

What is the value of rice fragrance? Consumer evidence from Senegal

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Abstract

Urban demand for fragrant rice is increasing rapidly in Senegal, but little is known about the value of rice fragrance and the drivers of its demand. We conducted experimental auctions in Dakar to elicit urban consumers' willingness to upgrade from non-fragrant to fragrant rice and their willingness to pay for domestic versus imported fragrant rice, and assessed the drivers of demand for rice fragrance through a double-hurdle model. The average value of rice fragrance is estimated to be around US\$ 0.12 kg⁻¹, as suggested by the 20% price premiums consumers are willing to pay on top of the price of non-fragrant rice. These price premiums further increase to 35% for consumers who express positive buying intentions towards domestic fragrant rice. The value of rice fragrance is found to be driven by factors such as ethnicity, household size, and awareness of fragrance and local fragrant rice.

Key words: aromatic rice; competitiveness; framed field experiment; value chain; Africa

1. Introduction

In West Africa, rice consumption has increased dramatically in recent years. Average annual growth rates of rice consumption were 4.94% and 7.50% during the periods 2000 to 2008 and 2008 to 2015 respectively. The three biggest rice importers in the region witnessed the highest growth in consumption during these periods: Nigeria recorded 4.83% and 5.99%; Cote d'Ivoire 3.12% and 10.91%; and Senegal 5.16% and 7.16% (USDA 2016). The main drivers of this increase are population growth with increasing urbanisation, an increase in income, and changing consumer habits. Preferences for rice may vary between countries, and even within countries between rural and urban areas. While local rice is popular in some countries (e.g. Mali), urban consumers in other countries (e.g. Senegal) have developed strong preferences for imported fragrant rice (Demont & Ndour 2015).

In the last 50 years, traditional staple grains such as millet and sorghum have been surpassed by rice as the most imported cereal in the Senegalese diet (World Bank 2013). Urban dwellers consume more rice (around 95 kg per capita) than rural dwellers (around 65 kg per capita) and have markedly different preferences for rice (World Bank 2013; Niang *et al.* 2014). Urban consumers tend to prefer imported broken rice, whereas rural consumers demand whole-grain local rice (World Bank 2013).

Rice grain quality can be defined in terms of physical, cooking and sensory characteristics; consumers value the quality of rice based on the appearance, shape and size of the grain, the behaviour upon cooking, and the taste, tenderness and flavour (Singh *et al.* 2000; Fitzgerald 2010). Aromatic rice, also known as fragrant, perfumed, scented, flavoured or pecan varieties, has been cultivated for centuries in South and South-East Asia and is highly prized (Itani *et al.* 2004). Aromatic rice is characterised by the presence of a popcorn or baked bread-like flavour compound called 2-acetyl-1-pyrroline (2AP), and the aroma could also be determined by smelling and tasting cooked grains (Calingacion *et al.* 2014). Renowned fragrant rice varieties like Basmati and Jasmine are very popular in Africa, Europe, Australia and the USA, allowing them to command substantial price premiums over their non-fragrant counterparts (Bhattacharjee *et al.* 2002). African rice-breeding programmes therefore increasingly turn their attention towards breeding for fragrance (Asante *et al.* 2010).

On the international market, three main rice varieties are traded, viz. Indica, Japonica and fragrant rice. Indica rice varieties thrive well in tropical climates, and also in temperate climatic conditions, and represent the lion's share of world rice production. In temperate and tropical-upland climatic zones, the main rice type cultivated and consumed is Japonica rice. Fragrant rice belongs to the Indica long-grain rice family and is often considered separately because of its distinctive aroma (FAO 2006). According to Slayton (2015), fragrant rice typically accounts for 15% of total world trade; it exceeded 5.7 million tons in 2010. The three leading exporters of aromatic rice are Thailand, Pakistan and India. High-quality fragrant rice is exported to rich countries, whereas fragrant broken grain is often exported to Africa, mainly to the Ivory Coast, Senegal and Ghana. Thai Jasmine broken rice averaged almost 725 000 tons from 2008 to 2010, with about 85% of the shipments destined for Africa, while the balance is almost evenly split between Asian and European markets. Senegal and Côte d'Ivoire are the leading import markets for Thai Jasmine broken, with each taking almost 225 000 tons in 2010. The actual trend of consumer preferences in these two countries is increasingly oriented toward the consumption of inexpensive, mostly Jasmine broken rice from Thailand, which is suitable for a rice dish paired with fish called *Céebu jën* that originated in Senegal (Coulibaly *et al.* 2015). Aromatic Thai rice represents about 25% of Senegalese rice imports (World Bank 2013). In 2009, AfricaRice and its National Agricultural Research and Extension Services (NARES) partners released three fragrant rice varieties, viz. Sahel 177, Sahel 328 and Sahel 329. Sahel 177 has the highest yield potential, Sahel 328 has the shortest growth duration and Sahel 329 is appreciated the most for its taste (Kumashiro *et al.* 2013). In 2013, the total production of fragrant rice in Senegal was estimated at 40 000 tons (USDA 2013), representing around 15% of the total fragrant rice imports of the country. Although aromatic rice varieties are of great interest to farmers, as they command a higher price than non-aromatic rice, very little is known about the value of rice fragrance and the determinants of the demand for fragrant rice in Africa. Filling this knowledge gap would provide crucial information to rice breeders, policy makers and value chain stakeholders in their struggle to upgrade rice value chains in order to enhance the competitiveness of domestic versus imported rice (Demont 2013; Demont & Ndour 2015).

Experimental auctions are commonly used to assess consumers' valuation of the quality attributes of food products (Lusk & Shogren 2007). Attributes are product characteristics that are either *intrinsic*, like taste, texture and colour, or *extrinsic*, like packaging, brand and label (Rutsaert *et al.* 2013). In an experimental auction, people bid to buy real products using real money in a setting employing rules that provide incentives for people to truthfully reveal their value for each product up for sale. The bids obtained in experimental auctions are interpreted as the maximum amount consumers are willing to pay for the new good. Since 2008, experimental auctions have been conducted by AfricaRice in Senegal (Saint-Louis, Dakar and Kolda), Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Mauritania, Niger, Nigeria, Tanzania, the Gambia, and Uganda in order to elicit consumers' willingness to pay (WTP) for rice quality and marketing attributes (Demont & Ndour 2015; Demont *et al.* 2017). The current study was conducted in Dakar and aimed to analyse whether the three

fragrant rice varieties recently introduced in the Senegal River Valley are competitive against imported fragrant rice. The Dakar region is a huge, urban consumption pole; although it only covers 0.3% of the national area, it is home to nearly 23% of the total population and 75% of the urban population (ANSD & ICF International 2012). Hence, understanding the drivers of urban demand for rice fragrance in Dakar is of crucial importance for rice value chain upgrading and enabling poor farmers to tap into these market opportunities to improve their livelihood.

The remainder of the paper is organised as follows: Section 2 outlines the methodology, Section 3 describes the data and results, and Section 4 concludes.

2. Methodology

2.1 Experimental design

We conducted a series of framed field experiments based on experimental auctions in the major urban consumption zones of fragrant rice, remote from the rice production zones. We used a similar procedure as described in Akoa Etoa *et al.* (2016) and Demont *et al.* (2012; 2013a; 2013b) and reviewed by Demont and Ndour (2015). The experiments were conducted during four days in July 2011, during which eight experimental auction sessions were conducted, with one in the morning and one in the afternoon. Female rice shoppers were targeted, as women are the major decision makers in households' rice purchases (Demont & Ndour 2015). The experimental auctions were carried out in the *Salle Docteur Samba Gueye* at the Tilène market of Dakar. All types of consumers visit it and all types of rice can be found there. Dakar is the largest area for fragrant rice consumption in the country. For each session, 15 women were randomly selected and recruited on the spot. The auctions were based on the “endow-and-upgrade” method, in which each participant is endowed with a fixed “benchmark” rice and is presented four times with the option to upgrade it to an alternative rice type.

We purposely selected the benchmark and four alternative “upgrades” so that we could benchmark local fragrant rice against non-fragrant and fragrant imported rice, which provides crucial information for value chain upgrading. Since the dominant grain quality demanded by urban consumers in Senegal is broken rice (World Bank 2013), all rice types were 100% broken. The benchmark was imported, non-fragrant “Baobab” rice from Thailand, while the four upgrades were (i) imported fragrant “Thai Hom Mali” rice from Thailand; (ii) local fragrant Sahel 177; (iii) local fragrant Sahel 328; and (iv) local fragrant Sahel 329. In order to avoid lining-up bias (Demont *et al.* 2012), we avoided any linear presentation of the rice types on the participants' tables and instead presented the benchmark rice in the middle and surrounded it by the four alternative upgrades in a quadrangular way. We asked the auctioneers to collect WTP values in random order, avoiding any perception of a linear relationship or ranking among the alternative rice types.

We endowed women with one kilogram of the benchmark and asked them what price premium they were willing to pay to upgrade to any of “four alternative fragrant rice types”. We did not reveal the variety or origin of the products, but only mentioned that the benchmark rice was non-fragrant and the alternative rice types were fragrant. The auction procedure was explained in *Wolof*, with translations to *Pulaar* and French where necessary.

During the experiment, the participants could examine the visual (purity and homogeneity) and sensory (taste and aroma) quality attributes of the uncooked rice types (taste is typically tested by biting on the uncooked grains). We chose the Vickrey (1961) second-price auction mechanism, according to which participants submit sealed bids on a product in a group context and the highest bidder buys the product at the second price. In combination with the endow-and-upgrade method, this implies that the bids represent the price premiums bidders are willing to pay in order to upgrade the

benchmark rice to an alternative rice type. The winner exchanges her benchmark for the upgrade and all losing bidders retain their benchmark. This auction mechanism has proven to be successful for assessing consumers' willingness to pay for rice quality attributes in the African context (Demont & Ndour 2015).

We conducted two bidding rounds, separated by a "within-subjects" sensory test to capture the effect of post-cooking quality attributes on WTP. During the sensory test we provided the participants with cooked samples of the five rice types and requested them to taste the rice types and rinse their mouths to cleanse their palates between samples. This provided the participants with an opportunity to observe the swelling capacity and experience the sensory quality attributes (aroma, taste, texture and stickiness) of the cooked rice types. At the end of the two bidding rounds, we randomly selected one upgrade and one round as binding. Finally, we administered a questionnaire to collect socio-demographic data.

2.2 Methodology for analysing the drivers of demand for rice fragrance

Food consumption decisions can be modelled as a two-stage process (Haines *et al.* 1988; Wooldridge 2001). The double-hurdle model of Cragg (1971) correctly represents this process. Participants first decide whether they are willing to upgrade their endowed kilogram of rice or not and, if yes, they then decide which price premium they are willing to pay for the upgrade.

In this regard, let WTU_{ijpr} be the variable representing the willingness to upgrade an endowed kilogram of rice as a dichotomous 'adoption' variable (willing to upgrade or not), and let WTP_{ijpr} be the amount spent on the upgrade by the i th consumer ($i = 1, \dots, 15$) in the j th session ($j = 1, \dots, 8$) for the p th rice type ($p =$ imported Thai Hom Mali fragrant rice; local fragrant Sahel 177; local fragrant Sahel 328; local fragrant Sahel 329) in the r th bidding round ($r = 0$ before tasting, $r = 1$ after tasting):

$$WTU_{ijpr} = \alpha' x_{ijpr} + u_{ij} + v_{ijpr},$$

$$WTP_{ijpr} = \alpha' x_{ijpr} + u_{ij} + v_{ijpr},$$

where x_{ijpr} is a vector of independent variables, including three product dummy variables (Sahel 177, Sahel 328 and Sahel 329) identifying the three alternative rice types (Thai Hom Mali fragrant rice is set as the reference), one dummy variable for the bidding round, a dummy variable for the time of the day, and a vector of socio-demographic variables x_v ($v = 1, \dots, s = 32$); α is a conformable vector of coefficients, u_{ij} is an individual specific disturbance for participant i in session j , and v_{ijpr} is the overall error term. Following Cragg (1971), WTP_{ijpr} is the consumers' bid to upgrade the mediocre-quality benchmark rice to any of the three alternatives. The first hurdle is the consumer's decision on whether or not to upgrade (willingness to upgrade or WTU). The probability of the respondent choosing not to bid a positive amount in order to upgrade ($WTP_{ijpr} = 0$) is expressed by:

$$P(WTP_{ijpr} = 0) = \Phi(-\alpha_1' x_{ijpr}),$$

where Φ is the standard normal density function. The second hurdle determines the effect of independent variables on WTP_{ijpr} , given $WTU_{ijpr} = 1 > 0$. The distribution of WTP_{ijpr} conditional on being positive is truncated at zero and assumed normal with mean $\alpha_2' x_{ijpr}$ and variance σ^2 . The second hurdle is formulated as:

$$f(WTP_{ijpr} | WTP_{ijpr} > 0) = \frac{(1/\sigma)\Phi[(WTP_{ijpr} - \alpha_2'x_{ijpr})/\sigma]}{\Phi(\alpha_2'x_{ijpr}/\sigma)},$$

where Φ is the standard normal density function and α_2 is a vector of coefficients.

3. Results

3.1 Socio-demographic characteristics of the sample of rice shoppers

Table 1 summarises the key sociodemographic characteristics of the rice shoppers. A total of 120 women participated in the auctions. Although Senegal has more than 20 ethnic groups, over 90% of the population belongs to five dominant ethnic groups: *Wolof* (43%), *Pulaar* (24%), *Sereer* (15%), *Diola* (5%) and *Mandingo* (4%) (ANSD & ICF International 2012). The ethnic composition of our urban sample was remarkably consistent with these national averages, as these ethnic groups represented 83% of the sample, with *Wolof* at 45%, *Pulaar* at 11%, *Sereer* at 18%, *Diola* at 4%, *Bambara* at 5% and *Lebou* at 3%. This suggests that our sample is representative with respect to ethnic representation.

The average age was around 39 years. Eighteen percent of the women had achieved secondary education and 62% were active as traders, 5% as restaurant holders, 15% were housewives and 13% were employed. Forty-three percent of the women were members of a social network. Only 7% of the women had a cooking housemaid, meaning that most of the women were involved in housekeeping and cooking. The average monthly household income was about 188 000 FCFA (US\$ 409.59). The average household size was around 10 persons, which is consistent with the national average of eight to nine (ANSD 2014). The results show that 55% of the participants preferred fragrant rice and, more interestingly, 62% preferred local rice. In our study, only 23% of the sample claimed that they consumed more whole-grain than before, while 53% tended to be loyal to a certain rice type.

Female-headed households represented 17% of the sample and 89% of the women were involved in rice purchasing decisions. This is consistent with similar studies (Demont & Ndour 2015) and justifies our choice of women as target respondents for our study. Almost all the women (94%) claimed to be able to distinguish fragrant rice from non-fragrant rice, and 83% of them were aware of imported fragrant rice, i.e. the competing product analysed in this study.

Households tend to purchase rice mainly on a monthly (46%) or daily (39%) basis. The bi-serial correlation coefficient indicates that there is a small, negative correlation between purchasing rice daily and the income level of the household, and a small, positive correlation between purchasing rice monthly and the level of income. Annual per capita consumption amounts to 103 kg, which is consistent with the World Bank's (2013) estimate of 100 kg and similar to consumption levels observed in Asian rice-producing countries. The sample is therefore representative and relevant to the purpose of our study.

In our study, the 77% preference for broken rice over whole-grain rice (Table 1) confirms that Senegalese as a whole have a strong preference for broken rice, which makes up 95% of the country's imports (USAID 2009). The opportunity for growth of local fragrant rice in urban markets is high, given that 95% intended to buy it whenever available. We found strong evidence for a significant market potential for fragrant rice in Dakar; for example, households with prior preferences for fragrant or even local rice tended to upgrade to fragrant rice, and even those who were loyal to a particular brand or rice type were willing to pay price premiums for fragrant rice.

Two thirds (64%) of the participants were able to correctly identify imported fragrant rice among the four upgrades (Table 1), and those who did tended to pay less for rice fragrance in general, although the effect is not significant. Akoa Etoa *et al.* (2016), in contrast, found that consumers who confused the local upgrade with imported rice tended to pay significantly higher price premiums for it.

Table 1: Definition of variables and socio-demographic profile of rice shoppers in the experimental sample

Variable name	Description	Mean (Std. dev.)
<i>Morning</i>	1 if the morning session; 0 otherwise	0.50 (0.50)
<i>Hungry</i>	1 if the participant is hungry; 0 otherwise	0.46 (0.49)
<i>Wolof</i>	1 if participant's ethnicity is <i>Wolof</i> ; 0 otherwise	0.46 (0.49)
<i>Bambara</i>	1 if participant's ethnicity is <i>Bambara</i> ; 0 otherwise	0.05 (0.21)
<i>Sereer</i>	1 if participant's ethnicity is <i>Sereer</i> ; 0 otherwise	0.20 (0.40)
<i>Pulaar</i>	1 if participant's ethnicity is <i>Pulaar</i> ; 0 otherwise	0.11 (0.31)
<i>Diola</i>	1 if participant's ethnicity is <i>Diola</i> ; 0 otherwise	0.03 (0.17)
<i>Lebou</i>	1 if participant's ethnicity is <i>Lebou</i> ; 0 otherwise	0.03 (0.16)
<i>Age</i>	Age of the participant (years)	39.34 (12.25)
<i>Secondary education</i>	1 if participant has had secondary education; 0 otherwise	0.18 (0.38)
<i>Trader</i>	1 if trader as profession; 0 otherwise	0.62 (0.48)
<i>Restaurant</i>	1 if restaurant holder as profession; 0 otherwise	0.05 (0.21)
<i>Housewife</i>	1 if participant is a housewife; 0 otherwise	0.15 (0.35)
<i>Employed</i>	1 if employed; 0 otherwise	0.13 (0.33)
<i>Social network</i>	1 if member of a social network; 0 otherwise	0.43 (0.49)
<i>Cooking housemaid</i>	1 if household employs a cooking housemaid; 0 otherwise	0.07 (0.24)
<i>Household income^a</i>	Monthly income of the household (1 000 FCFA)	187.55 (97.79)
<i>Household size</i>	Size of the household	10.30 (5.67)
<i>Consumes fragrant</i>	1 if household consumes fragrant rice; 0 otherwise	0.88 (0.33)
<i>Consumes local</i>	1 if household consumes local rice; 0 otherwise	0.71 (0.46)
<i>Prefers fragrant</i>	1 if household prefers fragrant rice; 0 otherwise	0.55 (0.49)
<i>Prefers local</i>	1 if household prefers local rice; 0 otherwise	0.62 (0.48)
<i>Broken</i>	1 if household prefers broken rice over whole-grain rice; 0 otherwise	0.77 (0.42)
<i>Loyalty</i>	1 if household buys the same rice; 0 otherwise	0.53 (0.49)
<i>More whole-grain</i>	1 if household consumes more whole-grain rice than before; 0 otherwise	0.23 (0.42)
<i>Head</i>	1 if the participant is the head of the household; 0 otherwise	0.17 (0.37)
<i>Involved</i>	1 if the participant is involved in rice purchase decision-making; 0 otherwise	0.89 (0.31)
<i>Monthly</i>	1 if the household purchases rice monthly; 0 otherwise	0.46 (0.49)
<i>Daily</i>	1 if the household purchased rice daily; 0 otherwise	0.39 (0.48)
<i>Per capita consumption</i>	Annual per capita consumption of rice (kg capita ⁻¹)	103.70 (40.79)
<i>Purchased</i>	1 if the participant already purchased rice that day; 0 otherwise	0.39 (0.48)
<i>Distinguish</i>	1 if participant is able to distinguish between fragrant and non-fragrant rice; 0 otherwise	0.94 (0.23)
<i>Awareness fragrance</i>	1 if aware of imported fragrant rice; 0 otherwise	0.83 (0.37)
<i>Awareness local fragrant rice</i>	1 if aware of local fragrant rice; 0 otherwise	0.28 (0.44)
<i>Correct</i>	1 if correctly identified imported fragrant rice among the four upgrades; 0 otherwise	0.64 (0.47)
<i>Buying intention</i>	1 if intend to buy local fragrant rice when available; 0 otherwise	0.95 (0.21)
Number of observations		120

Note: ^a Due to 14 missing values, the number of observations is 106 for this variable.

Table 2 reports some descriptive statistics on willingness to upgrade (WTU) and willingness to pay (WTP) for rice fragrance. WTP values can be interpreted as the price premiums consumers are willing to pay on top of the price of the benchmark, which was priced at 260 FCFA (US\$ 0.57) kg⁻¹ in July 2011. Given the mass of non-positive bids and the censored character of our WTP records, we report the mean of the positive bids and the mean of all bids. Based on the mean of all post-sensory bids, the average value of rice fragrance is estimated to be around 52 FCFA (US\$ 0.12) kg⁻¹, which translates into a 20% price premium relative to the price of non-fragrant rice. After being exposed to the visual characteristics of the rice samples, consumers' WTU from non-fragrant rice to fragrant rice is on average 74%, i.e. very consistent with a USAID (2010) stated-preference survey that was conducted a year before and found that 72% of consumers in Dakar preferred fragrant rice. However, after being exposed to the sensory characteristics of the rice samples, market shares (WTU) dropped substantially towards 50%. Many participants claimed that they were surprised by the good taste of the benchmark, a finding also reported by Demont *et al.* (2013a; 2013b). Since 88% of the participants consumed fragrant rice (Table 1), our sensory test may have exposed some consumers to a rice type they had never tried before. Mean positive bids varied from 91 to 117 FCFA (US\$ 0.20 to 0.25) kg⁻¹, with price premiums accruing to Thai Hom Mali. In general, our results show that fragrant rice in the urban market has more value than non-fragrant rice. Even the local fragrant rice, Sahel 329, repeatedly received the same WTP bid after the sensory test (Table 2).

Table 2: Descriptive statistics of willingness to upgrade (WTU) and willingness to pay (WTP) for rice fragrance in Dakar, Senegal

	Rice type	Pre-tasting	Post-tasting
Willingness to upgrade (WTU, %)	Thai Hom Mali	76	52
	Sahel 177	71	50
	Sahel 328	73	50
	Sahel 329	74	49
	Average	74	50
Willingness to pay (WTP), mean of positive bids (FCFA)	Thai Hom Mali	117 (74)	112 (79)
	Sahel 177	94 (77)	91 (68)
	Sahel 328	104 (74)	99 (76)
	Sahel 329	105 (62)	107 (82)
	Average	105 (72)	102 (76)
Willingness to pay (WTP), mean of all bids (FCFA)	Thai Hom Mali	90 (81)	59 (80)
	Sahel 177	67 ((78)	46 (66)
	Sahel 328	76 (78)	49 (73)
	Sahel 329	78 (71)	53 (78)
	Average	78 (77)	52 (75)

3.2 Drivers of demand for rice fragrance

The results of the double hurdle model are presented in Table 3. The first three data columns report the effect of variety, tasting, timing and the socio-demographic characteristics of the consumers on the probability to upgrade (WTU) the benchmark rice to fragrant rice, while the last three columns present the estimates of the determinants of WTP. We defined our variety dummies Sahel 177, Sahel 328 and Sahel 329 such that they would be relative to imported Thai Hom Mali as the reference. This enables double-benchmarking these varieties against non-fragrant and fragrant imported rice. The insignificant coefficients for the three variety dummies in the first hurdle suggest that consumers are indifferent to the origin of the rice in their upgrading decision from non-fragrant to fragrant rice. Consistent with Table 2, after tasting we found a significant drop of 21% in market share for fragrant rice in favour of non-fragrant rice. Although consumers are generally willing to pay price premiums for fragrance relative to the upper market benchmark of imported fragrant rice, they discount local fragrant rice by 13 to 24 FCFA (US\$ 0.03 to 0.05) kg⁻¹, which is a marginal price discount of 4% to 8% relative to the price of 300 FCFA (US\$ 0.65) kg⁻¹ (July 2011) for Thai Hom Mali in Dakar.

Table 3: Drivers of consumers' willingness to upgrade (WTU) and willingness to pay (WTP) for rice fragrance in Dakar, Senegal

Variable	Tier 1 (First hurdle: WTU)			Tier 2 (Second hurdle: WTP)		
	Coefficient	Robust SE	Partial effect	Coefficient	Robust SE	Partial effect
<i>Sahel 177</i>	-0.144	0.095	-0.038	-40.468***	8.637	-24.067***
<i>Sahel 328</i>	-0.132	0.099	-0.035	-23.366***	6.639	-13.896***
<i>Sahel 329</i>	-0.070	0.088	-0.019	-21.673***	8.030	-12.889***
<i>Post-tasting</i>	-0.782***	0.131	-0.208***	-5.738	8.912	-3.412
<i>Morning</i>	-0.096	0.271	-0.025	-13.242	31.973	-7.875
<i>Hungry</i>	-0.072	0.230	-0.019	17.781	20.288	10.574
<i>Wolof</i>	1.041***	0.354	0.277***	58.355*	35.449	34.704*
<i>Bambara</i>	-0.089	0.615	-0.023	-46.122	70.883	-27.429
<i>Sereer</i>	1.092**	0.471**	0.291**	136.641***	46.323	81.261***
<i>Pulaar</i>	0.988**	0.439**	0.263**	92.585**	40.796	55.060**
<i>Diola</i>	1.099*	0.656*	0.293*	129.648***	38.364	77.102***
<i>Lebou</i>	1.527***	0.513***	0.407***	-45.021	38.672	-26.774
<i>Age</i>	-0.014	0.014	-0.003	-1.383	1.076	-0.822
<i>Secondary education</i>	0.694	0.438	0.185	-12.442	36.054	-7.399
<i>Trader</i>	-0.353	0.457	-0.094	100.506	92.813	50.771
<i>Restaurant holder</i>	-1.020*	0.599*	-0.272*	96.377	105.667	57.315
<i>Housewife</i>	-0.157	0.517	-0.041	94.737	91.428	56.340
<i>Employed</i>	0.011	7	0.003	86.841	79.738	51.644
<i>Social network</i>	-0.411	0.260	-0.109	-56.277**	28.035	-33.468**
<i>Cooking housemaid</i>	1.032*	0.583	0.275*	10.335	33.310	6.146
<i>Household income</i>	-0.000	0.002	-0.000	0.032	0.121	0.019
<i>Household size</i>	0.054*	0.028	0.014*	5.286***	1.858	3.143***
<i>Prefers fragrant</i>	1.055***	0.275	0.281***	16.634	26.548	9.892
<i>Prefers local</i>	0.697**	0.311	0.186**	-39.976	29.421	-23.774
<i>Broken</i>	-0.030	0.274	-0.008	-13.763	27.068	-8.185
<i>Loyalty</i>	-0.282	0.239	-0.075	34.707*	20.492	20.640*
<i>More whole-grain</i>	0.188	0.278	0.050	63.659**	29.057	37.858**
<i>Head</i>	-0.207	0.369	-0.055	-70.345**	33.197	-41.834**
<i>Involved</i>	0.492	0.413	0.131	72.481**	32.767	43.104*
<i>Monthly</i>	-1.096**	0.387	-0.292**	9.700	24.419	5.768
<i>Daily</i>	-0.773**	0.370	-0.206**	62.420**	27.575	37.121**
<i>Per capita consumption</i>	0.004	0.002	0.001	-0.130	0.221	-0.077
<i>Purchased</i>	-0.011	0.246	-0.003	-53.397*	29.321	-31.755*
<i>Distinguish</i>	0.527	0.502	0.150	-26.009	51.661	-15.468
<i>Awareness fragrant</i>	-0.894***	0.306	-0.238***	57.732**	27.850	34.333**
<i>Awareness local fragrant rice</i>	-0.143	0.280	-0.038	76.236***	25.261	45.338***
<i>Correct</i>	0.157	0.252	0.041	-32.678	23.291	-19.433
<i>Buying intention</i>	0.757**	0.360	0.202**	153.082***	42.816	91.038***
<i>Constant</i>	-0.869	1.058		-267.298**	129.839	

***: Significant at 1%; **: Significant at 5%; *: Significant at 10%

Number of observations = 960

Sigma (error variance) = 72.398 **** (8.508)

Standard errors (SE) are robust and cluster corrected

Similarly to Demont and Ndour (2015), we found no significant income effect on both WTU and WTP. Poorer households might consider fragrant rice to be a luxury product. However, in the literature, even the poor in developing countries are characterised as having an increasing preference for food quality and taste over quantity (Jensen & Miller 2008; Deaton & Drèze 2009). In Dakar, fragrant rice is sold in small packages of 1 kg (\$1.6)¹ and 5 kg (\$8 to \$9) in markets and supermarkets. Customers who cannot afford to buy 50 kg bags (\$42) might only buy small packages on special

¹ In USDA (2013), US\$ 1 = 500 FCFA.

occasions (USDA 2013; 2014). However, the share of higher quality rice is found to be rapidly increasing in rice markets, with rising price premiums for quality rice in developing countries (Demont *et al.* 2012; Minten *et al.* 2013). Therefore, we added two variables that can serve as proxies for income. Indeed, households that employed a cooking housemaid or were not organised in social networks were more likely to upgrade or pay price premiums for fragrant rice. Employing a cooking housemaid is a proxy for wealth and increases consumers' WTP to fragrant rice by 28%, while being organised in associations, most of them savings associations ("tontines"), is a proxy for low income and reduces WTP by 33 FCFA (US\$ 0.07) kg^{-1} , i.e. a price discount of 13%. We also found that larger households are more likely to upgrade and tend to pay higher price premiums for fragrant rice. However the partial effect is low, with a price premium of only 3.14 FCFA (US\$ 0.01) kg^{-1} (around 1% of the price of the benchmark) per unit increase in the household size. Household members involved in rice purchase decisions tend to pay 43 FCFA (US\$ 0.09) kg^{-1} more (17% of the price of the benchmark) for rice fragrance, a premium that is offset by household heads.

The study also shows that, despite the fact that local fragrant rice varieties were released in 2009, only 28% of the participants claimed to be aware of them at the time of the experiment. This suggests that there is still some scope for making consumers aware of these new rice products. Consumers are willing to upgrade to fragrant rice, whether imported or local, as differences in market share between origins are not significant. Those who had prior awareness of fragrant rice tend to have a 24% lower willingness to upgrade to it, but when they do, pay price premiums of 34 FCFA (US\$ 0.07) kg^{-1} (13% of the price of the benchmark). However, those who are aware of the existence of local fragrant rice in the Senegal River Valley (28%, Table 1) tend to pay higher price premiums for fragrance (45 FCFA (US\$ 0.10) kg^{-1} ; 17% of the price of the benchmark), while those with positive purchase intentions for fragrant Senegal River Valley rice (95%, Table 1) pay very high price premiums of 91 FCFA (US\$ 0.20) kg^{-1} (35% of the price of the benchmark). Moreover, almost a quarter of the consumers claimed they consumed more whole-grain rice than before (Table 1), and those who do, pay higher price premiums for fragrance (38 FCFA (US\$ 0.08) kg^{-1} ; 15% of the price of the benchmark).

Households purchasing rice on a monthly or daily basis tend to be less willing to upgrade to fragrant rice relative to households purchasing rice on a weekly or two-weekly basis, while those purchasing on a daily basis tend to pay higher price premiums for it, probably due to the higher relative premiums for fragrance in retail. Our analysis also controls for rice stocks at home (*Purchased* variable), which negatively affects willingness to pay for upgrading. We also find evidence for ethnic market segmentation; *Wolof*, *Sereer*, *Pulaar*, *Diola* and *Lebou* consumers were more likely to upgrade to fragrant rice and, except for *Lebou* consumers, also to pay significantly higher price premiums for it. Since these ethnic groups represent at least 87% of the national population (83% in our sample), this illustrates the sensitivity of urban Senegalese consumers to fragrant rice in Dakar and the importance of this market segment. This clearly shows the need to develop value chains of local fragrant rice varieties so that domestic rice farmers can tap into these urban markets.

4. Conclusion

In this study we assessed the competitiveness of local relative to imported rice on the market for fragrant rice in Dakar, the capital city of Senegal. An experimental auction approach based on the "endow-and-upgrade" method was used to identify the main drivers of consumers' willingness to upgrade and willingness to pay for rice fragrance. The experimental results suggest that three quarters of consumers are willing to upgrade from non-fragrant to fragrant rice, whether imported or not. We found local rice to be competitive with imported rice on the market for fragrant rice in Dakar, as it fetched only small price discounts of 4% to 8% relative to Thai Hom Mali. The market prospects for local fragrant rice look good, as 95% of the participants expressed positive buying intentions for this

product, and those who do are 20% more likely to buy it while paying substantial price premiums of 35% on top of the price of non-fragrant rice.

Fragrant rice research and development programmes in Senegal require a lot of attention from policy makers. To improve food security, public rice-breeding programmes should consistently and sustainably include market research on consumer and farmer preferences regarding their strategic planning (Custodio *et al.* 2016). Fragrant rice value chains should target market segments that prefer aromatic rice and can afford the price premiums for fragrance. This should be reflected in the production and processing segment of the value chain as a source of incentive. This also implies increasing the production of local fragrant rice, which will necessitate the implementation of a strong and sustainable seed-production system for fragrant rice, along with the application of good agricultural practices (GAP) to attain the yield potential of the varieties. However, with deficient promotion of local fragrant rice, imports of fragrant broken rice, for instance from Thailand, could increase as consumers' total expenditure on rice increases (Coulibaly *et al.* 2015).

Our experiment has also revealed that the market share of non-fragrant rice may increase after consumers are exposed to its post-cooking sensory characteristics. Policy makers and value chain stakeholders should not neglect the substantial market potential for high-quality non-fragrant rice varieties, which are already widely available in the Senegal River Valley (Demont *et al.* 2013a; 2013b).

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