Received 10 August 2022
Revised 28 December 2022
7 February 2023
Accepted 7 February 2023

Consumer preferences for rice in East Africa

Edgar Edwin Twine
Africa Rice Center, Kampala, Uganda
Sali Atanga Ndindeng
Africa Rice Center, Bouake, Cote d'Ivoire
Gaudiose Mujawamariya
Africa Rice Center, Antananarivo, Madagascar
Stella Everline Adur-Okello
National Agricultural Research Organization, Entebbe, Uganda, and
Celestine Kilongosi
Formerly at Africa Rice Center, Abidjan, Cote d'Ivoire

Abstract

Purpose – Improving the competitiveness of East Africa's rice industries necessitates increased and viable production of rice of the quality desired by consumers. This paper aims to understand consumer preferences for rice quality attributes in Uganda and Kenya to inform the countries' rice breeding programs and value chain development interventions.

Design/methodology/approach – Rice samples are obtained from retail markets in various districts/counties across the two countries. The samples are analyzed in a grain quality laboratory for the rice's physicochemical characteristics and the resulting data are used to non-parametrically estimate hedonic price functions. District/county dummies are included to account for potential heterogeneity in consumer preferences.

Findings – Ugandan consumers are willing to pay a price premium for rice with a relatively high proportion of intact grains, but the consumers discount chalkiness. Kenyan consumers discount high amylose content and impurities. There is evidence of heterogeneity in consumer preferences for rice in Mbale, Butaleja and Arua districts of Uganda and in Kericho and Busia counties of Kenya.

Originality/value – The study makes a novel contribution to the literature on consumer preferences for rice in East Africa by applying a hedonic pricing model to the data generated from a laboratory analysis of the physicochemical characteristics of rice samples obtained from the market. Rather than base our analysis on consumers' subjective sensory assessment of the quality characteristics of rice, standard laboratory methods are used to generate the data, which enables a more objective assessment of the relationship between market prices and the quantities of attributes present in the rice samples.

Keywords Rice quality attributes, Shadow prices, Non-parametric estimation, East Africa

Paper type Research paper

1. Introduction

As consumption of rice in East Africa grows – making it the second most important crop in the region after maize (Kilimo Trust, 2018) – Kenya and Uganda, through the second phase of their national rice development strategies, intend to increase the competitiveness of their rice

The study was funded by the International Fund for Agricultural Development, Grant Number 2000002009. Also, support from the CGIAR Market Intelligence Initiative is gratefully acknowledged.

British Food Journal
Vol. 125 No. 13, 2023
pp. 316-329
Emerald Publishing Limited
0007-070X
DOI 10.1108/BFJ-08-2022-0698

industries. By doing so, they hope to reduce their rice import bills and safeguard household and national food security against global shocks to international food trade. The rice self-sufficiency ratio, defined as the ratio of domestic production to total consumption, stands at 67% for Uganda and at a meager 10% [1] for Kenya, and Kenya's imports are worth 26bn Kenya Shillings annually, equivalent to about US$ 712,329 daily (Ministry of Agriculture, Livestock, Fisheries and Cooperatives, 2020).

Strengthening the competitiveness of locally produced rice requires that national rice varietal improvement programs, seed systems, farmers and local marketers including millers, wholesalers and retailers produce and supply rice of the desired quantity and quality. To supply rice of the desired quality, information on consumer preferences for the different rice quality attributes is crucial. However, robust evidence on consumer preferences for rice in East Africa is hardly available (European Cooperative for Rural Development, 2012; Mgendi, 2014). This is an important gap in the published literature that we attempt to address in this paper, at least for the case of Uganda and Kenya.

The study seeks to address two essential questions. First, what rice quality attributes are important to consumers in Uganda and Kenya? Based mostly on expert views of breeders, agronomists and other biological scientists, the consultative group on international agricultural research (CGIAR) Excellence in Breeding (EiB) Platform has identified four seed product market segments for rice in Uganda and Kenya, namely, DELS-U, TMeLS-R and TMeLF-R in Uganda and DEMS-R in Kenya [2]. In these segments, the traits considered to be relevant to Ugandan consumers are grain shape (for which the preference is for slender grains), texture (preference for a soft texture when cooked), and firmness (preference for rice that is firm when cooked), while Kenyan consumers have similar preferences in terms of grain shape and texture. Could there be other attributes that are important to consumers? Second, how much are consumers willing to pay for the attributes they like? Answering these pertinent questions is especially important considering that the breeding pipelines that have been aligned with the identified seed product market segments may not necessarily address all the needs of heterogeneous consumers in those segments. In fact, some of the pipelines are to simply serve as a base for more targeted breeding in individual countries.

The study contributes to the literature by estimating the shadow prices associated with important rice quality attributes in the Ugandan and Kenyan markets. Consequently, it has practical implications for rice varietal improvement, post-harvest handling and processing. The EiB Platform and partners are currently engaged in efforts to align breeding pipelines with product profiles so that investments in breeding can have a stronger impact on food security and livelihoods (Excellence in Breeding Platform, 2021). However, the recently launched Market Intelligence Initiative of One CGIAR and partners, which aims to provide strategic information on market segments and preferences of farmers, consumers and other value chain agents, observes that the design of current product profiles has been strongly biased toward agronomic and stress tolerance traits and less on consumer traits and those that would have wider impact on gender equity, social inclusion, nutrition and opportunities for the youth (CGIAR, 2021). The evidence generated by this study is expected to inform the identification of market segments, the design of product profiles and consequently the development of appropriate rice breeding pipelines for the two countries. Also to the extent that certain quality attributes are partly influenced by practices at the post-harvest handling, milling, wholesale and retail nodes of the value chain, the study offers recommendations for quality improvement relevant to these nodes.

The remainder of this article is organized as follows. In section two, we review the literature, and in section three, we present the analytical approach including the economic model, empirical estimation strategy and data. Section four discusses the results and limitations of the study, and section five summarizes and concludes the paper with recommendations for improving the competitiveness of East Africa's domestic rice.

2. Literature review

Some studies in Africa have elicited consumers' willingness to pay price premiums for different types of rice using stated and revealed preference methods. They have examined the socio-demographic and quality variables influencing both the decision to purchase and how much to pay (see, for instance, Rutsaert *et al.*, 2009; Demont *et al.*, 2013a, b; Demont and Ndour, 2015; Fiamohe *et al.*, 2015; Akoa Etoa *et al.*, 2016; Diagne *et al.*, 2017; Britwum *et al.*, 2020).

Stated preference methods (also known as conversational, direct or expressed preference methods) such as contingent valuation and choice experiments reveal preferences through non-market behavior, usually because of the absence of markets to rely on to determine preferences (Grafton *et al.*, 2004). They examine preferences by getting respondents to answer hypothetical questions about their choices in hypothetical markets. When markets actually exist, revealed preference methods such as attribute based models – including hedonic price models and random utility models – are often used. However, it is not always the case that the existence of a market precludes the use of stated preference methods. In fact, stated preference methods may be used in place of revealed preference methods to capture preferences more precisely [see Grafton *et al.* (2004) for some examples]. Moreover, in comparison to revealed preference methods, they tend to be cheaper and less time consuming, and if well executed, the data they yield can be reliable and suitable for in-depth analysis of preferences (Aubeeluck, 2010). Their major drawback, however, is hypothetical bias – the gap between non-hypothetical preference estimates and hypothetical estimates – for which *ex post* and *ex ante* methods for mitigating it have had limited success. Therefore, we turn to revealed preference methods to conduct this study.

Non-hypothetical experimental auctions is a revealed preference method that has increasingly become popular in examining consumer preferences. It is characterized by real transactions and economic costs, involves mechanisms that are strategy-free, and it is incentive compatible, at least in theory (Doyon and Bergeron, 2017). Britwum *et al.* (2020) applied this method and found Ugandan rice consumers to prefer aromatic to non-aromatic rice, an important attribute, which we, however, do not examine in this study because of the nature of our data.

Results of experimental methods, however, tend to vary with experimental procedures such as the size of consumer taste panels, the initial endowment and the choice of auction mechanism (Lusk *et al.*, 2004; Umberger and Feuz, 2004). Lusk *et al.* (2004) determined that a second price auction yields greater valuations than n^{th} price, Becker-DeGroot-Marschak (BDM) and English auctions and that a random n^{th} price auction generates lower valuations than BDM and English auctions. Only a handful of studies such as Morawetz *et al.* (2011) and more recently Hamukwala *et al.* (2019) have attempted to assess the applicability of experimental methods to the African context, which may be characterized by, among other things, non-familiarity of participants with different types of auctions, low levels of income and food security and little experience with computers. These factors have the potential to introduce bias in experimental results. Morawetz *et al.* (2011) found that experimenters, amount of cash-in-hand held by participants and the time of day an auction is held have significant influence on BDM bids, while Hamukwala *et al.* (2019) found BDM willingness to pay estimates for an improved maize variety to be significantly higher than those obtained from a non-hypothetical choice experiment. It is for these reasons that the current study applies the hedonic pricing method.

Several studies on hedonic pricing of rice quality attributes have been undertaken so far for Sub-Saharan Africa (SSA). Naseem *et al.* (2013) applied a hedonic price model to data obtained from Beninese consumers' subjective perceptions of rice quality. They found that consumers pay price premiums for broken grains, short grains, parboiled rice and imported rice. Ndindeng *et al.* (2021) too examined the Beninese market but used data from laboratory analysis of the physical and chemical attributes of grain samples collected from several markets countrywide. Applying latent class analysis to their hedonic price model, they found three classes of consumers in proportions of 56, 39 and 5%. The largest class discounts parboiled rice but does not place significant value on the origin of rice. The second largest class values neither the origin nor the type of rice (parboiled or non-parboiled), while the smallest class pays the highest price, discounts parboiled rice and prefers imported to local rice. Preferences for physicochemical attributes vary from one class to another, and there would be modest gains in consumer surplus from greater head rice and a reduction in chalkiness.

Twine *et al.* (2022) use parametric and non-parametric methods to estimate a hedonic price model using laboratory data on physicochemical characteristics of rice samples from five countries, namely Nigeria, Ghana, Cote d'Ivoire, Cameroon and Madagascar. They find the non-parametric specification to fit the data better than the parametric one. Consumers in these countries are willing to pay price premiums for head rice, slender grains, peak viscosity, parboiled rice and rice sold in urban markets, but they discount high amylose content, rice with impurities and imported rice. The current study draws upon Twine *et al.* (2022) by non-parametrically estimating a hedonic price model fitted to data obtained from the laboratory analysis of rice samples. More recently, Peterson-Wilhelm *et al.* (2022) have applied a hedonic price model to data from rice samples obtained from Abuja, Kano and Lagos in Nigeria. They find that Nigerian consumers prefer rice with long slender grains but discount rice with a high proportion of broken grains.

Other studies on hedonic pricing of rice but outside Africa include Unnevehr (1986), who applied the consumer goods characteristics model of Ladd and Suvannunt (1976) to estimate hedonic prices for Thailand, Indonesia and the Philippines, and Cuevas *et al.* (2016), who essentially applied Rosen's (1974) model to data from the Philippines. Data for both studies were obtained from the laboratory analyses of the rice samples.

3. Analytical approach

3.1 Economic model and empirical estimation

Following Twine *et al.* (2022), we apply Rosen's (1974) hedonic pricing model to the rice markets in Uganda and Kenya. The model, which is itself based on Lancaster's (1966) theory that consumers obtain utility from a good's attributes and not just the good by itself, places a perfectly competitive market of differentiated products between heterogeneous sellers and consumers. In a given market, consumers maximize utility $U(x, z_1, z_2, \ldots\ldots, z_n)$ subject to a nonlinear budget constraint $y = x + p(z)$ where y is income, z_i is the quantity of attribute i in a given type (variety) or brand of rice, x is all other goods consumed and the function $p(z)$ relates observed market prices of rice (obtained from market clearing conditions) with the vector of attributes. In this budget constraint, the price of x is set to unity. The utility function is assumed to be continuous, strictly concave and strictly increasing. The consumer has a bid or value function, which is the maximum amount they are willing to pay given their income and the rice attributes and at a certain level of utility. They maximize utility at the point where the bid function equates to the minimum price they must pay in the market.

In the case of sellers, a seller's objective is to maximize profit subject to their production function. Again, sellers are competitors who treat prices as being parametric to their decisions. They have an offer function, which defines the minimum amount they are willing to accept as a function of the costs they face and the good's attributes, at a certain level of profit. Profit is maximized at the point where their offer function equates to the maximum price they can get in the market. Market equilibrium is attained when the consumer's bid function touches the seller's offer function, implying a common slope of the two functions at that point. Since the market is characterized by heterogeneous sellers and consumers, a plot of observed market price against quantity of a given attribute has unique bid and offer functions of the different buyers and sellers. The curve that connects the common slopes of the different pairs of value and offer functions is essentially the equilibrium hedonic (implicit) price function.

Therefore, the markets for the different rice types can be represented by the following basic hedonic price function:

$$p(z) = p(z_1, \ldots\ldots\ldots\ldots, z_n) \quad (1)$$

Upon estimation, $\partial p(z)/\partial z_i$ is the hedonic price, also known as the shadow price or implicit marginal price of attribute i. If positive, then consumers are willing to pay a price premium for the attribute, but if negative, it means that consumers discount the attribute. Equation (1) can be augmented with demand and supply shifters such as income and factor prices, respectively, and taste variables such as age, education and gender.

In this study, the market price of a given type or variety of rice is a function of both extrinsic (physical) and chemical (cooking) quality attributes. Extrinsic attributes include head rice, length-width ratio, chalkiness, grain lightness (whiteness), moisture content, impurities and whether the rice is parboiled or not. Cooking attributes include amylose content and peak viscosity. Chalkiness is an undesirable quality attribute because it reduces milling quality and the attractiveness of rice. Amylose content determines the stickiness of rice when cooked; a low amylose content makes rice sticky and vice-versa. Peak viscosity determines the extent of swelling upon cooking and firmness upon cooling. The greater the peak viscosity, the higher the extent of swelling and the lower the firmness upon cooling. We posit that East African consumers are willing to pay price premiums for greater head rice, greater length-width ratio, greater whiteness and high peak viscosity. However, they discount high amylose content, chalkiness, impurities and high-moisture content. We do not have *a priori* expectations regarding parboiled rice, which is much less common in East Africa compared to West Africa despite its nutritional benefits.

In estimating shadow prices of rice quality attributes, we also include location dummies in Equation (1) – district and county dummies for Uganda and Kenya, respectively, to account for potential within-country heterogeneity in consumer preferences for rice quality attributes. In Uganda, a district is the highest administrative unit of the local governments and is comprised of several counties. It has several departments such as trade and industry, education, health, production and natural resources and can formulate ordinances to restrict or promote certain activities and to enable the implementation of central government programs. Currently, Uganda has a total of 136 districts (25 in the Central region, 37 in the Eastern region, 38 in the Northern region and 36 in the Western region). In Kenya, a county is the highest administrative unit of the local governments. The country's new constitution, adopted in 2010, abolished the districts by turning them into counties. At present, there are 47 counties, which provide public services and undertake several functions such as agricultural development, trade development and regulation of markets.

The finding of heterogeneity in consumer preferences would be important to rice breeders and marketers as it would enable them to better allocate their scarce resources. For instance, the recent ban by the Ugandan Government on rice cultivation in the rainfed lowland ecologies (Makula, 2021) means that it might not be prudent for the national breeding program to continue developing improved varieties with agronomic and stress tolerance traits suitable for the TMeLS-R and TMeLF-R market segments, yet the needs of consumers that depend on these segments still ought to be met. Therefore, knowledge of preferences of consumers that depend on rice from the rainfed lowland ecologies would enable breeders to adjust their breeding programs accordingly in breeding for varieties suitable for the country's other two ecologies – upland and irrigated lowland.

A major issue in the empirical estimation of Equation (1) is specification of the appropriate functional form for the first stage regression. Rosen (1974) does not recommend a specific functional form but observes that the model is unlikely to be linear, especially if sellers face increasing marginal cost of attributes. Twine *et al.* (2022) compared parametric and non-parametric specifications of the model and found the latter to perform better than the former. Thus, we estimate the model non-parametrically, and like Twine *et al.* (2022), we use the additive non-parametric specification owing to the relative ease with which it parses out the effects of individual attributes and the fact that it does not greatly suffer from the curse of dimensionality (Bontemps *et al.*, 2008). In the additive non-parametric model,

$$p(z) = p(z_1, \ldots\ldots\ldots, z_n) = c + \sum_{n=1}^{N} g_n(z_n) \tag{2}$$

where c is a constant and $g_n(\cdot)$, $n = 1, \ldots..N$ is a set of N unknown smooth functions satisfying the identifiability condition that $E[g_n(z_n)] = 0$ for every n. From Equation (2), our empirical model becomes:

$$p = c + \sum_{n=1}^{N} g_n(z_n) + e \tag{3}$$

where e is the error term. To estimate Equation (3), we need to choose an appropriate estimator. The two most common ones are kernel and series estimators. Because we do not have information on the precise bandwidth to use for the kernel estimator, we opt for the series estimator. Series estimation regresses prices on a function of the explanatory variables, also called the basis function (StataCorp, 2019). The estimates obtained are average marginal effects – the effect of a very small change in the covariate on the market price of rice. Since our variables are untransformed, the average marginal effects of quality attributes are essentially hedonic prices of the attributes.

3.2 Data

Data for the study were obtained from a laboratory analysis of the rice samples bought from rural and urban food markets in Kenya and Uganda from August to September 2020. For Kenya, a two-stage cluster sampling design was used to collect rice samples. A total of 241 rice samples were bought from 15 markets randomly selected from a list of 33 markets across 9 counties spanning 3 geographical regions: West, Central and Southeast. The counties include Busia, Kisumu, Kericho (West), Nakuru, Nairobi, Kirinyaga, Embu (Central), Mombasa and Taita Taveta (Southeast). For Uganda, 45 markets in 12 districts across the country's four administrative (geographical) regions, namely Northern, Central, Western and Eastern, were purposively sampled. The districts include Gulu, Amuru, Lira, Arua (Northern), Hoima, Kasese, Rubirizi (Western), Kampala (Central), Soroti, Mbale, Butaleja and Iganga (Eastern). A total of 345 rice samples were collected. In both countries, the rice samples were bought from randomly selected retailers at the asking price in quantities of 0.25 kg per sample. For the rice that was already packaged, the smallest package was bought.

The rice samples were analyzed in a grain quality laboratory for extrinsic (physical) and intrinsic (chemical or cooking) quality attributes and summary statistics are reported in Table 1 for each country. Extrinsic quality attributes examined include head rice ratio (measured as the proportion of intact grains), grain shape (measured in terms of length-width ratio), impurities (percentage of organic and inorganic foreign matter), moisture content, chalkiness (the opaque part of a grain, which makes rice unpleasant), lightness (the degree of whiteness of grains), color intensity (the red/green and yellow/blue aspects of grain color) and whether the rice is parboiled or not. Intrinsic attributes include amylose content and peak viscosity.

Table 1.
Summary statistics of rice attributes for Uganda and Kenya

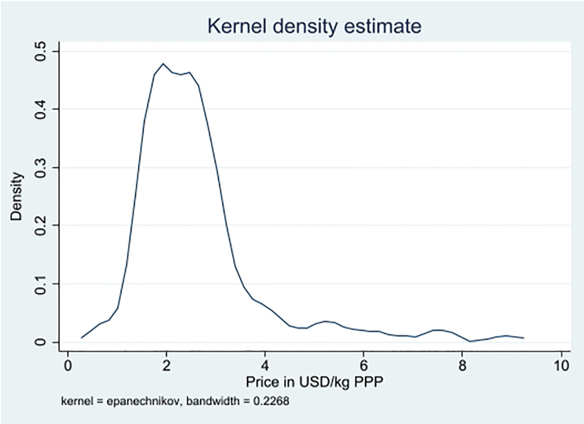
Variable	Country	Mean	Std. dev	Min	Max
Price (US$/kg)	Uganda	0.95	0.48	0.18	3.24
	Kenya	1.64	0.76	0.64	10.24
Price (constant international dollars, US$/kg)	Uganda	2.64	1.33	0.50	9.02
	Kenya	4.10	1.90	1.60	25.57
Head rice (%)	Uganda	74.74	14.65	5.24	99.99
	Kenya	94.48	7.38	60.17	99.99
Broken grain (%)	Uganda	25.26	14.65	0.01	94.76
	Kenya	5.52	7.38	0.01	39.83
Length-width ratio	Uganda	2.87	0.39	2.32	4.32
	Kenya	3.45	0.44	1.96	5.49
Chalkiness (%)	Uganda	14.28	9.76	0.03	54.17
	Kenya	23.87	15.32	0.01	62.85
Lightness (%)	Uganda	64.05	3.35	52.57	71.84
	Kenya	64.45	3.73	52.60	74.48
Amylose content (%)	Uganda	18.23	1.78	10.50	20.20
	Kenya	16.13	1.67	12.65	20.30
Color intensity	Uganda	8.48	3.30	5.99	67.38
	Kenya	9.40	2.04	6.23	15.60
Peak viscosity (centipoise)	Uganda	2656.64	682.00	285.00	4142.00
	Kenya	1594.82	642.65	86.00	3121.00
Moisture content (%)	Uganda	13.08	0.42	12.15	14.10
	Kenya	12.68	0.25	11.80	13.50
Impurities (total, %)	Uganda	0.14	0.21	0.00	1.65
	Kenya	0.12	0.32	0.00	3.85
Impurities (inorganic, %)	Uganda	0.02	0.06	0.00	0.55
	Kenya	0.10	0.31	0.00	3.80
Impurities (organic, %)	Uganda	0.12	0.20	0.00	1.65
	Kenya	0.10	0.31	0.00	3.80
Type (non-parboiled = 1, parboiled = 0)	Uganda	0.94	0.24	0.00	1.00
	Kenya	0.81	0.39	0.00	1.00

Source(s): Authors' work

Purchasing power parity conversion factors for 2020 (World Bank, 2022) are used to convert market prices to constant international dollars to enable comparison between the two countries. The average price of rice in Kenya is 55% greater than the price in Uganda. This is not surprising considering that 90% of rice consumed in Kenya is imported – mostly from Pakistan and other Asian countries – compared to 33% for Uganda. Rice imports from outside the East African Customs Union attract a common external tariff of US$ 345 per metric ton. Also, we compare the distribution of prices using kernel density estimates. These are shown in Figures 1 and 2 for Uganda and Kenya, respectively. In both countries, the prices are right-skewed, and therefore, the mean values are greater than the medians. Because of this skewness, we report the median prices of US$ 2.37/kg and US$ 4.07/kg for Uganda and Kenya, respectively, as better indicators of central tendency. The difference in median prices is about 42%. We can also clearly see that Kenyan prices have a bimodal distribution.

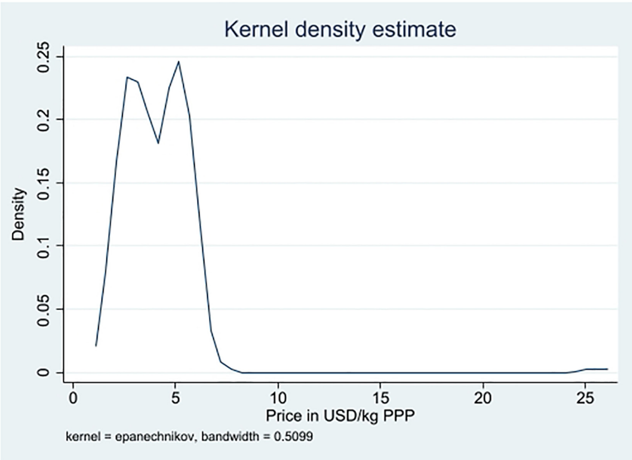
Kenyan rice has a relatively high proportion of intact grains or conversely low proportion of broken grains and a relatively low proportion of total impurities. This is probably because most of it is imported and imported rice generally has better extrinsic quality attributes than domestic rice. Also not surprising is that Kenya's rice has a larger length-width ratio. In fact, from our data, 87% of Kenya's rice samples are classified as having slender grains compared to only 19% of Ugandan samples.

Although Uganda's rice on average has greater amylose content than Kenya's rice (Table 1), almost all samples in the two countries (99 and 98%, respectively) fall in the range of



Source(s): Authors work

Figure 1.
Kernel density estimate of rice prices in Uganda



Source(s): Authors work

Figure 2.
Kernel density estimate of rice prices in Kenya

low amylose content (10–19%). However, chalkiness is relatively low in Uganda's rice (14.28%) compared to Kenya's (23.87%) and only 26% of Uganda's samples are classified as chalky compared to Kenya's 54%.

Comparison between the two countries can also be made in the context of the East African Standard for milled rice. Considering moisture content, organic matter, inorganic matter and percentage of broken grains, Kenya's rice, on average, meets the requirements for Grade 1 rice with respect to all attributes except percentage broken, for which it meets the Grade 2 requirement, having missed the Grade 1 cut-off point by a small margin. Uganda's rice meets Grade 1 requirements for moisture content and inorganic matter and Grade 2 requirement with respect to organic matter. The relatively large proportion of broken rice (25%) is because majority of the country's rice millers (69%) use the single-pass Engelberg type of mill (Twine *et al.*, 2021), which produces a lot of broken rice and impurities compared to the two-stage and multi-stage mills. These findings corroborate the fact that unlike Uganda's rice market, Kenya's market is dominated by imported rice, which must meet the set quality standards to be allowed into the country.

4. Results and discussion

In estimating the empirical model, we start with a parsimonious specification; one that includes only rice quality variables and omits location dummies. Results of the models with the best fit to the data are presented in Tables 2 and 3 for Uganda and Kenya, respectively [3]. For Uganda, three of the six coefficients are statistically significant: the coefficient on head rice ratio is positive, while the coefficients on chalkiness and peak viscosity are negative. For Kenya, two of the five coefficients are statistically significant and both are negative: the coefficients on amylose content and impurities.

Accounting for parboiling does not yield the best fitting model for either country. This is not surprising because parboiled rice is scarce on the East African market as shown by the descriptive statistics. Results of the less parsimonious specification are summarized in Table 4 for Uganda and Table 5 for Kenya. By including location dummies, we are accounting for the possibility of unobserved within-country heterogeneity in consumer preferences, and in doing so, we are also assessing the robustness of our results. Kampala district and Nairobi county are the reference locations in the regressions for Uganda and Kenya, respectively. The signs on all the coefficients in the two countries' regressions do not change and their magnitudes do not change much or at all. This suggests that our results are already fairly robust. Therefore, we discuss the regression results presented in Tables 4 and 5. To calculate the coefficient of determination for each country's regression, we regress the market price of rice on the basis terms (of the regressors) that are generated upon running the non-parametric series regression [4]. Both countries' regression models are statistically significant at one percent, with R-Squared values of 54.94% for Uganda and 39.71% for Kenya.

Table 2. Non-parametric regression results for Uganda without district dummies

Variable	Av. Marginal effect	*z*-statistic	*p*-value
Head rice ratio	0.02 (0.01)	4.08	0.000
Length-width ratio	0.26 (0.30)	0.89	0.372
Chalkiness	−0.03 (0.02)	−1.75	0.080
Amylose content	0.03 (0.12)	0.23	0.819
Peak viscosity	−0.0004 (0.0001)	−3.30	0.001
Impurities	0.24 (2.02)	0.12	0.905

Note(s): Dependent variable is price in constant international dollars. Figures in parentheses are robust standard errors. $N = 319$. The estimated average marginal effects are averages of derivatives for continuous variables and averages of contrasts (differences) in the case of dummy variables (StataCorp, 2019)
Source(s): Authors' work

Table 3. Non-parametric regression results for Kenya without county dummies

Variable	Av. Marginal effect	*z*-statistic	*p*-value
Head rice ratio	0.01 (0.14)	0.04	0.966
Length-width ratio	0.54 (0.56)	0.97	0.331
Amylose content	−0.34 (0.12)	−2.75	0.006
Peak viscosity	0.0002 (0.0003)	0.63	0.530
Impurities	−9.95 (5.75)	−1.73	0.083

Note(s): Dependent variable is price in constant international dollars. Figures in parentheses are robust standard errors. $N = 227$. The estimated average marginal effects are averages of derivatives for continuous variables and averages of contrasts (differences) in the case of dummy variables (StataCorp, 2019)
Source(s): Authors' work

Variable	Av. Marginal effect	z-statistic	p-value
Head rice ratio	0.02 (0.01)	2.68	0.007
Length-width ratio	0.49 (0.30)	1.62	0.105
Chalkiness	−0.03 (0.02)	−2.10	0.036
Amylose content	0.04 (0.11)	0.33	0.743
Peak viscosity	−0.0002 (0.0001)	−1.27	0.203
Impurities	0.58 (1.96)	0.29	0.769
Soroti	−0.0004 (0.28)	0.00	0.999
Hoima	−0.19 (0.27)	−0.69	0.492
Butaleja	−0.85 (0.28)	−3.00	0.003
Mbale	−0.51 (0.29)	−1.77	0.077
Lira	0.03 (0.29)	0.10	0.924
Gulu	−0.10 (0.30)	−0.32	0.748
Arua	0.66 (0.34)	1.94	0.052
Iganga	−0.20 (0.32)	−0.62	0.534
Amuru	−0.15 (0.31)	−0.47	0.639
Kasese	−0.31 (0.28)	−1.12	0.262
Rubirizi	0.45 (0.34)	1.30	0.193

Note(s): Dependent variable is price in constant international dollars. Figures in parentheses are robust standard errors. $N = 319$. The reference district is Kampala. The estimated average marginal effects are averages of derivatives for continuous variables and averages of contrasts (differences) in the case of dummy variables (StataCorp, 2019)
Source(s): Authors work

Table 4. Non-parametric regression results for Uganda with district dummies

Variable	Av. Marginal effect	z-statistic	p-value
Head rice ratio	0.06 (0.14)	0.44	0.659
Length-width ratio	0.55 (0.55)	0.99	0.322
Amylose content	−0.32 (0.12)	−2.80	0.005
Peak viscosity	0.0002 (0.0003)	0.68	0.499
Impurities	−10.91 (5.61)	−1.95	0.052
Kericho	1.47 (0.86)	1.71	0.087
Kisumu	1.30 (0.88)	1.47	0.141
Embu	0.87 (0.87)	1.00	0.318
Taita Taveta	1.00 (0.82)	1.22	0.224
Mombasa	1.94 (1.54)	1.26	0.207
Kirinyaga	0.82 (0.96)	0.85	0.393
Busia	1.67 (0.93)	1.80	0.072
Nakuru	1.14 (0.90)	1.27	0.204

Note(s): Dependent variable is price in constant international dollars. Figures in parentheses are robust standard errors. $N = 227$. The reference county is Nairobi. The estimated average marginal effects are averages of derivatives for continuous variables and averages of contrasts (differences) in the case of dummy variables (StataCorp, 2019)
Source(s): Authors' work

Table 5. Non-parametric regression results for Kenya with county dummies

We hypothesized that consumers are willing to pay a price premium for greater head rice. This is true only for Uganda; Ugandan consumers are willing to pay a price premium of 2 ¢/kg (or 0.8%) for a one percent increase in the head rice ratio, *ceteris paribus*. However, as theorized, they discount chalkiness by 3 ¢/kg (1.3%). Coefficients on the dummy variables for Butaleja and Mbale districts are negative and statistically significant at one and ten percent, respectively, while the coefficient on Arua district is positive and significant at ten percent.

This is indicative of heterogeneous preferences for rice in Uganda. That is, consumers in these districts might have different hedonic price functions.

As expected *a priori*, consumers discount high amylose content and impurities, at least for the case of Kenya. A one percent increase in amylose content would induce a price reduction of 32 ¢/kg (7.9%), *ceteris paribus*. The discount of US$ 10.91/kg (or 270%) with respect to total impurities seems unrealistically high. But of course, the actual discount in the population could be lower as shown by the coefficient's 95% confidence interval of [−21.90 0.10]. To determine the type of impurities that could be the source of this large coefficient, we run regressions in which we exclude total impurities and include organic and inorganic impurities, one at a time. However, we obtain even larger statistically significant coefficients for either type of impurities. Lastly, we also find evidence of heterogeneous preferences for rice in Kenya; the coefficients on the dummy variables for Kericho and Busia counties are positive and statistically significant at ten percent.

Our results are generally consistent with those in the literature. Using data from five countries in SSA, Twine *et al.* (2022) find that consumers are willing to pay a price premium of 1 ¢/kg for a one percent increase in head rice ratio, but they discount high amylose content by 7 ¢/kg and impurities by 21 ¢/kg. In an earlier study, Ndindeng *et al.* (2021) find three different classes of rice consumers in Benin and the two largest classes significantly discount chalkiness, with one class discounting it by as much as 2 ¢/kg. Peterson-Wilhelm *et al.* (2022) have found that Nigerian consumers generally discount rice with a relatively high proportion of broken grains.

The current study's limitation lies in not being able to determine the quality attributes for which there is preference heterogeneity. Several approaches can be applied to this end. One approach would be to interact the location dummies with the quality attributes. In the context of non-parametric regression, we would need larger samples. But even then, we would be confronted with the "curse of dimensionality" problem because of the interaction terms. Hence, we opt to estimate regression models without interaction terms. Another approach would be to estimate separate regressions for each district/county. But again, we would not have enough degrees of freedom to guarantee credible results. A third approach would have been to capture consumers' socio-economic and demographic data to enable us split up the sample into quintiles by some variable, say income, and run separate regressions for each quintile. However, the rice samples were obtained (purchased) from retailers as obtaining them from consumers would have required a bigger budget than we could afford. Nonetheless, our results are useful to breeding programs and rice value chain agents.

5. Summary and conclusions

The aim of this study is to provide evidence on consumer preferences for rice in East Africa – a critical gap in extant literature. The study applies a hedonic pricing model to data on physicochemical characteristics of rice samples obtained from Ugandan and Kenyan markets. The model is estimated non-parametrically, and the results suggest that Ugandan consumers prefer rice with intact rather than broken grains and they discount chalkiness. Their Kenyan counterparts discount rice with high amylose content and with a high quantity of impurities. In both countries, there are significant heterogeneities in consumer preferences in at least two districts in Uganda and two counties in Kenya. Determining the nature of the heterogeneous preferences, particularly for the case of Uganda, is an important area for further research. The two districts of Mbale and Butelaja for which heterogeneity is observed are also characterized by significant rice cultivation in the rainfed lowland ecology and are, therefore, likely to experience a substantial reduction in rice production due to the government's ban on rice cultivation in wetlands. This implies that understanding consumer preferences in the two districts will be critical to ensuring that farmers in the irrigated lowland ecologies as well as rice traders supply rice of the desired quality to consumers in those districts or to consumers in other locations but whose rice is procured from the two districts.

Grain quality improvements in terms of increasing head rice ratio and reducing chalkiness and amylose content can be achieved through breeding efforts. But increasing head rice ratio is also dependent on post-harvest handling practices and the quality of milling technology. As noted earlier, priority breeding pipelines for Uganda are aiming for long and slender grains, soft texture upon cooking and greater firmness upon cooling. Our results suggest that increasing the proportion of intact grains and reducing chalkiness should be added to this priority list. Kenya's only breeding pipeline is aimed at long and slender grains and soft texture. It would be beneficial to also aim for a reduction in amylose content. Good post-harvest handling and processing activities in Uganda should be undertaken to ensure that investments in breeding for greater head rice ratio are not wasted, while in Kenya minimizing or eliminating impurities should be a key focus of all post-harvest and off-farm value addition activities.

Our results also have societal and commercial implications. Improving grain quality leads to product and possibly channel upgrading of rice value chains, which would in turn improve nutrition, industry competitiveness and the welfare of value chain agents. Product upgrading is improvement in product quality, hence value, while channel upgrading is entry into new markets – domestic, regional or even global – in an effort to diversify revenue and manage risk. Indeed, studies such as Ndindeng *et al.* (2021) and Twine *et al.* (2022) have found that grain quality improvement in terms of increasing head rice, reducing chalkiness and reducing amylose content leads to welfare gains to society.

Furthermore, because of imperfect information, the study reveals the importance of analyzing willingness to pay for experience attributes such as amylose content. Unlike search attributes like head rice, chalkiness and level of impurities, experience attributes may present a greater challenge for the efficient functioning of the market, especially where there is symmetric imperfect information. That is, producers (or sellers) and consumers may not know the quality of the product with respect to a certain attribute prior to its purchase and consumption. Therefore, the finding that Kenyan consumers discount high amylose content calls for quality control strategies such as product testing and marketing strategies such as certification and labeling that support the product reputation mechanism. Rice with relatively low amylose content would be repeatedly purchased, and thus, producers or sellers that supply low amylose content rice should be able to charge a higher price for it.

Notes

1. Authors' own calculation using the United States Department of Agriculture (USDA) (2020) Production, Supply and Distribution (PSD) dataset on grains and pulses.
2. D = direct seeded, E = early maturing, L = long slender, S = soft texture, U = upland rice, T = transplanted, Me = medium maturing, R = rain-fed lowland rice, F = firm and dry and M = medium in shape.
3. The difference in sampling designs between the two countries precludes pooling of the data to estimate a pooled regression.
4. Unlike the non-parametric kernel regression, the Stata command for the non-parametric series regression (non-progress series) does not calculate an R-Squared statistic, but the statistic can be calculated manually.

References

Akoa Etoa, J.M., Ndindeng, S.A., Owusu, E.S., Woin, N., Bindzi, B. and Demont, M. (2016), "Consumer valuation of an improved rice parboiling technology: experimental evidence from Cameroon", *African Journal of Agricultural and Resource Economics*, Vol. 11 No. 1, pp. 8-21.

Aubeeluck, A. (2010), "A comparative analysis of consumer attitudes towards Food Safety, Animal Testing and Traceability in the Meat Industry: Japan and Canada", PhD thesis, University of Alberta.

Bontemps, C., Simioni, M. and Surry, Y. (2008), "Semiparametric hedonic price models: assessing the effects of agricultural nonpoint source pollution", *Journal of Applied Econometrics*, Vol. 23 No. 6, pp. 825-842.

Britwum, K., Owusu, E.S. and Demont, M. (2020), "Confronting genetic gains with markets: retrospective lessons from New Rice for Africa (NERICA) in Uganda", *Outlook on Agriculture*, Vol. 49 No. 4, pp. 298-310.

CGIAR (2021), "Market intelligence and product profiling", unpublished CGIAR Initiative Proposal, CGIAR.

Cuevas, R.P., Pede, V.O., McKinley, J., Valarde, O. and Demont, M. (2016), "Rice grain quality and consumer preferences: a case study of two rural towns in the Philippines", *PLoS One*, Vol. 11 No. 3, e0150345.

Demont, M. and Ndour, M. (2015), "Upgrading rice value chains: experimental evidence from 11 African markets", *Global Food Security*, Vol. 5, pp. 70-76.

Demont, M., Rutsaert, P., Ndour, M. and Verbeke, M. (2013a), "Reversing urban bias in African rice markets: evidence from Senegal", *World Development*, Vol. 45, pp. 63-74.

Demont, M., Rutsaert, P., Ndour, M., Verbeke, W., Seck, P.A. and Tollens, E. (2013b), "Experimental auctions, collective induction and choice shift: willingness-to-pay for rice quality in Senegal", *European Review of Agricultural Economics*, Vol. 40 No. 2, pp. 261-286.

Diagne, M., Demont, M. and Ndour, M. (2017), "What is the value of rice fragrance? Consumer evidence from Senegal", *African Journal of Agricultural and Resource Economics*, Vol. 12 No. 2, pp. 99-110.

Doyon, M. and Bergeron, S. (2017), "Survey designs based on experimental economics to assess consumers' preferences: do's and don'ts", *Canadian Agricultural Economics Society Post Conference Workshop*, Montreal, June 21, 2017.

European Cooperative for Rural Development (2012), "Rice sector development in East Africa", available at: CFC__Rice_Sector_Development_in_East_Africa_2012.pdf(eucord.org) (accessed 6 February 2023).

Excellence in Breeding Platform (2021), "Breeding by the numbers: EiB annual report", available at: https://excellenceinbreeding.org/annual-report/2020/ (accessed 2 August 2022).

Fiamohe, R., Nakelse, T., Diagne, A. and Seck, P.A. (2015), "Assessing the effect of consumer purchasing criteria for types of rice in Togo: a choice modeling approach", *Agribusiness*, Vol. 31 No. 3, pp. 433-452.

Grafton, R.Q., Adamowicz, W., Dupont, D., Nelson, H., Hill, R.J. and Renzetti, S. (2004), *The Economics of the Environment and Natural Resources*, Blackwell Publishing, Oxford.

Hamukwala, P., Oparinde, A., Binswanger-Mkhize, H.P. and Kirsten, J. (2019), "Design factors influencing willingness-to-pay estimates in the Becker-DeGroote-Marschak (BDM) mechanism and the non-hypothetical choice experiment: a case of biofortified maize in Zambia", *Journal of Agricultural Economics*, Vol. 70 No. 1, pp. 81-100.

Kilimo Trust (2018), "Expanding Rice Markets in the East African Community", available at: https://www.kilimotrust.org/documents/2018/Expanding_Rice_Markets_in_East_Africa.pdf (accessed 5 March 2019).

Ladd, G.W. and Suvannunt, V. (1976), "A model of consumer goods characteristics", *American Journal of Agricultural Economics*, Vol. 58 No. 3, pp. 504-510.

Lancaster, K.J. (1966), "A new approach to consumer theory", *Journal of Political Economy*, Vol. 74 No. 2, pp. 132-157.

Lusk, J.L., Feldkamp, T. and Schroeder, T.C. (2004), "Experimental auction procedure: impact on valuation of quality differentiated goods", *American Journal of Agricultural Economics*, Vol. 86 No. 2, pp. 389-405.

Makula, E. (2021), "Government issues new directives to reinforce environmental conservation", available at: https://chimpreports.com/govt-issues-new-directives-to-reinforce-environmental-conservation/ (accessed 3 July 2022).

Mgendi, G.S. (2014), "Consumer preferences for rice attributes in Dar-es-salaam city of Tanzania", PhD thesis, Sokoine University of Agriculture, Tanzania.

Ministry of Agriculture, Livestock, Fisheries and Cooperatives (2020), "National rice development strategy-2 (2019-2030)", available at: https://riceforafrica.net/images/countries/NRDS_rev/NRDS2_Kenya_en.pdf (accessed 15 November 2021).

Morawetz, U.B., De Groote, H. and Kimenju, S.C. (2011), "Improving the use of experimental auctions in Africa: theory and evidence", *Journal of Agricultural and Resource Economics*, Vol. 36 No. 2, pp. 263-279.

Naseem, A., Mhlanga, S., Diagne, A., Adegbola, P.Y. and Midingoyi, G.S.-K. (2013), "Economic analysis of consumer choices based on rice attributes in the food markets of West Africa – the case of Benin", *Food Security*, Vol. 5, pp. 575-589.

Ndindeng, S.A., Twine, E.E., Mujawamariya, G., Fiamohe, R. and Futakuchi, K. (2021), "Hedonic pricing of rice attributes, market sorting, and gains from quality improvement in the Beninese market", *Agricultural and Resource Economics Review*, Vol. 50, pp. 170-186.

Peterson-Wilhelm, B., Nalley, L.L., Durand-Morat, A. and Shew, A. (2022), "Does rice quality matter? Understanding consumer preferences for rice in Nigeria", *Journal of Agricultural and Applied Economics*, Vol. 54, pp. 769-791, doi: 10.1017/aae.2022.38.

Rosen, S. (1974), "Hedonic prices and implicit markets: product differentiation in pure competition", *Journal of Political Economy*, Vol. 82 No. 1, pp. 34-55.

Rutsaert, P., Demont, M., Ndour, M. and Tollens, E. (2009), "Competitive rivals: willingness-to-pay for Senegal River Valley versus imported rice", *Paper presented at the 2nd EAAE Workshop on Valuation Methods in Agro-food and Environmental Economics: Experimental Auctions: Theoretical Background and Empirical Applications*, Barcelona, July 2-3, 2009.

StataCorp (2019), *Stata: Release 16. Statistical Software*, StataCorp LLC, College Station, TX.

Twine, E.E., Adur-Okello, S.E., Mujawamariya, G. and Ndindeng, S.A. (2021), "Targeting millers to improve rice marketing in Uganda", *British Food Journal*, Vol. 123 No. 13, pp. 454-468.

Twine, E.E., Ndindeng, S.A., Mujawamariya, G. and Futakuchi, K. (2022), "Pricing rice quality attributes and returns to quality upgrading in Sub-Saharan Africa", *Journal of Agricultural and Applied Economics*, Vol. 54, pp. 175-196.

Umberger, W.J. and Feuz, D.M. (2004), "The usefulness of experimental auctions in determining consumers' willingness-to-pay for quality-differentiated products", *Review of Agricultural Economics*, Vol. 26 No. 2, pp. 170-185.

United States Department of Agriculture (USDA) (2020), "PSD datasets: grains and pulses", available at: https://apps.fas.usda.gov/psdonline/app/index.html#/app/downloads (accessed 2 May 2021).

Unnevehr, L.J. (1986), "Consumer demand for rice grain quality and returns to research for quality improvement in Southeast Asia", *American Journal of Agricultural Economics*, Vol. 68 No. 3, pp. 634-641.

World Bank (2022), "PPP conversion factor, private consumption (LCU per International $)", *International Comparison Program, World Development Indicators database*, available at: https://data.worldbank.org/indicator/PA.NUS.PRVT.PP (accessed 3 March 2022).

Corresponding author
Edgar Edwin Twine can be contacted at: E.Twine@cgiar.org