7	56.5	60.3	28.1	43.9
Other	= 1 if respondent is either unemployed, student or retired, 0 = otherwise	5.6	5.6	3.5	4.5	9.0	4.4	12.1
Access to internet	= 1 if yes, 0 = otherwise	6.9	6.7	18.7	18.2	37.6	43.1	12.1
Grocery decision maker	= 1 if respondents are the main grocery decision maker in the family, 0 = otherwise	60.0	62.8	82.7	91.4	82.7	78.8	93.1
Frequent buyer	= 1 if rice is purchased at least once a week, 0 = otherwise	12.7	13.2	32.6	11.3	74.5	31.0	7.6
Age	Age of the respondents, in years	33.8	37.2	37.8	34.5	39.5	37.7	41.4
Household size	Total number of members in household	4.5	4.0	4.5	4.7	5.1	3.6	4.4
Rice consumption	Annual per capita rice consumption, in kg	119.3	96.5	65.1	97.6	109.5	55.7	79.7
Rice price	Revealed willingness to pay for rice, in USD/kg	0.53	0.55	0.91	0.64	0.84	1.13	0.75
Income	Annual per capita income, in USD	699.3	667.8	654.3	1121.9	1073.8	3772.0	1471.3
Rice share	Consumers' spending on rice in total food expenditure (% of total food budget)	24.0	23.3	27.6	17.1	31.3	18.2	14.2

Note(s): Total sample size = 4,231
Source(s): Consumers' rice preference surveys in seven countries in South and Southeast Asia (2013–2014)

Table V. Preference ranking (response rate, %) by sample respondents in South and Southeast Asia

Rice attributes	Preference ranking	Bangladesh Urban	Bangladesh Rural	India East	India South	India Rural	Indonesia Urban	Cambodia Urban	Philippines Urban	Thailand Urban	Vietnam Urban	SA	SEA	All
Taste	0	36.7	60.5	39.4	76.8	42.5	88.2	99.8	78.9	48.4	55.7	52.0	73.2	62.4
	1	23.9	14.4	14.3	7.3	12.3	3.1	0.0	2.1	18.2	10.1	14.5	7.1	10.8
	2	31.0	15.7	33.3	9.4	28.8	2.6	0.0	11.4	29.9	25.9	23.1	14.6	18.9
	3	8.4	9.5	13.0	6.6	16.4	6.1	0.2	7.6	3.5	8.3	10.5	5.1	7.8
Texture	0	64.5	68.8	55.2	23.4	23.6	19.9	9.2	13.8	80.6	55.0	50.5	37.8	44.3
	1	8.6	6.7	12.3	35.6	44.9	43.3	64.2	51.2	2.6	5.7	18.7	31.1	24.8
	2	17.2	17.5	22.3	31.1	17.5	24.8	22.1	24.6	13.6	31.3	21.1	23.7	22.4
	3	9.6	7.0	10.2	9.8	14.0	12.1	4.6	10.4	3.3	8.0	9.7	7.4	8.6
Aroma	0	77.1	57.7	83.5	60.7	36.6	26.5	54.2	46.4	76.6	81.1	65.1	59.2	62.2
	1	5.7	8.2	3.5	5.6	15.1	16.8	5.0	12.1	1.4	1.7	7.0	6.6	6.8
	2	10.1	31.5	6.9	16.4	26.7	37.1	26.0	28.0	18.9	11.6	18.4	23.3	20.8
	3	7.1	2.6	6.1	17.3	21.6	19.6	14.8	13.5	3.0	5.6	9.4	10.8	10.1
Appearance	0	15.3	13.9	9.7	13.6	58.9	28.1	21.3	49.1	6.5	5.9	18.8	19.4	19.1
	1	53.2	65.4	60.0	43.3	16.8	25.8	21.9	23.2	67.8	79.5	51.6	46.9	49.3
	2	19.2	13.9	21.7	31.9	13.0	22.5	31.3	17.6	9.3	10.6	19.9	18.1	19.0
	3	12.3	6.9	8.6	11.2	11.3	23.6	25.6	10.0	16.4	4.0	9.6	15.7	12.6
Nutritional benefits	0	80.0	83.0	79.2	78.7	78.8	95.7	94.8	67.5	70.3	82.8	80.2	83.5	81.8
	1	4.9	1.8	5.9	6.8	5.1	0.9	1.7	9.3	2.6	0.9	4.7	2.5	3.6
	2	10.3	10.6	9.7	7.7	7.9	1.7	1.3	12.8	22.0	10.6	9.4	9.3	9.4
	3	4.7	4.6	5.2	6.8	8.2	1.7	2.3	10.4	5.1	5.7	5.6	4.7	5.2
Cooking characteristics	0	77.3	80.6	85.7	89.2	77.4	72.3	60.6	91.3	78.0	82.8	82.4	76.1	79.3
	1	2.7	3.4	3.7	0.9	5.8	9.9	7.3	2.1	7.5	1.9	3.2	5.7	4.4
	2	11.8	9.5	5.8	2.1	6.2	10.4	18.5	4.8	6.3	8.5	7.2	10.2	8.7
	3	8.1	6.5	4.8	7.7	10.6	7.3	13.5	1.7	8.2	6.8	7.2	8.0	7.6

Note(s): 1, 2, and 3 are the first, second, and third most-preferred attributes, respectively; 0 refers to a choice being unranked. SA and SEA denote South Asia and Southeast Asia, respectively

Table VI.
Estimated parameters from the rank-ordered logit regression

(Dependent variable = rank of the choices)	Taste	Texture	Aroma	Appearance	Nutritional benefits	Cooking characteristics
Age	0.021 (0.02)	0.0064 (0.01)	−0.0090 (0.02)	−0.0019 (0.01)	0.014 (0.03)	−0.029 (0.02)
Age squared	−0.00025 (0.00)	−0.000080 (0.00)	0.000059 (0.00)	0.000063 (0.00)	−0.00016 (0.00)	0.00037 (0.00)
Gender (male = 1)	0.038 (0.10)	0.073 (0.08)	−0.091 (0.10)	0.029 (0.07)	0.37*** (0.14)	0.037 (0.13)
Secondary education (yes = 1) [a]	−0.12** (0.06)	−0.043 (0.05)	0.23*** (0.07)	−0.019 (0.04)	0.031 (0.10)	−0.031 (0.09)
Higher education (yes = 1) [a]	−0.23** (0.11)	0.024 (0.08)	0.23** (0.10)	−0.033 (0.07)	0.19 (0.16)	−0.026 (0.14)
Household size	0.011 (0.02)	−0.024 (0.02)	0.046** (0.02)	−0.00077 (0.01)	0.060** (0.03)	−0.031 (0.03)
Employed (yes = 1)	0.043 (0.08)	−0.053 (0.05)	−0.053 (0.06)	0.016 (0.05)	−0.0022 (0.11)	0.064 (0.09)
Access to Internet (yes = 1)	0.0033 (0.10)	−0.036 (0.07)	0.0032 (0.08)	−0.075 (0.06)	−0.11 (0.14)	0.28** (0.11)
Log of per capita rice consumption	−0.17** (0.07)	−0.046 (0.05)	0.000051 (0.07)	−0.0017 (0.05)	0.52*** (0.12)	−0.063 (0.09)
Log of per capita income	0.25*** (0.06)	0.029 (0.04)	0.0052 (0.05)	0.023 (0.04)	−0.013 (0.09)	−0.050 (0.07)
Log of rice price	0.018 (0.16)	−0.071 (0.12)	−0.013 (0.16)	0.026 (0.11)	−0.046 (0.23)	0.087 (0.22)
Rice share (%)	0.010*** (0.00)	0.0013 (0.00)	−0.016*** (0.00)	−0.0039** (0.00)	−0.0063 (0.00)	0.0026 (0.00)
Women are the principal grocery decision-makers (yes = 1)	−0.19*** (0.06)	−0.045 (0.06)	0.20*** (0.07)	−0.087** (0.04)	−0.21** (0.10)	0.40*** (0.10)
Frequent rice buyer (yes = 1)	0.24*** (0.07)	0.076 (0.05)	−0.035 (0.07)	−0.00079 (0.05)	0.26*** (0.10)	0.15* (0.09)
Location dummies [b]						
Urban Bangladesh	6.90*** (1.24)	−0.98*** (0.14)	−0.90*** (0.18)	−0.27** (0.11)	1.10*** (0.34)	−0.42* (0.22)
Rural Bangladesh	6.29*** (1.24)	−0.50*** (0.14)	−1.05*** (0.19)	−0.30** (0.12)	0.89** (0.35)	−0.24 (0.23)
East India	6.38*** (1.24)	−1.32*** (0.15)	−0.11 (0.17)	−0.34*** (0.12)	0.69* (0.35)	−0.92*** (0.25)
South India	6.74*** (1.24)	−0.50*** (0.12)	−1.09*** (0.17)	−0.12 (0.10)	1.57*** (0.31)	−0.86*** (0.20)
Rural India	6.69*** (1.25)	−1.62*** (0.19)	−0.53** (0.21)	−.088 (0.14)	1.61*** (0.38)	−0.44 (0.27)
Indonesia	5.39*** (1.24)	0.042 (0.10)	−0.10 (0.13)	−0.042 (0.09)	1.85*** (0.29)	−1.14*** (0.19)
Cambodia	6.95*** (1.24)	0.014 (0.12)	0.38*** (0.14)	−1.18*** (0.13)	1.18*** (0.33)	−0.55*** (0.21)
The Philippines	4.76*** (1.24)	−0.0064 (0.10)	0.63*** (0.13)	−0.22** (0.10)	−0.50 (0.39)	−0.27 (0.17)
Vietnam	5.68*** (1.24)	0.11 (0.11)	−0.052 (0.14)	−0.88*** (0.12)	2.15*** (0.29)	−1.46*** (0.24)
Log likelihood	−12712.4	−18991.1	−13114.8	−28361.1	−5543.4	−6984.1
LR (χ^2)	919.0***	630.5***	588.9***	247.8***	308.2***	189.2***

Note(s): Figures between parentheses, are standard errors; *, **, and *** indicate 1%, 5%, and 10% level of significance, respectively; Base cases: [a] Primary and below levels of education; [b] Location dummies are relative to Thailand as a reference and leading rice exporter in the region

of its historical market leadership in aromatic rice export, implying that the coefficients of all location dummies need to be interpreted as being relative to the case of Thailand.

Four major conclusions can be drawn from Table VI. Firstly, we find that out of the 54 location dummy variables (6 attributes × 9 dummies), 40 are statistically significant with opposite signs, which suggests that preferences for rice attributes are heterogeneous among the surveyed countries. Specifically, we infer the following: (i) urban rice consumers in Thailand seem to care less about taste and nutrition and more about appearance and cooking characteristics, relative to all other surveyed consumers; (ii) Southeast Asian consumers seem to follow or amplify the Thai taste for texture and aroma as the geographic dummies are either insignificant or significantly positive, which is consistent with earlier findings (*Jasminization*) categorizing Vietnam and Cambodia as second-movers in the fragrant rice market after Thailand, and Indonesia and the Philippines as major rice importers (Custodio *et al.*, 2016); (iii) South Asian consumers seem to care less about texture and aroma than Southeast Asian consumers, which can be explained by the dominance of parboiling in these regions, a processing technology that generates a consistent dry and firm texture and largely eliminates aroma (Custodio *et al.*, 2016, 2019)[7]; (iv) finally, no major differences are found between urban and rural areas in South Asia, suggesting convergence of consumer preferences in urban and rural areas.

Secondly, women who are the sole decision-makers during grocery shopping tend to care more about aroma and cooking characteristics, but less about taste, appearance, and nutritional benefits than other shoppers (Table VI). Similar findings have been reported in West Africa, where women tend to favour cooking characteristics of imported Asian rice such as softness and swelling capacity (Demont *et al.*, 2017). Aoki *et al.* (2017) similarly found that Japanese women prefer premium rice with various quality attributes.

Thirdly, among the respondents' individual characteristics, we find that more highly educated (university or postgraduate) respondents are more likely to choose aroma and nutritional benefits than less highly educated respondents. This is consistent with the fact that educated persons are more likely to be better informed and aware of healthy diets so they may choose rice that has nutritious value (e.g. brown rice) as a preferred attribute. Household size also positively influences consumer preferences for rice fragrance and nutritional benefits, which is consistent with findings from Diagne *et al.* (2017) in urban Senegal.

Fourthly, consistent with studies in Africa (Demont and Ndour, 2015), consumer preferences for rice attributes are also influenced by household income, quantity of rice consumption, and the share of total food expenditure spent on rice. Furthermore, frequent (weekly) buyers tend to care more about taste, nutritional benefits, and cooking characteristics (convenience), than respondents who buy rice biweekly and monthly.

Finally, we conclude that demand for rice fragrance is mainly driven by women who are the primary grocery decision-makers, educated consumers, families that spend a lower share of food expenditures on rice, and consumers in Southeast Asia (particularly in the Philippines and Cambodia).

4.4 Predicted probability of choosing alternative rice attributes

Using Eqn 4, we estimate the predicted probability of attributes being chosen as the first, second, and third most-preferred attributes for consumers in rice importing and exporting countries and women decision-makers in South versus Southeast Asia (Figure 3). First, we observe that rice importers (Bangladesh, Indonesia, and the Philippines) and exporters (India, Cambodia, Thailand, and Vietnam) share very similar preference rankings, a trend that is consistent with previous observations (Table VI) and the literature (Custodio *et al.*, 2016; Demont *et al.*, 2017). We also find that Southeast Asian consumers prioritize their preferred rice attributes differently than South Asian consumers, even though rice is the

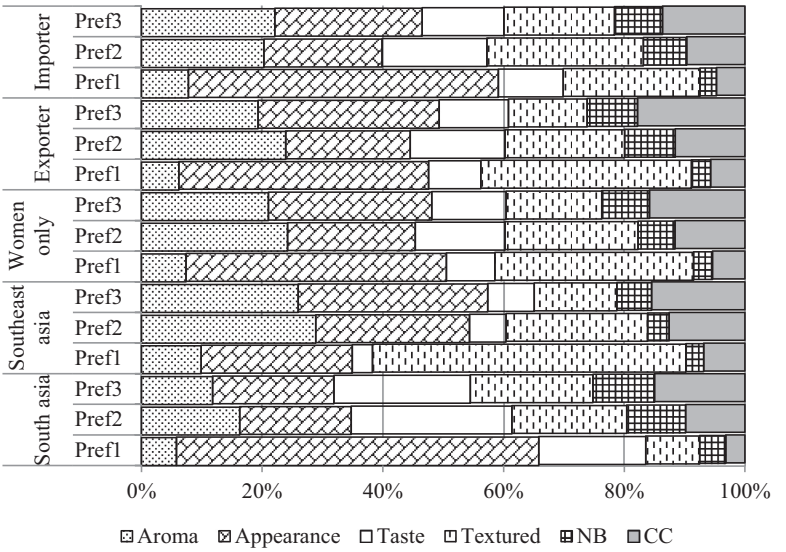


Figure 3.
Consumers' predicted probabilities for ranking alternative rice attributes

Note(s): NB stands for nutritional benefits; CC stands for cooking characteristics; Pref1, Pref2, and Pref3 are the first, second, and third ranking of the choices, respectively
Source(s): Authors' computation based on consumer preference survey in seven countries in South and Southeast Asia (2013–2014)

staple food in both regions. The predicted probability of choosing appearance as the first most-preferred attribute for South Asians is 60 percent, whereas taste has a probability of 25 percent of being chosen as second and third most-preferred attribute. In Southeast Asia, texture is ranked as the first most-preferred attribute (probability is 52 percent), whereas the second and third most-preferred attributes are aroma and appearance (respectively 29 percent and 32 percent). Finally, women who are empowered in grocery decision-making tend to focus primarily on appearance (ranked first and third with predicted probability of respectively 42 percent and 28 percent) and aroma (ranked second with predicted probability of 24 percent). Therefore, we expect women to play a major role in driving demand for rice fragrance, particularly in Southeast Asia. In other words, by anticipating and responding to increasing demand for rice fragrance, rice breeders can make their variety replacement programs not only more market-driven but also more gender-responsive. Relative to Thailand, this demand is even more pronounced in second-movers such as Cambodia and importers such as the Philippines (Table VI). This suggests that regional breeding programs focusing on Southeast Asia should base their variety replacement strategies on delivering fragrant rice germplasm, from which national programs can further tailor varieties to specific market segments.

4.5 Cross-country comparison

We estimated ROL models for each country across rice attributes, and results are in Annex Tables A1–A7. Findings indicate mixed outcomes, for example, the coefficient related to rice price differently affects demand for rice attributes across consumers in different countries. This is consistent with the findings presented before—consumer preferences toward rice attributes are heterogeneous. The following section highlights the main findings from cross-

country comparisons. First, coefficients related to age and age-squared variables are significant in demand equations for texture and aroma in Bangladesh, nutritional benefits in India, taste in Cambodia, and cooking characteristics in Thailand. However, the signs of age and age-squared are not the same for all of these equations. This implies that in some cases, the shape of the age response curve is concave and convex in other cases. Second, relative to men, women are found to exhibit a significantly higher demand for rice cooking characteristics in India and Vietnam, but the opposite was found in Bangladesh. Similarly, women's demand for aroma was also found to be higher in the Philippines, but lower in Thailand. This indicates that gender preferences toward different rice attributes are heterogeneous among countries. Third, higher education, taking a value of one if respondents had college and higher levels of education, positively affects demand for aroma, for most of the countries (except Thailand), indicating educated consumers' most-favored rice attribute. Fourth, the coefficient related to rice share is significant and negatively associated with demand for aroma and nutritional benefits attributes in most of the studied countries. This indicates that households who spend more on rice consumption did not rank the rice attributes aroma and nutritional benefits as their favorite choices. This is consistent with the fact that, first, consumers who spend more on rice are likely to be poor in the studied countries, and second, fragrant rice, such as Jasmine and Basmati, and nutritious rice such as pigmented rice, are expensive compared to standard rice. Finally, we find that women who are primary grocery decision-makers boost demand for rice fragrance in India and the Philippines, but in Bangladesh the opposite is found. For other countries, the coefficient related to this variable is positive but insignificant.

5. Conclusions

Examining consumer preferences for rice attributes is essential for guiding breeding priorities. Through a ROL regression with incomplete ranking choice data gathered from a stated-preference survey conducted in seven countries (Bangladesh, India, Cambodia, Indonesia, the Philippines, Thailand, and Vietnam), we identify the rice attributes that matter most to urban and rural consumers in South and Southeast Asia. We find that consumer preferences for rice attributes are geographically segmented; South Asians prefer rice that has great appearance and taste attributes, while Southeast Asians are more likely to choose rice based on texture; their second and third most-preferred attributes being aroma and appearance. The absence of certain quality characteristics in the top three (taste in Southeast Asia) does not automatically mean that consumers do not find those characteristics important in these regions; it can also mean that quality of rice has improved over time to such extent that consumers have taken these characteristics for granted. In other studies, it was similarly found that certain traits such as cleanliness disappear in the top rankings of consumers over time because after significant investment in postharvest infrastructure, consumers have become used to the upgraded characteristics of improved rice and tend to take these traits for granted (Custodio *et al.*, 2016, 2019).

Preferences for rice attributes are found to be segmented by gender, education levels, household size and income, rice consumption, expenditure share, and purchase frequency. Our evidence supports the trend of preferences converging toward aromatic rice (*Jasminization*) and suggests that this trend may continue in the future. First, aroma is featured in the top three most-preferred attributes by Southeast and South Asian consumers. Secondly, fragrant rice exports seem to affect preferences for rice fragrance in importing countries. Thirdly, demand for rice fragrance is found to be fueled by trends that are expected to continue over time, that is, rising education levels and decreasing rice expenditure shares. Finally, aroma is a preferred attribute of women who are empowered in grocery shopping decision-making. Therefore, as women become empowered, demand for aromatic rice is

expected to rise. These insights are crucial for market-driven and gender-responsive rice breeding programs and can assist them in simultaneously enhancing rice farmers' livelihoods *and* gender equity.

While the sample sizes in each individual country are probably too small to make generalizations to the entire national consumer populations, we believe that the sample size of our pooled dataset (4,231 observations) is large enough to capture regional heterogeneity, which was the main purpose of this article. Therefore, further research needs to be conducted to project demand for fragrant rice in the different countries to assess where demand growth is expected to be greatest. Moreover, although our dataset is from 2013–2014, we believe the preferences and drivers we identified are still relevant today. The demand shift for fragrant rice (Figure 1) is mainly caused by trade, globalization, urbanization, and income growth. From the supply side, we only observe dramatic increases in export of fragrant rice by Cambodia and India (Table I), which are mostly targeted to markets outside the regions studied in our article. Therefore, we expect that the drivers for the consumer preferences for fragrant rice identified in our study have not qualitatively changed and will remain relevant, but that the preference shares for aroma in the top three attributes may have slightly increased and will further increase in the next decade. This suggests that regional breeding programs can confidently include rice fragrance as a "must" trait into the germplasm targeted to national breeding programs, which on their turn can further tailor rice varieties to specific local market segments. These findings are important for international breeding networks and platforms such as the International Network for the Genetic Evaluation of Rice (INGER, http://inger.irri.org) and the CGIAR's Excellence in Breeding Platform (EiB, https://excellenceinbreeding.org). A final limitation of our Lancasterian interpretation of rice as a bundle of characteristics is that it assumes separability of traits, while in reality rice attributes overlap to some extent and are somewhat correlated. For example, Jasmine rice is typically characterized by its soft texture, slender grains, and aroma. Both aroma and texture (softness and slenderness) are part of consumers' overall taste experience, and hence, these attributes need to be interpreted jointly rather than individually. Therefore, we recommend these market studies to be further improved in terms of survey questionnaire design to capture "jointness" (nonseparability) of traits and to be repeated every 5–10 years—depending on resource availability—to enable rice breeding programs to incorporate market trends in their priority setting and variety development programs.

Notes

1. The likely growth in urbanization in African countries may further increase demand for aromatic rice. African consumers have already developed strong preferences for the superior quality attributes of imported rice in terms of grain quality, taste, and aroma, compared to local rice varieties (Demont and Ndour, 2015; Demont *et al.*, 2017; Diagne *et al.*, 2017).
2. It has significantly declined in many developed Asian countries (Japan, South Korea, and Taiwan) and has now started to decline in many other Asian countries (India and China) (Suwannaporn *et al.*, 2008).
3. Product attributes can be intrinsic (taste, texture, aroma, appearance, nutritional benefits, and cooking characteristics in the case of rice) or extrinsic (price, packaging, and branding) (Lancaster, 1966).
4. For all continuous variables in the regression analysis, we considered any value outside the range of five times the standard deviation above and under the median as outliers.
5. Some surveyed consumers only ranked their first and second choices, so the unranked third one is set to zero.

6. Since we have 10 locations, subdividing Bangladesh into two groups (urban and rural) and India into three regions (east, west, and rural), nine location dummies were included.

7. This does not mean that nonparboiled "raw" fragrant rice is not an important market in these regions. Fine-textured (long and slender) fragrant rice is usually consumed during special occasions and religious rituals. In the surveyed regions, parboiled rice is, however, the broadly consumed rice type for daily meals.

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Table A1.
Parameters estimated from ROL models, Bangladesh

Dependent variable = rank of the choices	Taste	Texture	Aroma	Appearance	Nutritional benefits	Cooking characteristics
Age	0.0097 (0.03)	0.068** (0.03)	−0.079* (0.05)	0.024 (0.02)	−0.053 (0.05)	−0.047 (0.04)
Age squared	−0.00013 (0.00)	−0.00094** (0.00)	0.0011* (0.00)	−0.00031 (0.00)	0.00073 (0.00)	0.00068 (0.00)
Gender (male = 1)	−0.23 (0.28)	0.41 (0.31)	−0.20 (0.46)	0.20 (0.21)	0.66 (0.41)	−1.21* (0.67)
Secondary education (yes = 1)	−0.12 (0.12)	0.0053 (0.12)	0.055 (0.19)	0.046 (0.08)	−0.11 (0.21)	0.35* (0.19)
Higher education (yes = 1)	−0.49** (0.22)	−0.081 (0.24)	0.53* (0.31)	0.14 (0.15)	0.34 (0.35)	0.54* (0.31)
Household size	0.0094 (0.03)	0.038 (0.04)	0.14*** (0.05)	−0.029 (0.03)	0.22*** (0.06)	−0.11** (0.06)
Employed (yes = 1)	0.13 (0.20)	−0.39 (0.27)	−0.033 (0.32)	0.22 (0.15)	−0.49 (0.40)	0.21 (0.29)
Access to internet (yes = 1)	−0.18 (0.20)	−0.23 (0.28)	−0.12 (0.30)	0.087 (0.15)	−0.17 (0.38)	0.44 (0.28)
Log of per capita rice consumption	−0.19 (0.16)	0.34* (0.18)	0.12 (0.27)	0.027 (0.12)	1.46*** (0.30)	−0.40 (0.26)
Log of per capita income	0.22** (0.09)	0.026 (0.11)	−0.15 (0.15)	−0.027 (0.07)	0.092 (0.17)	−0.088 (0.15)
Log of rice price	−0.18 (0.43)	−1.15*** (0.44)	0.00074 (0.70)	−0.10 (0.30)	−1.73** (0.74)	−0.10 (0.66)
Rice share (%)	0.00016 (0.01)	0.0028 (0.01)	−0.021** (0.01)	0.00042 (0.00)	−0.021** (0.01)	0.0061 (0.01)
Women are the principal grocery decision maker (yes = 1)	−0.025 (0.11)	−0.10 (0.11)	−0.43*** (0.16)	0.014 (0.07)	−0.13 (0.19)	0.44*** (0.16)
Frequent rice buyer (yes = 1)	0.19 (0.15)	−0.058 (0.17)	0.52** (0.23)	0.083 (0.12)	−0.34 (0.32)	0.14 (0.24)
Urban Bangladesh	0.62*** (0.12)	−0.16 (0.14)	0.39** (0.20)	0.045 (0.09)	0.35 (0.23)	−0.31 (0.19)
Log likelihood	−2994.2	−2517.2	−1157.1	−5581.3	−856.3	−1289.6
LR ($\chi 2$)	69.3***	41.5***	41.3***	10.7	55.4***	30.3**
Observations	906	906	906	906	906	906

Note(s): Figures between parentheses, are standard errors; *, **, and *** indicate 1%, 5%, and 10% level of significance, respectively. Base case for education is the primary and below levels of education

Table AII. Parameters estimated from ROL models, India

Dependent variable = rank of the choices	Taste	Texture	Aroma	Appearance	Nutritional benefits	Cooking characteristics
Age	0.025 (0.03)	−0.052 (0.03)	−0.053 (0.03)	0.015 (0.02)	0.091** (0.05)	−0.036 (0.05)
Age squared	−0.00023 (0.00)	0.00063* (0.00)	0.00054 (0.00)	−0.00015 (0.00)	−0.0012** (0.00)	0.00044 (0.00)
Gender (male = 1)	0.21 (0.13)	0.39** (0.20)	−0.23 (0.18)	−0.077 (0.10)	0.31 (0.22)	0.65*** (0.24)
Secondary education (yes = 1)	−0.12 (0.09)	−0.25** (0.11)	0.44*** (0.13)	−0.031 (0.07)	0.14 (0.14)	−0.18 (0.15)
Higher education (yes = 1)	−0.014 (0.14)	−0.14 (0.18)	0.19 (0.19)	−0.14 (0.11)	0.25 (0.26)	0.052 (0.26)
Household size	0.077** (0.03)	−0.041 (0.05)	−0.10** (0.05)	0.019 (0.03)	0.17*** (0.06)	−0.071 (0.07)
Employed (yes = 1)	−0.051 (0.12)	−0.42** (0.18)	−0.12 (0.17)	0.11 (0.09)	0.28 (0.20)	−0.47** (0.23)
Access to internet (yes = 1)	0.16 (0.17)	−0.40 (0.27)	0.26 (0.22)	−0.076 (0.13)	−0.30 (0.34)	−0.093 (0.34)
Log of per capita rice consumption	−0.023 (0.10)	−0.24* (0.13)	−0.11 (0.14)	−0.094 (0.08)	0.64*** (0.18)	0.56*** (0.20)
Log of per capita income	0.27*** (0.09)	0.27** (0.11)	−0.16 (0.12)	0.13** (0.07)	0.11 (0.16)	−0.58*** (0.18)
Log of rice price	0.040 (0.20)	0.0071 (0.24)	−0.87*** (0.28)	0.20 (0.16)	0.82** (0.39)	2.16*** (0.42)
Rice share (%)	0.014*** (0.00)	−0.0046 (0.00)	−0.019*** (0.01)	−0.0011 (0.00)	−0.014** (0.01)	−0.025*** (0.01)
Women are the principal grocery decision maker (yes = 1)	−0.33*** (0.09)	0.17 (0.12)	0.61*** (0.12)	−0.18*** (0.06)	−0.43*** (0.14)	0.23 (0.16)
Frequent rice buyer (yes = 1)	0.27*** (0.09)	0.34*** (0.13)	−0.79*** (0.17)	0.068 (0.07)	0.64*** (0.14)	−0.047 (0.17)
East India[a]	−0.25** (0.12)	0.15 (0.17)	0.45*** (0.14)	−0.31*** (0.09)	−1.04*** (0.21)	−0.68*** (0.21)
South India[a]	0.16 (0.15)	0.90*** (0.19)	−0.32 (0.20)	−0.16 (0.11)	−0.28 (0.27)	−1.09*** (0.29)
Log likelihood	−5437.8	−3249.1	−3171.2	−9810.3	−1989.3	−1682.5
LR ($\chi 2$)	96.4***	123.3***	218.4***	29.8	129.4***	68.1***
Observations	1438	1438	1438	1438	1438	1438

Note(s): Figures between parentheses, are standard errors; *, **, and *** indicate 1%, 5%, and 10% level of significance, respectively. [a] Base case is rural India. Base case for education is the primary and below levels of education

Table AIII.
Parameters estimated from ROL models, Indonesia

Dependent variable = rank of the choices	Taste	Texture	Aroma	Appearance	Nutritional benefits	Cooking characteristics
Age	−0.13 (0.09)	0.012 (0.05)	0.026 (0.07)	0.027 (0.04)	0.048 (0.09)	−0.021 (0.11)
Age squared	0.0012 (0.00)	−0.000059 (0.00)	−0.00042 (0.00)	−0.00023 (0.00)	−0.00056 (0.00)	0.00051 (0.00)
Gender (male = 1)	−0.48 (0.72)	0.42 (0.32)	0.36 (0.44)	−0.10 (0.32)	0.26 (0.59)	−46.4 (.)[a]
Secondary education (yes = 1)	−0.72** (0.34)	0.17 (0.19)	0.53* (0.32)	−0.11 (0.16)	0.28 (0.36)	−0.85** (0.38)
Higher education (yes = 1)	−0.82 (0.61)	0.22 (0.30)	0.24 (0.44)	−0.0028 (0.29)	−0.14 (0.61)	−1.41 (0.96)
Household size	0.057 (0.10)	−0.097* (0.05)	0.13** (0.07)	0.011 (0.04)	−0.21** (0.10)	−0.21* (0.12)
Employed (yes = 1)	0.083 (0.28)	−0.36** (0.16)	0.18 (0.20)	0.033 (0.14)	0.40 (0.25)	0.34 (0.38)
Access to internet (yes = 1)	−0.11 (0.33)	0.083 (0.17)	0.36 (0.22)	−0.044 (0.17)	0.026 (0.31)	0.37 (0.50)
Log of per capita rice consumption	0.46 (0.40)	−0.012 (0.20)	0.040 (0.26)	−0.097 (0.17)	−0.93*** (0.30)	−0.71 (0.45)
Log of per capita income	0.12 (0.37)	−0.27 (0.18)	0.20 (0.26)	0.12 (0.16)	0.57* (0.32)	−1.15*** (0.42)
Log of rice price	−0.82** (0.38)	0.083 (0.27)	0.43 (0.48)	−0.45 (0.34)	−0.14 (0.50)	−0.42 (0.68)
Rice share (%)	−0.018 (0.01)	0.0042 (0.01)	−0.017** (0.01)	−0.0064 (0.01)	0.019** (0.01)	0.0062 (0.01)
Women are the principal grocery decision maker (yes = 1)	0.070 (0.40)	−0.086 (0.20)	0.25 (0.31)	−0.019 (0.19)	0.30 (0.41)	−1.27*** (0.38)
Frequent rice buyer (yes = 1)	−0.44* (0.26)	−0.083 (0.12)	0.25 (0.17)	0.014 (0.12)	0.32 (0.22)	0.065 (0.30)
Log likelihood	−507.6	−1886.2	−969.0	−2177.2	−601.6	−290.9
LR ($\chi 2$)	24.2**	13.4	27.4**	8.91	25.5**	38.6***
Observations	427	427	427	427	427	427

Note(s): Figures between parentheses, are standard errors; *, **, and *** indicate 1%, 5%, and 10% level of significance, respectively. Base case for education is the primary and below levels of education. [a] Standard error cannot be calculated due to perfect predictability

Table AIV. Parameters estimated from ROL models, Cambodia

Dependent variable = rank of the choices	Taste	Texture	Aroma	Appearance	Nutritional benefits	Cooking characteristics
Age	0.12** (0.06)	0.023 (0.05)	−0.0084 (0.05)	−0.039 (0.07)	−0.032 (0.11)	−0.11 (0.09)
Age squared	−0.0014** (0.00)	−0.00042 (0.00)	0.000087 (0.00)	0.00052 (0.00)	0.00038 (0.00)	0.0012 (0.00)
Gender (male = 1)	−0.48 (0.79)	−0.34 (0.80)	0.30 (0.69)	0.27 (1.03)	−41.6 (.)[a]	0.023 (1.57)
Secondary education (yes = 1)	0.29 (0.19)	−0.065 (0.16)	−0.16 (0.18)	−0.20 (0.24)	0.32 (0.40)	0.079 (0.34)
Higher education (yes = 1)	0.27 (0.38)	−0.24 (0.35)	0.22 (0.39)	−0.29 (0.58)	−0.084 (0.97)	−0.78 (0.78)
Household size	−0.061 (0.05)	−0.096** (0.05)	0.034 (0.05)	0.062 (0.06)	−0.13 (0.10)	−0.035 (0.10)
Employed (yes = 1)	−0.019 (0.18)	0.19 (0.15)	−0.32** (0.16)	0.36* (0.22)	−0.52 (0.41)	0.24 (0.31)
Access to internet (yes = 1)	−0.022 (0.28)	−0.17 (0.28)	−0.021 (0.30)	−0.22 (0.44)	1.34** (0.67)	0.66 (0.55)
Log of per capita rice consumption	−0.53** (0.23)	−0.14 (0.22)	0.12 (0.23)	−0.29 (0.33)	1.23** (0.57)	0.27 (0.47)
Log of per capita income	0.33* (0.19)	0.0094 (0.17)	0.13 (0.17)	0.17 (0.24)	−1.82*** (0.40)	−0.26 (0.35)
Log of rice price	0.71 (0.52)	0.56 (0.46)	1.32** (0.53)	−1.46** (0.62)	−3.01*** (1.00)	−3.35*** (0.87)
Rice share (%)	0.015 (0.01)	−0.0011 (0.01)	0.00088 (0.01)	0.018 (0.01)	−0.041* (0.02)	−0.015 (0.02)
Women are the principal grocery decision maker (yes = 1)	−0.26 (0.27)	−0.59** (0.25)	−0.32 (0.27)	0.23 (0.45)	37.5 (.)[a]	1.64 (1.03)
Frequent rice buyer (yes = 1)	0.51** (0.22)	−0.067 (0.22)	0.14 (0.23)	−0.32 (0.33)	−0.40 (0.46)	−0.41 (0.45)
Log likelihood	−927.7	−1129.5	−963.1	−532.5	−201.1	−274.1
LR ($\chi 2$)	25.5**	17.9	17.7	17.9	55.9***	26.9***
Observations	289	289	289	289	289	289

Note(s): Figures between parentheses, are standard errors; *, **, and *** indicate 1%, 5%, and 10% level of significance, respectively. Base case for education is the primary and below levels of education. [a]Standard error cannot be calculated due to perfect predictability

Table AV.
Parameters estimated from ROL models, Philippines

Dependent variable = rank of the choices	Taste	Texture	Aroma	Appearance	Nutritional benefits	Cooking characteristics
Age	0.084 (0.10)	0.026 (0.03)	0.046 (0.04)	−0.070** (0.04)	−0.33** (0.15)	0.015 (0.06)
Age squared	−0.0013 (0.00)	−0.00024 (0.00)	−0.00067 (0.00)	0.00090** (0.00)	0.0044** (0.00)	−0.00035 (0.00)
Gender (male = 1)	−0.13 (0.47)	−0.085 (0.20)	0.57*** (0.19)	0.048 (0.19)	−36.2 (3.72E+07)[a]	−0.33 (0.30)
Secondary education (yes = 1)	−1.39*** (0.39)	0.096 (0.20)	0.18 (0.21)	0.47** (0.23)	−0.19 (0.96)	−0.18 (0.30)
Higher education (yes = 1)	−1.52*** (0.59)	0.040 (0.25)	0.35 (0.26)	0.41 (0.28)	−1.07 (1.27)	−0.21 (0.40)
Household size	0.16* (0.08)	−0.044 (0.04)	0.018 (0.04)	−0.032 (0.04)	0.052 (0.16)	0.047 (0.06)
Employed (yes = 1)	−0.094 (0.38)	−0.053 (0.15)	−0.26* (0.15)	−0.0084 (0.15)	−1.34 (1.08)	0.42* (0.22)
Access to internet (yes = 1)	0.058 (0.42)	−0.042 (0.15)	−0.16 (0.15)	0.033 (0.16)	1.13 (0.70)	0.18 (0.25)
Log of per capita rice consumption	−0.46 (0.30)	−0.11 (0.14)	0.12 (0.15)	0.22 (0.15)	−0.94 (0.64)	−0.12 (0.22)
Log of per capita income	0.96*** (0.28)	−0.15 (0.12)	0.00030 (0.12)	−0.19 (0.13)	0.52 (0.59)	0.21 (0.19)
Log of rice price	−1.98 (1.42)	−0.042 (0.64)	−0.042 (0.63)	1.15* (0.68)	1.03 (3.37)	−3.52*** (0.83)
Rice share (%)	0.038*** (0.01)	−0.00058 (0.01)	−0.0049 (0.01)	−0.0095* (0.01)	0.023 (0.03)	0.011 (0.01)
Women are the principal grocery decision maker (yes = 1)	0.88 (1.14)	−0.34 (0.24)	0.51* (0.28)	−0.067 (0.27)	−2.10*** (0.80)	0.94 (0.67)
Frequent rice buyer (yes = 1)	0.41 (0.38)	−0.087 (0.13)	0.24* (0.14)	0.099 (0.14)	−0.38 (0.65)	0.0086 (0.21)
Log likelihood	−262.0	−1767.1	−1608.6	−1547.1	−71.8	−694.2
LR ($\chi 2$)	33.2***	9.22	20.8*	20.8*	25.3**	35.3***
Observations	403	403	403	403	403	403

Note(s): Figures between parentheses, are standard errors; *, **, and *** indicate 1%, 5%, and 10% level of significance, respectively. Base case for education is the primary and below levels of education. [a] The large standard error is caused by almost perfect predictability

Table AVI. Parameters estimated from ROL models, Thailand

Dependent variable = rank of the choices	Texture	Aroma	Appearance	Nutritional benefits	Cooking characteristics
Age	0.011 (0.03)	−0.0030 (0.04)	−0.012 (0.03)	0.24 (0.21)	−0.091* (0.05)
Age squared	−0.00022 (0.00)	−0.000023 (0.00)	0.00016 (0.00)	−0.0027 (0.00)	0.0012** (0.00)
Gender (male = 1)	0.15 (0.18)	−0.69** (0.31)	0.074 (0.19)	−36.6 (5.24e+07)[a]	0.011 (0.28)
Secondary education (yes = 1)	−0.15 (0.15)	−0.083 (0.21)	0.094 (0.15)	1.73 (1.12)	0.11 (0.25)
Higher education (yes = 1)	−0.0026 (0.19)	−0.16 (0.28)	0.057 (0.21)	2.26* (1.28)	0.026 (0.32)
Household size	0.014 (0.04)	0.052 (0.06)	−0.059 (0.04)	0.25 (0.18)	0.082 (0.06)
Employed (yes = 1)	0.020 (0.11)	0.18 (0.16)	−0.22* (0.11)	0.033 (0.59)	0.070 (0.18)
Access to internet (yes = 1)	0.067 (0.14)	−0.100 (0.21)	−0.13 (0.16)	0.28 (0.70)	0.36 (0.23)
Log of per capita rice consumption	−0.034 (0.10)	0.11 (0.14)	−0.013 (0.10)	−0.23 (0.55)	−0.26* (0.15)
Log of per capita income	0.062 (0.09)	0.24* (0.13)	−0.078 (0.10)	−0.24 (0.52)	0.31** (0.15)
Log of rice price	−0.54* (0.28)	0.78* (0.41)	−0.25 (0.28)	−0.94 (1.08)	−0.082 (0.46)
Rice share (%)	0.0047 (0.01)	−0.037*** (0.01)	−0.0073 (0.01)	0.0010 (0.03)	0.012 (0.01)
Women are the principal grocery decision maker (yes = 1)	0.14 (0.18)	−0.066 (0.26)	−0.018 (0.19)	−0.64 (0.81)	0.84** (0.34)
Frequent rice buyer (yes = 1)	0.21* (0.12)	0.029 (0.17)	−0.26** (0.13)	−0.42 (0.73)	0.66*** (0.19)
Log likelihood	−2511.6	−1287.9	−2287.2	−94.7	−1033.8
LR ($\chi 2$)	9.88	42.9***	15.5	21.5*	33.0***
Observations	480	480	480	480	480

Note(s): Figures between parentheses, are standard errors; *, **, and *** indicate 1%, 5%, and 10% level of significance, respectively. Base case for education is the primary and below levels of education. Since only 0.2% of all observations include the taste category, we excluded it from the estimation. [a] The large standard error is caused by almost perfect predictability

Table AVII.
Parameters estimated from ROL models, Vietnam

Dependent variable = rank of the choices	Taste	Texture	Aroma	Appearance	Nutritional benefits	Cooking characteristics
Age	0.10 (0.09)	−0.031 (0.04)	−0.028 (0.06)	−0.057 (0.06)	−0.035 (0.07)	0.23 (0.17)
Age squared	−0.0010 (0.00)	0.00040 (0.00)	0.00047 (0.00)	0.00062 (0.00)	0.00035 (0.00)	−0.0040* (0.00)
Gender (male = 1)	−45.3 (.)[a]	−0.68 (0.46)	−0.30 (0.73)	0.067 (0.59)	−0.49 (0.91)	2.20*** (0.80)
Secondary education (yes = 1)	−0.058 (0.49)	0.18 (0.29)	0.53 (0.42)	−0.21 (0.35)	−0.61* (0.35)	−0.28 (0.92)
Higher education (yes = 1)	−0.37 (0.69)	0.21 (0.36)	0.42 (0.51)	−0.30 (0.47)	−0.35 (0.52)	−0.66 (1.17)
Household size	−0.36*** (0.13)	−0.0097 (0.05)	0.14** (0.06)	0.13** (0.06)	−0.068 (0.09)	−0.29 (0.22)
Employed (yes = 1)	0.048 (0.29)	0.22 (0.16)	0.20 (0.20)	0.089 (0.21)	−0.21 (0.26)	−0.93* (0.55)
Access to internet (yes = 1)	0.35 (0.36)	0.24 (0.19)	−0.070 (0.24)	−0.35 (0.26)	−0.38 (0.33)	−0.38 (0.54)
Log of per capita rice consumption	−0.43 (0.44)	−0.024 (0.23)	-0.52* (0.30)	−0.21 (0.31)	0.72* (0.37)	0.34 (0.79)
Log of per capita income	0.031 (0.36)	−0.074 (0.19)	−0.11 (0.25)	0.16 (0.25)	−0.068 (0.30)	0.064 (0.55)
Log of rice price	−0.99 (0.85)	0.099 (0.40)	0.42 (0.54)	0.021 (0.58)	0.66 (0.67)	1.27 (1.38)
Rice share (%)	0.035 (0.02)	0.0026 (0.01)	−0.021 (0.02)	−0.027 (0.02)	0.0051 (0.02)	0.043 (0.04)
Women are the principal grocery decision maker (yes = 1)	0.13 (0.66)	−0.21 (0.28)	0.58 (0.47)	−0.21 (0.38)	0.20 (0.52)	0.96 (1.04)
Frequent rice buyer (yes = 1)	0.0021 (0.48)	0.20 (0.24)	−0.050 (0.34)	−0.26 (0.35)	−1.45** (0.71)	−0.21 (0.89)
Log likelihood	−357.2	−1344.7	−804.3	−764.1	−526.2	−130.2
LR ($\chi 2$)	17.1	11.7	28.2**	11.7	23.3**	26.4**
Observations	288	288	288	288	288	288

Note(s): Figures between parentheses, are standard errors; *, **, and *** indicate 1%, 5%, and 10% level of significance, respectively. Base case for education is the primary and below levels of education. Standard error of gender coefficient of demand for taste show (.), which implies that not many female indicated taste as their preferred option. [a]Standard error cannot be calculated due to perfect predictability