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RESEARCH ARTICLE
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Demand for Rice Varieties in Eastern Saudi Arabia with Special Emphasis on Hasawi Rice

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ABSTRACT

The study investigated four commonly consumed rice varieties in the Eastern region of Saudi Arabia known as: Hasawi rice (*Oryza Sativa* L.), Basmati rice, Egyptian (Calrose) rice, and American (Parboiled) rice. The results showed that most respondents consume Hasawi rice because it has been a well -known food item since ancient times, while the main reason causing consumers to refrain from consuming Hasawi rice was a lack of awareness of its preparation. The results of the own-price elasticities of demand for rice showed that the demand for rice is price inelastic. Income elasticities identified Hasawi rice and Basmati rice as luxury rice items, while Egyptian and American rice were identified as necessities. Also, cross-price elasticities indicate that the only rice variety that can substitute Basmati rice is American rice. The other socio-economic factors influencing rice demand in Saudi Arabia are gender, place of residence, and education level.

Keywords: Rice, Two-step demand, Price elasticity, Income Elasticity.

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INTRODUCTION

Rice, scientifically known as Oryza sativa, holds significant agricultural and nutritional value as a vital staple food crop, meeting the dietary needs of over 60% of the world's population. China is the largest global rice producer with a production capacity surpassing 211 million tons, and India follows closely behind with a production of 195 million tons (AtlasBig, 2024). According to (FAO, 2016), Saudi Arabia held the seventh position globally as a rice importer in 2013, with a 3% share and an import volume of 1.26 million tons. Rice cultivation is considered to be unsuitable in Saudi Arabia due to factors like climate and water conditions, as noted by (Baazeem, 2007; Mousa, 2015). From 2009 to 2015, Saudi Arabia ranked fourth in terms of global rice import quantity and second in terms of global rice value (USDA, 2015; FAO, 2016). Consumer preferences have led Saudi Arabia to import more expensive rice (Alamri & Saghaian, 2018). As rice is a staple food for over half of the world's population, its widespread consumption and importance contribute significantly to both the national economy and food security.

Rice serves as a staple food for approximately 70% of the global population. Global rice consumption has been on increasing trend as shown in Fig. 1. We can also notice that the global consumed quantity of rice almost follow steady increasing patterns from 2008 to 2024, which is consistent the global population increase whereas the average consumed quantity during that period reached 482457 (in 1000 metric tons). According to (Straits, 2025), the ten highest rice consuming countries are (in descending ranking): China, India, Indonesia, Bangladesh, Philippines, Vietnam, Myanmar, Thailand, Japan, and Brazil. Most of the mentioned top ten consuming rice countries are from the Asian continent, which reflect the importance of rice in the diet of Asian countries population.

In Saudi Arabia, rice has a position of great popularity, and its consumption is influenced by cultural norms and traditions. According to (Alamri et al., 2020), the average individual in Saudi Arabia consumed 47 kg of rice in 2016. Rice comes in a range of varieties such as (Oryza sativa subsp. Indica) whole grain varieties like American rice and long-grain like Basmati rice. There are also medium and small grain types (Oryza sativa subsp. japonica), like Egyptian rice.

It is well-documented that the Al-Ahsa oasis, located in the Eastern region of Saudi Arabia as shown in Fig. 2, is the historical birthplace of Hasawi rice (Oryza sativa L.).

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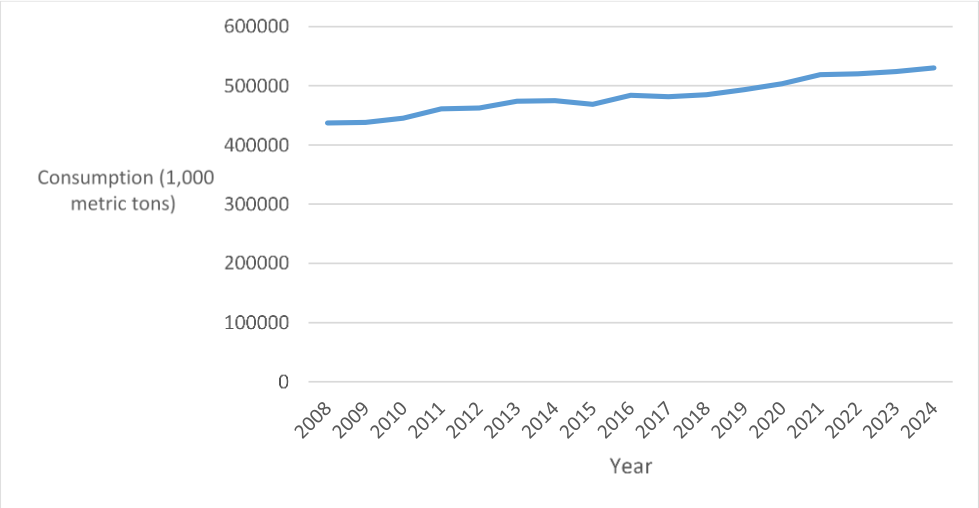

Fig. 1: Global Annual Rice Consumption; Source: Statistica (2025).

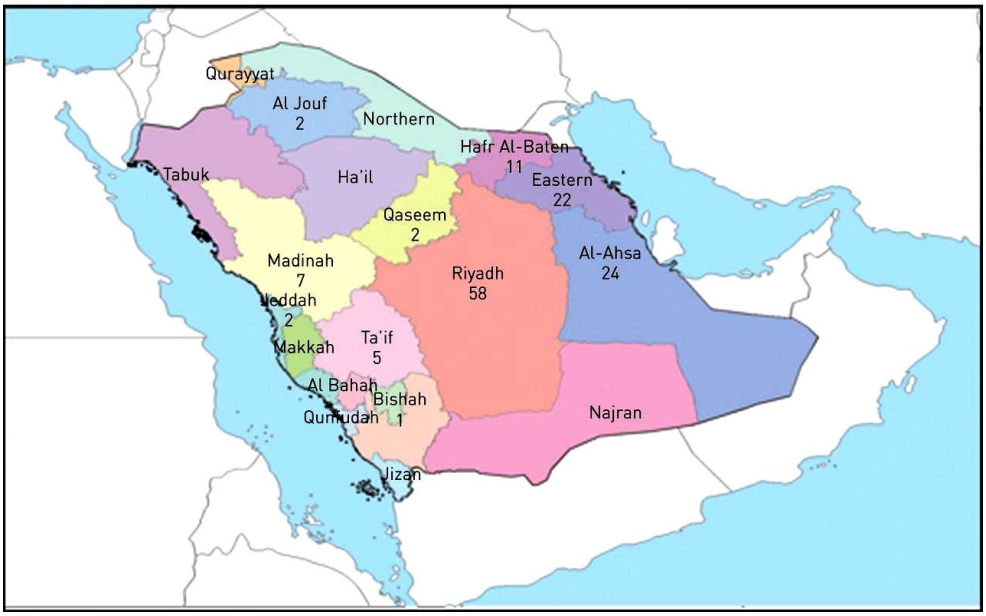

Fig. 2: Location of Al-Ahsa in the Eastern Region of Saudi Arabia; Source: Maps Saudi Arabia.

This rice variety has been cultivated in the region for centuries. Over the past seven decades, Hasawi rice has played a crucial role in ensuring food and nutritional security in the Al-Ahsa Oasis and its surrounding areas. It has been considered a staple food alongside date fruits, providing stability and sustenance to the local population. Hasawi rice is considered in Al-Ahsa to be a food inherited from parents and grandparents, who have farmed Hasawi rice for ages. The residents of the Al-Ahsa region are familiar with this crop as Hasawi rice. Hasawi rice is grown in farms in the Al-Ahsa region in the villages of Al-Qurain and Batalia, as well as the town of Al-Ghuwaiba. Al-Ahsa is known for both its fresh natural water and irrigation water for the Hasawi rice plant, so this means that it is extremely important to have fresh water for irrigation. However, this rice variety needs a large amount of water. This particular rice variety is a summer crop that necessitates specific traditional techniques for cultivation until the soil conditions are suitable for agriculture. Subsequently, it is harvested using specialized machinery. The price of Hasawi rice is influenced by the expertise and dedication of the farmers cultivating this crop. While Hasawi rice may be considered one of the most expensive varieties, it is also recognized as the most nutritious unprocessed rice worldwide (Alghazal, 2021). Despite experiencing a decline in cultivation recently, Hasawi rice remains the second-largest crop produced in Al-Ahsa, following date palms. In 1962, Al-Ahsa yielded approximately 20,000 tons of rice. Presently, the production quantity has decreased to around 400 to 500 tons due to factors like drought and diminishing arable land. According to data from the Irrigation and Drainage Project Authority in Al-Ahsa, in 2003, approximately 1569 dunums of land were dedicated to rice cultivation, resulting in a production rate of 392 tons. In 2004, the rice farming area decreased to 1414 dunums, with an estimated output of 353 tons. Presently, Hasawi rice farmers estimate an annual production of around 4,000 seasonal units, equivalent to approximately 480,000kilograms. The production rates per farm range between 10 and 15 seasonal units, depending on the cultivated area. One advantage of Hasawi rice is its ability to thrive as a summer crop in hot climates, unlike other plant varieties in Al-Ahsa that require more attentive care. Hasawi rice, one of the most notable rice varieties globally, naturally possesses health benefits and is characterized by its brown color, which signifies the presence of beneficial natural dietary fiber. Unlike many other rice types, Hasawi rice does not undergo artificial fortification with minerals

and vitamins. Its natural healthiness contributes to its significance as a highly nutritious rice type. Hasawi rice offers a multitude of health advantages, including cholesterol reduction, diabetes risk mitigation, immune system enhancement, and being rich in fiber (Elsheikh et al., 2014). Because of its high nutritional content and the type of carbs it contains, Hasawi rice is the ideal choice for diabetics and those who prefer to manage their health and weight (Al-Mssallem & Alqurashi, 2021).

The research problem arises from the shortage of economic studies on Hasawi rice consumption and the factors influencing its consumption, the results of which would allow decision-makers to make informed choices that could result in an increase in Hasawi rice consumption based on recommendations from an economic perspective. Thus, this study aims to evaluate the demand system for rice varieties in Saudi Arabia, including Hasawi rice.

Saudi Arabia has witnessed an annual increase of 14,000 tons in rice imports. The six major rice-exporting countries are: India, Pakistan, the US, Thailand, Australia, and Egypt, collectively accounted for the majority of Saudi Arabia's rice imports during the period from 2010 to 2014. Their respective shares were 66, 12, 10, 9, 1, and 1%, respectively. Moreover, the elasticities derived from the estimation of residual demand and lerner index to account for market power indicate that Pakistan, India, and Australia are exerting market power over the Saudi rice import market. (Alamri & Saghaian, 2018). Also, the study identified four main types of rice that Saudi Arabia imports, which include broken rice, semi-milled or fully milled rice, husked (brown) rice, and rice in the husk (paddy or rough). In a related study, (Alamri et al., 2020) examined the Saudi rice market, which experiences intense competition. They applied the Two-Stage Least Squares regression (2SLS) approach to estimate the exporter's inverse demand function for rice to Saudi Arabia from 1993 to 2014. Their findings indicate that Australia, India, and Pakistan possessed significant market power in the Saudi market, whereas Egypt was subject to a flexible demand curve. Conversely, Thailand and the US exhibited flexible inverse demand, indicating a lack of power in the Saudi market. Likewise, (Bashir et al., 2022) applied the vector error correction model (VECM) using time series data from 1983 to 2018 to calculate the import demand function of Saudi Arabia's Indica rice. The results established a long-term relationship between import demand, import prices, per capita income, population, and crop production index. Rice appears to be an essential everyday product based on short-term price and income demand elasticities. Low-income elasticity indicates that rice is a necessity.

The United Arab Emirates and Saudi Arabia are recognized as stable markets, while Benin, Bangladesh, and the United Arab Emirates are significant destinations for non-smart rice exports. On the other hand, Kot devoir and Liberia are considered less stable markets among non-smart rice importing countries. To thrive in the international market, exporters need to offer competitive prices along with improved quality and health standards, as highlighted by (Udhayakumar & Karunakaran, 2020).

In Nigeria, the demand for rice is influenced by various factors beyond price. These factors include the age of the respondents, household size, income, the frequency of rice purchases, and the cost of alternative items like beans and yams that can be used as substitutes for rice, as highlighted by (Kassali et al., 2010). Kouekam et al. (2018) showed the factors that influence rice demand at the 5% significance level are rice own price, consumer income, family size, and the prices of alternative options. In Benin, (Codjo et al., 2021) conducted a study examining the market for rice and its alternatives. The findings show that even consumers with modest income appreciate good rice. Low- and middle-class consumers are more likely to choose high-quality domestic rice from the available options, while high-income consumers are more likely to choose premium imported rice. The demand for premium rice, both domestically produced and imported, is price-inelastic among high-income consumers. Consumers living in rural areas react quickly to changes in rice prices. On the other hand, maize is the commodity that low- and middle-class consumers are most likely to choose, however, consumers do not react to variations in corn prices across the three income levels. Onyeneke et al. (2020) analyzed the demand for imported rice, local rice, maize, and other grains in Nigeria by utilizing data from the integrated survey of agriculture, specifically the second wave of the Nigerian standard-of-living measurements survey. They employed a semi-optimal quadripartite demand system model for experimental analysis. The findings reveal that local rice is considered to be a necessity, while imported rice is viewed as a luxury commodity. Furthermore, the price flexibility of imported rice, both in terms of price and non-compensatory price, was observed to be negative. Bairagi et al. (2021) investigated the factors influencing the consumer demand for packaged rice in Thailand. Their findings suggest that variables such as income, education, employment, household size, intrinsic quality attributes (such as rice fragrance), per capita consumption, and purchase frequency were the key drivers of packaged rice demand. The study also highlighted that the drivers of demand varied depending on the extent of the retail market revolution.

In the municipality of Buea, Cameroon, the demand for rice was found to be price-inelastic, as observed by (Kouekam et al., 2018). On the other hand, in Indonesia, the income elasticity of the demand for fish, shrimp, beef, and chicken meat varied, while it remained inelastic for rice (Devi & Purnomosidi, 2019). Conversely, in Brazil, the income elasticity of the demand for rice was lower compared to the Middle West and Southeast regions, indicating that rice was considered an essential item there. Furthermore, rice was often complemented by beans, and alternative options for rice included bread and cassava flour (Zanin et al., 2019). In Bangladesh, the elasticity of the demand for rice in relation to income was found to be 0.76, indicating that rice is considered an essential and staple food item. The price elasticity of rice indicates that a 10% decrease in rice price would result in an 8.21% increase in rice demand. Additionally, the elasticity of

substitution and non-compensatory demand revealed that all food items had relatively rigid price elasticities. This suggests that changes in price may not significantly impact the demand for food commodities, as stated by (Siddique et al., 2020).

On the other hand, in Pakistan, all crops were estimated to have a price elasticities ranging from -0.1 to -0.5. Pulses exhibited higher elasticities compared to wheat and rice. The price-demand elasticity was generally rigid, except for fruit and poultry, which were considered luxury goods. Furthermore, the income elasticity for pulses was also inelastic, as noted by (Rani et al., 2020). To evaluate the various possible effects of population and income growth, rice consumption in Indonesia has been estimated on a per capita basis. The findings indicate that there is a negative relationship between income elasticity and rice demand, and this relationship will persist for at least the next five years. According to the report, agriculture needs to modernize to protect farmers' wealth. To speed up this change, the government has supported initiatives including Dan Smart Irrigation, Simluhtan, Katam, Si Mantap, Smart Farming, Smart Green House, and Autonomous Tractor (Arsani, 2020). In Vietnam, all food commodities exhibited positive average expenditure (income) elasticity for rice, with a value of 0.36. On the other hand, the average price elasticity for rice was negative, recorded at -0.80. Based on the predicted elasticity, a 20% increase in rice prices would correspond to a 1.3% increase in the overall welfare of the average family. Notably, middle-class households were the ones who benefited the most from the rise in rice prices, while the poorest individuals experienced the least gain in welfare. According to (Vu, 2020), it is crucial to develop targeted food policies that take into account the unique patterns of food consumption. Furthermore, support programs should be directed towards the poorest families, particularly in regions where price increases are more likely to occur.

Obayelu et al. (2022) conducted a study on the response of demand to changes in rice price during periods of food inflation in Nigeria. The findings revealed that more than 70% of households demanded long-pill imported rice, as well as wet and dry domestic brown rice. The expenditure elasticity (income) for both imported short-grain rice (ISGR) and local short-brown rice (LSBWR) was positive and less than 1, indicating that these food items are considered necessary and normal items. The study also examined the rice production sub-models and found that the yield of the rice-harvesting region in Nigeria remained rigid. However, advancements in technology had a positive impact on the rice-harvesting area. While wheat serves as a substitute for rice, the demand for rice remained inelastic, as highlighted by (Abdulsalam et al., 2021).

In Tanzania, the demand elasticities for milk and dairy products were found to be monolithic, meaning that it remained relatively stable regardless of price or income changes. Most food groups exhibited elastic income-demand elasticity, indicating that changes in household income had a notable impact on the demand for these products. However, food items such as maize, rice, other cereals, pulses, sugar, oils, fish, cash, fruit, vegetables, meat, and other foods displayed inelastic price-demand elasticity, suggesting that changes in their prices had a limited influence on the quantity demand.

The study conducted by (Weliwita et al., 2011) also highlighted the significant influence of family size and income on food demand patterns in Tanzania. Impoverished households were found to heavily rely on lower-quality Raskin rice, with a larger portion of their expenditure allocated to rice and a comparatively lower portion spent on milk. Raskin rice, in particular, exhibited the highest coefficients for both price and income elasticities as reported by (Suriani et al., 2018).

Utami et al. (2023) found a significant price relationship between medium-quality and low-quality rice, as well as between high-quality and medium-quality rice. They concluded that changes in the prices of low-quality and high-quality rice would have a significant impact on the price of medium-quality rice, rather than the other way around. In China, the price elasticities of corn and rice with respect to rice yield implied that an increase in corn price negatively affect rice yield while an increase in rice price positively affect rice yield (Yu et al., 2022). The study also highlighted the importance of crop price policies and climate factors in determining rice yield. Additionally, a price support policy for rice plays a role in establishing the expected rice prices.

It is commonly known that dietary consumption patterns, diet composition, and content are controlled by a wide range of factors which interact complicatedly to create dietary consumption patterns in every given community. Individual preferences and views, cultural traditions, income, prices, and various geographic, environmental, social, and economic factors are some of the primary determinants of dietary consumption patterns. During the last thirty years, starting from the 1980s, Saudi Arabia has experienced notable and impactful transformations in its population's demographics and lifestyle, leading to significant changes in the country's overall food consumption patterns and preferences (Adam et al., 2014). In the context of rice, two distinct categories of quality attributes have been identified, specifically intrinsic and extrinsic qualities. Intrinsic qualities encompass characteristics such as color, cleanliness, grain size and shape, softness and aroma (fragrance), while extrinsic qualities pertain to packaging, branding, labeling, and information associated with the rice product (Bairagi et al., 2020).

Rice holds a significant place in Saudi Arabian cuisine, with consumption varying based on customs and culture. A traditional rice and meat dish called "kabsah" is commonly prepared and enjoyed. In 2016, the average person in Saudi Arabia consumed approximately 47 kg of rice (Saudi General Authority for Statistics, 2019). It is worth noting that there are over 1500 rice varieties available worldwide (Baazeem, 2007). In Saudi Arabia, the most popular rice variety is Basmati, followed by American and Calrose rice (Mousa, 2015). Apart from its consumption as a staple food, rice is also utilized in various

industries. For instance, it is used to produce baby food made from short- or medium-grain rice, and there are other industries that focus on rice-derived products like rice oil, which finds applications in leather lubrication and cosmetics (Baazeem, 2007).

In the Philippines, sociodemographic factors such as income, socioeconomic class, sex, age, level of education, and the work status of the family head play a significant role in determining rice intake and expenditure. Additionally, the location of consumers, whether they are residing in urban or rural areas, and the relative wealth or poverty of their surroundings also influence rice consumption and expenditure patterns (Lantican et al., 2013). In Indonesia, various factors contribute to rice consumption patterns, including the number of households, rice prices, oil prices, chicken prices, age, social assistance, income, and the possibility of food diversification, leading to lower rice consumption due to alternative consumption options offered by social assistance programs (Wardani et al., 2019). Similarly, in Vietnam, the pattern of food consumption by Vietnamese families are influenced by factors such as income, price, and other socioeconomic and regional factors (Vu, 2020). Market data on consumer behavior in the growing Indian rice industry, particularly regarding branded rice products, can provide valuable insights into how consumers perceive and interact with specific brands. This research can be highly beneficial for the producers, processors (rice mills), packaging companies, and marketing outlets involved in the entire rice production process (Talukdar & Lindsey, 2013).

Through a study conducted in Bangladesh to examine the factors influencing household preferences for various types of rice grain. The findings revealed that affluent, educated, and urban households in Bangladesh are transitioning from consuming short and bold-grain ordinary rice to long and thin-grain fine rice (Mottaleb & Mishra, 2016). Furthermore, a study conducted by (Musa et al., 2011) delved into the factors influencing sample of customers' rice purchasing decisions and discovered that preferences for rice grain vary across different nations. The primary concerns for customers during the purchase decision-making process are typically the price and quality of the product. In the American context, customers show a preference for rice that complements specific dishes, whereas in the Middle East, there is a higher inclination towards long-grain, well-milled rice with a strong aroma. According to a study by (Bairagi et al., 2017), there are notable variations in rice attribute preferences among consumers in South and Southeast Asia. Rice consumers in India and Bangladesh prioritize excellent flavor and appearance when selecting rice. In contrast, customers in Southeast Asia tend to prioritize textural characteristics as their primary preference. Aroma and appearance are ranked second and third, respectively, in their list of favored qualities. The findings also demonstrate that confident women select rice with appealing looks and fragrance qualities. Lastly, family size, level of education, income, the quantity of rice consumed, and proportion of rice expenditure are main determinants of rice preference. When choosing the desired rice qualities, consumers are influenced by geographic segmentation. The preference of the consumer is also positively and considerably impacted if women make the majority of the decisions regarding food shopping. Abukari et al. (2022) conducted research that revealed that households exhibit a lower preference for imported rice compared to vending level. The study highlights that various rice attributes, including cooking time, cleanliness, color, aroma, grain size, texture, expansion capacity, and perceived nutritional benefits, play a significant role in shaping consumer preferences at both the home and vending levels. The findings suggest that when conducting research and formulating legislation aimed at reducing rice imports, it is crucial to consider the perspectives and practices of rice traders. Furthermore, the study recommends the inclusion of rice processing businesses in initiatives such as the One District One Factory (1D1F) program, which aims to promote local industrial development. By incorporating these stakeholders and their insights, policymakers and researchers can devise effective strategies to support domestic rice production and reduce the reliance on imports. In Koji State, Nigeria, according to the findings of (Ojo et al., 2019), households prioritizes their food expenditure on local rice. A sample of 120 respondents was chosen using a simple random sampling technique, and primary data was collected from local civil servants. Descriptive statistics and regression models were used as statistical tools to evaluate household position, monthly expenditure, and the factors influencing consumption preferences and the demand for local rice. The results show that 58.3% of the household's spending was on food, whereas 72.2% of families spent money on local rice each month. Most households favored local rice because of its health benefits and lure.

The primary determinants of local rice preference were family income, size, age, and food expenditure; the demand for local rice was elastic in terms of price but inelastic in terms of income. Furthermore, consumers preferred local rice due to its improved quality and the growing awareness of its nutritional advantages. The study conducted by (Bairagi et al., 2020) aimed to investigate the geographical variation in consumer preferences and the demand for essential rice quality standards across South and Southeast Asia. In 37 cities across seven countries (India, Cambodia, Indonesia, Philippines, Thailand, and Vietnam), around 4231 urban and rural consumers participated in a survey between 2013 and 2014 using logistical decline. The results show that the South and Southeast Asian consumers' preferences for rice specifications were very similar. Thai consumers in urban areas prioritized appearance and cooking qualities over taste and food benefits compared to all other consumers surveyed, and South Asian consumers largely adopted Thai preferences for the feel and smell of the rice.

This study distinguishes itself from prior research through the following key points:
1. The economic analysis of Hasawi rice remains an unexplored research topic in the eastern region of the Kingdom of Saudi Arabia, representing a novel and

pressing concern.

2. This study has investigated four types of rice, namely Hasawi rice, Basmati rice, Egyptian rice, and American rice, to assess their sensitivity to income and price changes since they represent a major commodity in the diet of Saudi consumers.

MATERIALS & METHODS

The data for this study was collected in 2023 using a questionnaire that was distributed randomly to consumers residing in the Eastern Province of Saudi Arabia. All study participants provided informed consent, and the study questionnaire was approved by Scientific Research Committed at King Faisal University (approval number: KFU-REC-2022-NOV-ETHICS327). The minimum required sample size was calculated using the Steven K. Thompson equation (Thompson, 2012) as below:

$$n = \frac{N \times p(1-p)}{\left[[N \times 1(d^2 \div z^2)] + p(1-p)\right]} \qquad (1)$$

$$n = 384.1565768 \cong 385$$

Where n is the required minimum sample size, N is the Saudi total population size equal to 43,110,821 (Saudi General Authority for Statistics, 2019), z is the standardized score equal to 1.96 at the 95% confidence level, d is the error margin and equal 0.05, and p is the probability value ranging from 0 to 1 and was set to 0.5. The minimum required sample size based on formula (1) was 385, and the total collected data after removing unreliable and missing observations reached 402. The collected data were mainly divided into two classification types. The first type was quantitative data, and the second type was categorical data. Table 1 shows the summary statistics of the collected data. Here, 44% of respondents were men and 56% were women, and the average age was 26 years old. The average household size in the sample consisted of 6 members, and almost half of the respondents (58%) held a bachelor's degree. Almost all respondents consume Basmati rice (95%), and the majority consume Hasawi and Egyptian rice (72%) and (76%), respectively. Conversely, more than half of the respondents did not consume American rice (63%). The largest consumer expenditure was allocated to Basmati rice with an average value of SAR 79, and the average purchased quantity was 6kilos. As for Hasawi rice, the average consumer spending on this type reached SAR 75 and the average purchased quantity was 3kilos.

We further explored the reasons behind the consumers' preference for Hasawi rice by asking the respondents who consumed Hasawi rice for the reasons behind their consumption. Fig. 3 shows that most of the respondents indicated that they consume Hasawi rice because it is considered to be a traditional food that is inherited from their grandparents. The other reasons behind Hasawi rice consumption have been classified in descending order according to the respondents as follows: nutritional benefits, taste, its benefits for pregnant women (childbirth), as a main meal, its price, its benefits to do with children growth, and that they enjoy preparing and cooking Hasawi rice in various forms (prepared). Conversely, most of the respondents who did not consume Hasawi rice, as shown in Fig. 4, indicated that they did not consume it because they did not know how to prepare it. The other reasons for not consuming Hasawi rice are attributed to the following in descending order: do not like its taste, do not know about it, ignorance about its nutritional benefits, expensive price, do not want to try it, unavailability in popular supermarkets, ignorance about its benefits for child growth, do not like its color, and ignorance about Hasawi rice preservation and storing methods.

Table 1: Sample Summary Statistics

Variable	N (%)	Variable	Min	Mean	Max	Sd
Gender:		Age	15.000	26.149	65.000	8.449
Male	177 (44.03%)	Household size	0.000	5.948	15.000	2.801
Female	225 (55.97%)					
Education:		EXP. Hasawi	0.000	75.487	500.000	92.271
Postgraduate Studies	42 (10.45%)	EXP. Basmati	0.000	78.564	500.000	64.704
Bachelor	234 (58.21%)	EXP. Egyptian	0.000	35.567	500.000	45.747
Diploma	31 (7.71%)	EXP. American	0.000	25.654	500.000	55.023
High School or less	95 (23.63%)	Q. Hasawi	0.000	3.017	25.000	3.262
Do you consume Hasawi rice		Q. Basmati	0.000	6.350	40.000	4.008
Yes	288 (71.64%)	Q. Egyptian	0.000	2.440	10.000	2.497
No	114 (28.36%)	Q. American	0.000	1.375	10.000	2.494
Do you consume Basmati rice						
Yes	381 (94.776%)					
No	16 (3.980%)					
Do you consume Egyptian rice						
Yes	306 (76.119%)					
No	96 (23.880%)					
Do you consume American rice						
Yes	145 (36.069%)					
No	255 (63.432%)					
Monthly Income:						
0-20000	391 (97.263%)					
20000-40000	5 (1.243%)					
40000-60000	4 (0.995%)					
60000-80000	2 (0.497%)					

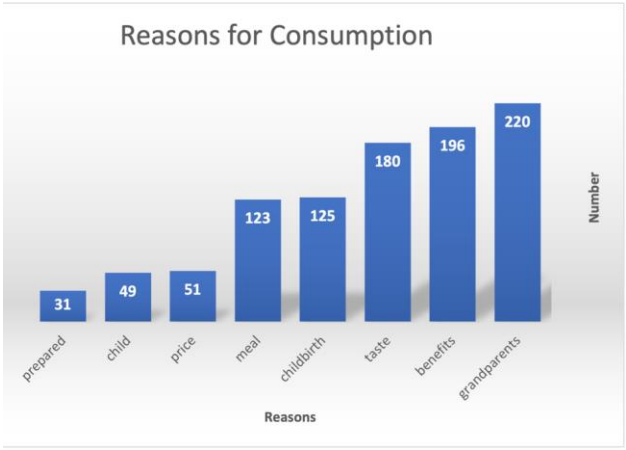

Fig. 3: Factors behind the Consumers' Preference for Hasawi Rice.

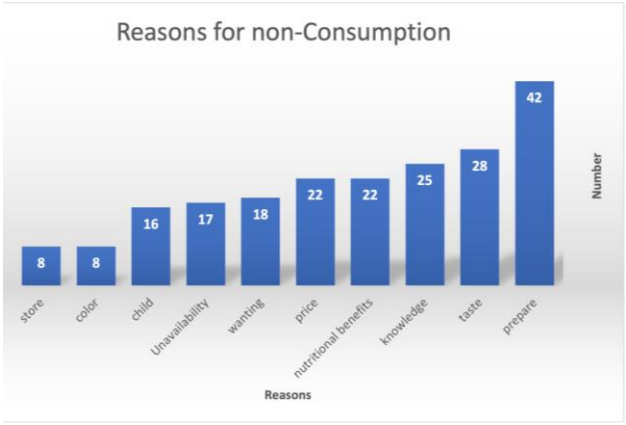

Fig. 4: Factors behind the Consumers' Aversion to Hasawi Rice.

Considering the fact that some respondents did not consume all rice varieties under consideration as shown in Table 1, our empirical strategy should take zero consumption observations (censoring) under consideration (Pan et al., 2006). Therefore, the two step estimation strategy was used (Heckman, 2015) where the first step is concerned with using the probit model to obtain the inverse mills ratios for rice variety I as below:

$$\Phi_{\text{ih}} = \frac{\theta(p_1, \ldots, p_j, d_1, \ldots, d_s)}{1 - \Theta(p_1, \ldots, p_j, d_1, \ldots, d_s)} \quad (1)$$

Where: Φ_{ih} is inverse mills ratio, θ is the standardized normal density function, $\text{and } \Theta$ = is the cumulative density function. Also, we calculated the marginal effect of the probit model parameters for the numerical independent variables as shown below (Fernihough, 2019):

$$\frac{\partial y}{\partial x_i} = \hat{\beta}_i \times \phi(X\hat{\beta}) \quad (2)$$

The marginal effect formula for the categorical variables is:

$$\frac{\Delta y}{\Delta x_i} = \Phi(\bar{X}^{-j}\hat{\beta}^{-j} + \hat{\beta}_j) - \Phi(\bar{X}^{-j}\hat{\beta}^{-j}) \quad (3)$$

In the second step, we used the inverse mills ratios (1) as an independent variable in constructing the following double log demand model (Alston et al., 2002):

$$lnQ_i = \alpha_i + \eta_1 lnp_1 + \eta_2 lnp_2 + \cdots + \eta_N lnp_N + \eta_I lnI + \text{b}_\text{i}\text{D} + \text{C}_\text{i}\Phi \quad (4)$$

Where Q_i is the quantity demanded of rice item i, p_i is the price of the rice item i, I is the consumer's income or total expenditures, and D is the vector of sociodemographic variables. Furthermore, α_i is the intercept, η_i are the own and cross price parameters interpreted as Marshallian own and cross-price elasticities, η_I is the income elasticity parameter, b_i is the regression parameter for the sociodemographic variables, and C_i is the parameter for the mills inverse ration. The double-log demand model was selected because it allows us to estimate each demand equation separately for each type of rice under investigation unlike the other competing demand models such as the Almost Ideal Demand System (AIDS), which requires estimating demand equations jointly as system of equations. This gives us the flexibility not to include the inverse mills ratios in Basmati rice demand equation because the demand for Basmati rice does not suffer from selection bias since almost all respondent consume it as shown in Table 1.

In order for the double log demand model (4) to confirm microeconomic theory, the following adding-up condition should either hold through hypothesis testing or impose on the estimation process:

$$(\eta_1 + \eta_2 + \cdots + \eta_N + \eta_I) = 0 \quad (5)$$

Since the won and cross-price elasticities of the double log demand model are Marshallian (uncompensated) elasticities, the Hicksian (compensated) elasticities can be computed via the Slutsky equation as below:

$$\eta_{ij}^{*} = \eta_{ij} + S_j\eta_I \quad (6)$$

Where η_{ij}^{*} is the Hicksian elasticity for rice variety I and s_i represents the budget share for rice variety i.

RESULTS AND DISCUSSION

We started our analysis by first estimating the probit model. We reported the marginal effect coefficients using equations (2) and (3) because they are easier to interpret, and the results for the four rice varieties are shown in Table 2.

Table 2: Marginal Effect of the Probit Model

Independent Variable	Hasawi rice	Basmati rice	Egyptian rice	American rice
Age	0.0009	8.463	3.616	0.001
	(0.003)	(8.064)	(3.078)	(0.003)
Residence AlAhsa:	0.372 ***	2.199	7.155	−0.161 ***
Yes	(0.061)	(1.915)	(5.387)	(0.062)
Education: Diploma	0.082	−4.391	−2.828	0.012
	(0.063)	(4.751)	(8.478)	(0.094)
Education: High	−0.047	−6.421 *	3.168	−0.116 **
school or less	(0.060)	(3.717)	(5.298)	(0.056)
Education:	−0.185 **	−9.323	7.750	−0.186 **
Postgraduate studies	(0.085)	(6.090)	(6.923)	(0.075)
Household size	−0.002	−3.529	−7.042	−0.013
	(0.007)	(2.819)	(8.018)	(0.009)
Average rice price	0.002 ***	1.296	6.749 ***	0.001 ***
	(0.0004)	(8.058)	(1.796)	(0.0002)
Gender: Male	–	–	−1.151 **	–
			(4.961)	

Note: ***, **, * indicate the significance levels at 1, 5 and 10%.

The results show that a consumer residing in Al-Ahsa has a higher probability of purchasing Hasawi rice and a lower probability of purchasing American rice compared to

a customer living outside Al-Aha. In addition, respondents with a postgraduate degree have a lower probability of buying both Hasawi and American rice compared to bachelor's degree holders. The change in average rice price does not affect the probability of purchasing Basmati rice. Conversely, the increase in average rice price increases the probability of purchasing other rice types, which confirms that consumers can substitute other rice types, while Basmati rice is not substitutable regardless of changes in the average rice prices. The next step in the analysis was to extract the inverse mills ratio and to estimate the double log demand model, and then to examine the adding-up condition (5) hypothesis.

The results of the adding-up condition hypothesis test as shown in Table 3 indicate the rejection of the null hypothesis at the 5% level or less for the Basmati rice and Egyptian rice demand models, respectively. Also, there is a rejection of the null hypothesis at the 10% significance level in the case of Hasawi rice. Conversely, we failed to reject the null hypothesis in the case of American rice. Thus, we imposed the adding-up condition when estimating the Hasawi rice, Basmati rice and Egyptian rice demand models. Also, when estimating the Basmati rice demand model, we didn't use the two-step estimation approach because almost all respondents (95%) consumed Basmati rice. Therefore, the dependent variable was almost observable for all observations, which indicates that the model does not suffer from self-selection bias, unlike the other rice demand models. The flexibility of the single equation demand model to make different specifications for each demand equation on a case by case basis was the main reason why we used the single equation demand model compared with other competing demand models such as the Almost Ideal Demand Model (AIDS). The results of the estimated demand models are shown in Table 4. Since the inverse mills ratios are predicted values, the regression standard errors needed to be corrected to take this fact into account (Wooldridge, 2003). Thus, the reported standard errors in Table 4 are bootstrapped standard errors. The results show that the inverse mills ratios are insignificant in all estimated rice demand models, except for the Hasawi rice demand model. This indicates no selection bias in the case of American rice and Egyptian rice. However, it does not mean that the two-step estimation approach is unnecessary in the case of these two rice varieties (Hill et al., 2019; Wooldridge, 2003). On the other hand, the goodness of fit measures, as represented by the r-squared value for the estimated models, ranged in value from 0.415 to 0.682 and the residual standard errors for all models did not exceed 0.626.

Table 3: Adding-up Condition Hypothesis Test

Rice Type	F Statistics	Decision
Hasawi Rice	3.7017*	Reject the null
Basmati Rice	85.675 ***	Reject the null
Egyptian Rice	5.588 **	Reject the null
American Rice	0.5934	Fail to reject the null

Note:***,**,* indicate the significance levels at 1, 5 and 10%.

The results of the Marshallian (uncompensated) own price elasticities for all rice varieties under investigation were negative and less than one, showing that the demand for rice in Saudi Arabia is price inelastic. Our results for the inelastic own price elasticities of rice demand are consistent with those of (Weliwita et al., 2011; Kouekam et al., 2018; Wardani et al., 2019; Onyeneke et al., 2020; Rani et al., 2020; Siddique et al., 2020; Vu, 2020; Abdulsalam et al., 2021; Yu et al., 2022, Reyes-Santiago et al., 2024, Ignanga et al., 2025). Conversely, our findings of inelastic own price elasticity for the rice disagrees with (Ojo et al., 2019; Suriani et al., 2018), who found elastic (larger than one in absolute value) own price elasticity in the rice demand. Phetcharat et al. (2025) indicated the own-price Marshallian demand elasticities for rice in rural Thailand is price elastic for all aggregated consumers' income categories. However, by disaggregating income categories of consumers into groups, the results showed that the low and upper-middle income categories face inelastic price elasticities while lower-middle, middle, and higher income categories face elastic own price categories. Regarding the rice expenditure elasticities, the results show that Hasawi rice is considered to be a luxury food item (larger than one income elasticity), while both American and Egyptian rice were identified as necessities (less than one income elasticity). Surprisingly, the expenditure elasticity of Basmati rice is almost unitary, indicating that a change in consumer income is expected to result in the same proportionate change in the consumer demand of Basmati rice. This indicates that consumers' demand for Basmati rice will maintain the same portion of consumers' expenditure even with income changes. Rice was identified as a necessity by (Weliwita et al., 2011; Ojo et al., 2019; Siddique et al., 2020; Vu, 2020; Reyes-Santiago et al., 2024, Ignanga et al., 2025). On the other hand, rice was identified as a luxury food item by (Kouekam et al., 2018; Suriani et al., 2018). (Onyeneke et al., 2020) concluded that the imported rice is a luxury food item while the local rice is considered to be a necessity in Nigeria. Furthermore, the results in Rural Thailand showed that the expenditure elasticities of rice is larger than one (Phetcharat et al., 2025). The uncompensated cross-price elasticities were all negative and significant at the 5% level or less, except for the demand for American rice with respect to the Egyptian rice price. The negative uncompensated cross-price elasticities indicate that the rice varieties under investigation are considered complements in the eyes of consumers, not substitutes.

To further investigate the relationship among the rice varieties with more precision, we report the results of the Hicksian (compensated) cross-price elasticities in Table 5. The results of the compensated elasticities differ from the uncompensated ones as follows: 1) Basmati and Egyptian rice are a substitute for Hasawi rice, 2) American rice is a substitute for Basmati rice, 3) all rice varieties were identified as a substitute for Egyptian rice. We can conclude from the results of the Marshallian and Hicksian elasticities that Saudi consumers purchase the four rice varieties with the intention of using them for different purposes, either to complement or substitute one for another. For example, Hasawi rice is mainly consumed by consumers living in Al-Ahsa on an irregular basis, Basmati is the main rice mostly used for lunch or dinner in Saudi

Arabia, Egyptian rice is used with other dishes such as toasted vermicelli or grape leaves stuffed with rice, and American rice can be used for making some rice recipes such as bukhari and kabsah, as is the case with Basmati rice. Rice was found to be a complement product with spaghetti (Kouekam et al., 2018) and beans (Zanin et al., 2019) while (Tenriawaru et al., 2021) identified domestic rice as a substitute for imported rice in Nigeria. (Abdulsalam et al., 2021) stated that wheat is a substitute product for rice.

Table 4: Double Log Demand Model Coefficient Estimates for Rice Varieties

Independent Variable	Hasawi Rice	Basmati Rice	Egyptian Rice	American Rice
Intercept	-2.893***	-1.956***	-1.333	-1.653*
	(0.479)	(0.372)	(0.681)	(0.955)
Hasawi Rice Price	-0.680***	-0.157***	-0144***	-0.271***
	(0.045)	(0.022)	(0.033)	(0.056)
Basmati Rice Price	-0.421***	-0.702***	-0.192***	-0.197**
	(0.044)	(0.033)	(0.052)	(0.090)
Egyptian Rice Price	-0.127***	-0.084***	-0.495***	-0.262***
	(0.028)	(0.022)	(0.051)	(0.080)
American Rice Price	-0.154***	-0.140***	0.028	-0.263**
	(0.023)	(0.018)	(0.027)	(0.119)
Total Expenditure	1.381***	1.082***	0.803***	0.920***
	(0.064)	(0.047)	(0.073)	(0.112)
Gender: Male	0.165**	-0.089***	0.224***	0.044
	(0.064)	(0.054)	(0.080)	(0.118)
Age	-0.063	0.047	0.173	0.094
	(0.109)	(0.094)	(0.136)	(0.218)
Residence: AlAhsa	-0.052	0.310***	-0.727	-0.422
	(0.224)	(0.148)	(0.348)	(0.501)
Residence: Dammam, Dharan, Khobar	0.101	0.191*	-0.715	-0.559
	(0.242)	(0.155)	(0.351)	(0.497)
Residence: Jubail	0.095	0.341***	-0.421	-0.214
	(0.271)	(0.199)	(0.390)	(0.588)
Residence: Other	0.076	0.551***	-0.467	-0.515
	(0.393)	(0.192)	(0.425)	(0.511)
Education: Diploma	0.034	-0.107	-0.240*	-0.418**
	(0.101)	(0.085)	(0.128)	(0.222)
Education: High school or less	-0.037	0.073	-0.233**	-0.089
	(0.069)	(0.058)	(0.087)	(0.170)
Education: Postgraduate studies	-0.011	-0.037	0.094	-0.233
	(0.104)	(0.080)	(0.113)	(0.194)
Household Size	0.029	-0.033	0.043	0.124
	(0.057)	(0.047)	(0.072)	(0.107)
Mills Ratio	0.072*	-	-0.047	-0.041
	(0.042)		(0.064)	(0.122)
Residual Standard Error	0.445	0.4785	0.574	0.626
R-squared	0.671	0.682	0.449	0.415
Adjusted R-squared	0.666	0.607	0.438	0.341

Note: ***, **, * indicate significance levels at the 1%, 5%, and 10%.

Table 5: Hicksian (Compensated) Demand Elasticities

Rice Type	Hasawi Rice Price	Basmati Rice Price	Egyptian Rice Price	American Rice Price
Hasawi Rice	-0.278***	0.189***	0.114**	-0.022
	(0.041)	(0.045)	(0.028)	(0.023)
Basmati Rice	0.158***	-0.224***	0.105***	-0.039***
	(0.017)	(0.034)	(0.022)	(0.018)
Egyptian Rice	0.089**	0.162*	-0.355***	0.104**
	(0.026)	(0.054)	(0.051)	(0.027)
American Rice	-0.004**	0.209**	-0.102*	-0.176**
	(0.046)	(0.088)	(0.071)	(0.0734)

Note:***,**,* indicate the significance levels at 1%, 5%, and 10%.

The results for the explanatory variables intended to measure the impact of the socio-economics factors on rice demand in Saudi Arabia show that age and household size do not have a significant influence on the rice demand in Saudi Arabia. This confirms the fact that Saudi consumers' will continue demanding rice regardless of their age or households size. (Weliwita et al., 2011; Kouekam et al., 2018; Suriani et al., 2018; Ojo et al., 2019; Wardani et al., 2019; Ignanga et al., 2025) found that household size significantly influences rice demand. Also, (Wardani et al., 2019) indicated that age is a significant determinant of rice demand in Indonesia. On the other hand, the results show that gender has a significant influence on rice variety consumption. The results indicate that men consume more Hasawi and Egyptian rice compared to women, while women consume more Basmati rice compared to men. Conversely, gender is not significant determinant of American rice consumption. Furthermore, we noticed that place of residence only influences Basmati rice consumption. Indeed, consumers residing in Al-Ahsa, Dammam, Dharan, Khobar, Jubail, and other cities in Eastern province of Saudi Arabia will consume more quantity of Basmati rice compared to consumers residing in Abqaiq. Respondents holding a diploma degree (associate degree) and those whose level of education was high school or less, on average, consume less Egyptian and American rice compared to the respondents holding a bachelor's degree.

Conclusion

Rice is considered to be a main meal in Saudi Arabia and is consumed almost on a daily basis. Due to the importance of rice in the Saudi consumers' diet, the purpose of this paper was to investigate the factors influencing rice demand in Saudi Arabia using a random sample of 402 respondents residing in the Easter Province of Saudi Arabia. The paper examined the demand for the four types of rice commonly consumed in the Eastern Province of Saudi Arabia, namely: Hasawi rice (Oriza Sativa L.), Basmati rice, Egyptian rice, and American rice. Also, this paper investigated the factors that motivate consumers to consume Hasawi rice, and the results showed that Hasawi rice image as a traditional inherited food alongside its nutritional benefits were the highest factors motivating consumers to consume it. On the other hand, consumer's lack of awareness about Hasawi rice cooking and preparation methods were the highest obstacle preventing potential consumers from consuming Hasawi rice. In order to deal with the self-selection bias resulting from consuming certain rice varieties, this paper used the two-step estimation approach where in the first step the probit model was used to extract the inverse mills ratios associated with the probability of consuming certain rice varieties. In the second step, we used the double-log demand model to estimate the own and cross-price elasticities of rice demand as well as identify the factors affecting rice demand in Saudi Arabia. The results show that the demand for the four rice varieties under investigation was price inelastic (negative and less than one own-price elasticity). Although, the uncompensated cross-price elasticities showed that all rice varieties in Saudi Arabia are considered to complement and not substitute for Basmati rice, the compensated cross-price elasticities show that the only rice variety that can substitute for Basmati rice is American rice. Also, the income elasticities show that Hasawi and Basmati rice are considered luxury rice items, while

Egyptian and American rice are considered necessities. Also, the results show that, on average, men consume Egyptian and Hasawi rice more than women while women consume Basmati rice more than men. Furthermore, place of residence and education were found to be significant determinants of rice consumption.

The main limitation of this study is its reliance on consumer self-reporting survey data, which is prone to reporting errors. For future research, we recommend using scanner data to investigate rice demand in Saudi Arabia. Also, this study recommends that decision-makers try to increase consumers' awareness in Saudi Arabia about Hasawi rice as a potential rice variety that could complement or at least partially replace Basmati rice by educating them about its cooking and preparation methods.

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Author's Contribution: HA and MA conceived and designed the study. HA and MA performed the study. HA and MA conducted data analyses. MA supervised and coordinated the study and HA provided respondents data. HA and MA performed statistical analyses of collected data. HA and MA prepared the draft of the manuscript. All authors critically revised the manuscript and approved the final version.

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