RESEARCH ARTICLE

QUADRATIC ALMOST IDEAL DEMAND SYSTEM ANALYSIS OF DEMAND FOR SELECTED VEGETABLES AND FRUITS IN NIGERIA

Obisesan AA

Federal University of Technology Akure, Ondo State, P.M.B 704, Akure, Ondo State, Nigeria

Received: 26 November 2022, Accepted: 02 May 2023, Published: 30 June 2023

ABSTRACT

This study analyzed the demand for selected vegetables and fruits in Nigeria. It determined price effects on demand for fruits and vegetables, examined the demographic variables influencing demand and revealed the expenditure elasticity across income quartiles and sectors. Data from the three waves of Living Standard Measurement Survey-Integrated Survey on Agriculture namely 2010/11, 2012/13 and 2015/16, were employed in the analysis. The demand for bananas, citrus, pineapples, fresh okra, onions pepper and tomatoes was examined using the Quadratic Almost Ideal Demand System. Households in Nigeria consumed more vegetables than fruits. The results revealed that the staple vegetables in Nigerian diets are tomatoes, onions and pepper. It was observed that movement in relative prices elicited high quantity response. All the fruits and vegetables included in the model were normal goods. Vegetables and fruits responded similarly to expenditure increases in urban and rural Nigeria. The own-price elasticities, both uncompensated and compensated agree with the demand theory. More consideration should be given to the intensifying production of fruits and vegetables in technology development and investment to make them available and affordable.

Keywords: Demand elasticity, Food, Income, Nutrition security, Price

INTRODUCTION

Malnutrition continues to be a major burden to the international community (World Health Organization [WHO] 2020). In emerging nations, roughly 13 percent of the populace is undernourished. In 2019, two billion individuals regularly lack access to sufficient, nutritious and safe food (Food and Agriculture Organization [FAO] 2020). According to Luchuo *et al.* (2013), malnutrition contributes significantly to high mortality rate of children worldwide.

Nutrition is getting worse in many African nations with 19.1% of the population being undernourished (FAO 2020). Over 23% of the population (210 million) in Sub-Saharan Africa (SSA) are undernourished and poor nutrition is the leading cause of death particularly in children under the age of five (FAO 2015). In SSA, over 50% lack the resources to eat healthy diets (World Food Programme (WFP), 2020).

Fruits and Vegetables (FV) are essential components of a healthy diet. They have health-enhancing properties. According to WHO, there is inverse relationship between increased consumption of FV and increased risks of Non-Communicable Diseases (NCDs) (WHO 2020). In 2017, 3.9 million deaths were linked to insufficient consumption of FV (WHO 2020). Hence, WHO recommends consumption of more than 400g of FV in a day to enhance good health and reduce risks of some NCDs. Findings have further shown that high consumption of FV ward off chronic illnesses such as heart diseases and specific cancers (Liu 2003). Intake of fruits and vegetables has been positively linked to increase in birth weight (Rao *et al.* 2001; Mikkelsen *et al.* 2006; Loy *et al.* 2011).

*Corresponding author: kemi_triumph@yahoo.com

According to Hall *et al.* (2009), the daily recommended amount of vegetables and fruits is not met by Africans. In contrast to high-income nations, low-income countries (including Nigeria) rely more on basic foods and less on fruits and vegetables (FAO *et. al.* 2020). According to Global Food Policy Report (2015), the majority of African countries' children who are stunted live in Nigeria. Therefore, going by the growing thrust to improve nutrition by 2030, which is substantiated by the second sustainable development goal (SDG 2), it is of vital importance to examine households' consumption of vegetables and fruits on a disaggregated basis in order to ensure nutrition security and healthy diet in Nigeria. This will have implications on the national food policy interventions in the country.

Hence, this study explores households' demand of selected vegetables and fruits in Nigeria. There are previous studies on fruits and vegetables demand in developed and developing countries (Mutuc *et al.* 2007; Tey *et al.* 2009; Bundi *et al.* 2013) to name a few. Similarly, in Nigeria, Tsegai and Kormawa (2009), Akinleye (2009), Ogundari and Arifalo, (2013), Otunaiya and Shittu (2014) have explored food demand in Nigeria with the aid of double logarithms function, double hurdle, almost ideal demand system and its variants while Obayelu *et al*. (2009), Fashogbon and Oni (2013), Khaliukova (2013) and Obisesan (2019) used quadratic almost ideal demand system. However, these studies with the exception of Khaliukova (2013), Ogundari & Arifalo (2013), and Obisesan (2019) took into account the entire food basket and viewed FV as a group of food item in the demand system. Therefore, this study distinguishes itself from previous studies on the demand for vegetables and fruits in Nigeria by using panel data, the three waves of the Living Standard Measurement Survey-Integrated Survey on Agriculture (LSMS-ISA) namely 2010/11, 2012/13 and 2015/16. It employs QUAIDS within a panel framework to estimate the price and income elasticities of different fruits and vegetables in Nigeria following (Banks *et al*. 1997). However, the research issue of estimating demand elasticity of vegetables and fruits on a disaggregated basis nationally and across sectors and income quartiles is crucial in order to have a more thorough understanding of how domestic food policy initiatives affect consumption (Mutuc *et al.* 2007). Therefore, this study achieved the following objectives:to determine the households' demand for vegetables and fruits response to changes in income and price; to estimate the expenditure elasticity across income quartiles and sectors and to isolate the household's demographic factors influencing fruits and vegetables demand in Nigeria.

MATERIALS AND METHODS

Data

The study utilized secondary data of the three waves of the Living Standard Measurement Survey-Integrated Survey on Agriculture (LSMS-ISA) namely 2010/11, 2012/13 and 2015/16 (World Bank 2017). Based on the agricultural seasons, there were two visits per year namely post-planting, September-November, and post-harvest, February-April. Detailed information were collected in the survey on the quantities of household food consumption from gifts, own consumption and purchases. The amount spent each week on food purchases by the households was reported. Prices were derived from transaction data and then used to impute values to own-production and gifts. The data used in this study include prices, age, household size, sex, marital status, educational attainment, households' consumption of vegetables and fruits and households' food expenditure.

Quadratic Almost Ideal Demand System

In empirical analysis, QUAIDS approximates non-linear Engel curves more accurately than other demand system analyses. Furthermore, the study used a modified routine of Poi (2012) which allows the inclusion of demographic variables to the model, and compute expenditure and price elasticities. This helps in controlling for factors such as gender, age, education and rural or urban residence which may affect the quantity of fruits and vegetables demanded. The empirical demand system which have been developed to accommodate the expenditure nonlinearity include QUAIDS model developed by Banks *et al*. (1997), which features budget shares that are quadrat-

ic in log total expenditure. The QUAIDS model is a generalization of Price Invariant Generalized Logarithmic (PIGLOG) preferences based on the following indirect utility (V) function:

$$\ln V = \left\{ \left[\frac{\ln x - \ln a(p)}{b(p)} \right]^{-1} + \lambda(p) \right\}^{-1} \quad \text{..}$$

……..Eqn 01

Where: x is total expenditure, **p** is a vector of prices (in Naira), a(**p**) is a function that is homogenous of degree one in prices, and b(**p**) and λ (**p**) are functions that are homogeneous of degree zero in prices. As in the original AIDS model, ln a(**p**) and ln b(**p**) are specified as the translog and Cobb-Douglas equations:

$$\ln a(p) = \alpha_0 + \sum_{i=1}^{K} \alpha_i \ln p_i + \frac{1}{2} \sum_{i=1}^{K} \sum_{j=1}^{K} \gamma_{ij} \ln p_i \ln p_j$$

……..Eqn 02

$$b(p) = \prod_{i=1}^{K} p_i^{\beta_i} \text{ .....Eqn 03}$$

Where, i=1, …….K denote commodities. The function λ (p) is specified as:

$$\lambda(p) = \sum_{i=1}^{K} \lambda_i \ln p_i \text{ .....Eqn 04}$$

Where,

$$\sum_{i=1}^{K} \lambda_i = 0$$

The QUAIDS budget share equations results from the application of Roy's identity to (equation 1). The linear demographic translating method will be used to incorporate demographic variables (z) into the QUAIDS model. This controls for varying preference structures and heterogeneity across households, resulting to the following empirical specification of the QUAIDS budget share equations:

$$w_i = \alpha_i + \sum_{j=1}^{K} \gamma_{ij} \ln p_j + \beta_i \ln \left[\frac{x}{a(p)} \right] + \frac{\lambda_i}{b(p)} \left\{ \ln \left[\frac{x}{a(p)} \right] \right\}^2 + \sum_{s=1}^{L} \delta_{is} z_s$$

……..Eqn 05

Where: $z_s = (z_1, \ldots\ldots\ldots, z_L)$ is a set of demographic variables and w_i is the budget share of the i^{th} item. By differentiating the budget share equations with respect to ln x and ln pj, respectively, we obtain the formulas for the QUAIDS expenditure and price elasticities.

A probit regression analysis is done in order to estimate the probability that a given household consumes the individual fruit and vegetable in question. In order to address any bias that may have been caused by the presence of zero consumption, this regression is then utilized to produce the Inverse Mills Ratio (IMR) for each household. (Heien and Wessels, 1990).

$$w_i = \alpha_i + \sum_{j=1}^{K} \gamma_{ij} \ln p_j + \beta_i \ln \left[\frac{x}{a(p)} \right] + \frac{\lambda_i}{b(p)} \left\{ \ln \left[\frac{x}{a(p)} \right] \right\}^2 + \sum_{s=1}^{L} \delta_{is} z_s \ldots\ldots + IMR_i$$

……..Eqn 06

Using the intermediate results, the expressions for the elasticity formulas is simplified as follows:

$$\mu_i \equiv \frac{\partial w_i}{\partial \ln x} = \beta_i + \frac{2\lambda_i}{b(p)} \left\{ \ln \left[\frac{x}{a(p)} \right] \right\}$$

……..Eqn 07

$$\mu_{ij} \equiv \frac{\partial w_i}{\partial \ln p_j} = \gamma_{ij} - \mu_i \left(\alpha_j + \sum_{i=1}^{K} \gamma_{ji} \ln p_i \right) - \frac{\lambda_i \beta_j}{b(p)} \left\{ \ln \left[\frac{x}{a(p)} \right] \right\}^2$$

……..Eqn 08

The formula for expenditure elasticities can be expressed in terms of the μ_i as:

$$e_i = 1 + \frac{\mu_i}{w_i} \text{ .....Eqn 09}$$

The expression for the Marshallian or uncompensated price elasticities can be written as:

$$e_i = \frac{\mu_{ij}}{w_i} - \delta_{ij} \text{ .....Eqn 10}$$

Where δ_{ij} = the Kronecker delta. The compensated or Hicksian price elasticities are derived from the Slutsky equation:

$$e^c_{ij} = e^u_{ij} + w_j e_i \text{ .....Eqn 11}$$

Variables definition

The independent variables included in the model are Sex (male-1, female-0) and age of the household head (years), household size (number), educational status of the household head (educated=1, 0 otherwise), sector (urban=1, 0-otherwise), prices of tomatoes, pepper, onion, okra, banana, pineapples and citrus (Naira); household's expenditure on fruits and vegetables (Naira) and income.

RESULTS AND DISCUSSION

Fruits and vegetables consumption in Nigeria

Over 90% of the households had at least one type of FV included in their weekly food consumption in the survey period. The proportion of households consuming FV increased from 85.8 in 2010 to 97.8 in 2015 (Table 1). Urban households consumed more of fruits and vegetables than rural households. Urban residents might have better knowledge about the health benefits of FV. Nigerian households consumed more vegetables than fruits from 2010-2015 (Table 2). From the results, on the average, 74.9% of Nigerian households consumed onions with average quantity of 0.92kg, pep-

Table 01: Share of households consuming fruits and vegetables in Nigeria

Year	All	Urban	Rural
2010	85.8	89.6	84.2
2012	96.2	97.7	95.5
2015	97.8	98.7	97.3

Source: Author's estimation

Table 02: Households consuming fruits and vegetables in Nigeria by FV Types(%)

Year	Tomatoes	Pepper	Onion	Okra	Banana	Citrus	Pineapple
2010 All	69.3	73.5	76.4	39.7	14.8	12.9	6.07
RURAL	63.6	70.6	74.9	32.8	12.9	10.6	4.8
URBAN	80.3	79.3	79.2	53.2	18.5	17.7	9.9
2012 All	66.9	69.3	85.9	44.6	14.1	20.8	4.9
RURAL	60.6	64.5	89.1	45.9	12.3	17.9	3.7
URBAN	80.8	79.9	84.5	41.7	18.2	27.4	7.7
2015 All	75.3	69.4	92.5	47.5	20.3	26.2	5.2
RURAL	69.7	63.6	91.5	45.2	24.7	23.7	4.0
URBAN	87.1	81.4	93.9	48.6	18.3	31.5	7.7

Source: Author's estimations

*FV types means Fruits and Vegetable types

per was consumed by 70.7% households with average quantity of 0.65kg, 69.0% households consumed tomatoes with mean quantity of 1.60kg, okra was consumed by 40.6% with an average quantity of 0.68kg while 19.0%, 15.5% and 5.24% consumed citrus (2.01kg), banana (1.64kg) and pineapple (2.6kg) respectively from 2010-2015. Furthermore, Table 2 reveals that households consuming the fruits and vegetables considered in the study (except okra) were higher in the urban sector than rural irrespective of the fact that their production is more concentrated in the rural areas.

Estimated parameters of the QUAIDS model

Some households in the LSMS-ISA data used in the study recorded zero expenditure in the survey. Three major factors have been identified in the literature as potential causes of zero expenditures in data at household level: households may never consume the good of interest; some households may have zero consumption of the commodity during limited survey period; thirdly due to the fact that it is not the best course of action, given the current situation with respect to prices and income, some households may chose not to report consuming the commodity (Meyerhoefer *et al.* 2005; Tafere *et al.* 2011). A two stage estimation approach was used to address this problem. The first stage involved using probit regression to capture household (h) decision to demand the specific commodity (i) or not. The Inverse Mills Ratio (IMR) for each household was later derived using the estimate of the maximum likelihood. In the second stage, in order to include the censoring latent variable in the regression, the IMR was used as an independent variable (Heins and Wessels 1990; Bundi *et al.* 2013) see eq. 6.

Table 3 displays the QUAIDS model's estimated parameters. Out of the 28 price effects, 17 are significant, indicating that Nigerian households have a high quantity response to movements in relative prices. This could be as a result of the disaggregation of the fruits and vegetables which allows for a better understanding of how sensitive households are to price changes than when treated as a food group.

The expenditure coefficients (LNEXP and $LNEXP^2$) which are the Beta and Lambda (λs) components of the equation show the linear nature of the demand (since AIDS is nested in QUAIDS (eq. 6). The $LNEXP^2$ are the quadratic terms, thus testing if all λs equal zero in the model. This examines whether the AIDS model or the QUAIDS better fits the data. From the results, the coefficients of (λ) for the different fruits and vegetables considered are significant suggesting that the QUAIDS model fits the data more accurately than the AIDS. This shows that, there is non-linear relationship between the demand for all the fruits and vegetables and a rise in total expenditure, strongly supports the rejection of the zero quadratic expenditure term hypothesis. This demonstrates how the QUAIDS model is more appropriate than the conventional AIDS model.

In addition, Table 3 showed how demographic variables affect the household's demand for the various fruits and vegetables. Thirty of the demographic factors' effect estimates (out of forty-two) are statistically different from zero. The household head's age has positive and significant effect on the demand for citrus ($p<0.1$), onion ($p<0.01$), and pineapple ($p<0.1$) while it has negative effect on tomatoes ($p<0.05$) as well as banana and okra at 5% and 10% significant level respectively. Larger households consume more tomatoes and pepper while those with small sizes consume more fruits. This is because practically all other food categories are consumed with stew made of peppers and tomatoes in Nigeria. This, however, is not in tandem with Khaliukova (2013), who claimed that consumption of tomatoes and pepper in Nigeria, decreases with family size. The low consumption of fruits by households with large size could be regarded to as economic non-consumption that is, due to economic recession/ high poverty rate in Nigeria. This authenticates the fact that economic downturns undermine nutrition security in Nigeria.

Table 03: Estimated parameters of the QUAIDS model

Variables	Tomatoes	Pepper	Onion	Banana	Okra	Citrus	Pineapple
Constant	-0.3362* (0.3319)	-0.0110 (0.0451)	0.5097* (0.0350)	0.3046* (0.0309)	-0.1241* (0.0387)	0.3915* (0.0295)	0.2656* (0.1894)
PTOMA	0.1138* (0.0125)						
PPEPR	0.0303* (0.0079)	0.0008 (0.0057)					
PONION	-0.1166* (0.0080)	-0.0132* (0.0068)	0.1001* (0.0089)				
PBANA	-0.0036 (0.0059)	-0.0128* (0.0030)	0.0063 (0.0047)	-0.0084* (0.0038)			
POKRA	0.0608* (0.0067)	0.00078 (0.0034)	-0.0508* (0.0060)	0.0008 (0.0031)	0.1183** (0.0051)		
PCITRU	-0.0507* (0.0059)	-0.0048 (0.0039)	0.0450* (0.0045)	0.1834* (0.0032)	-0.0113* (0.0036)	0.0028 (0.0061)	
PPINE	-0.0340* (0.0038)	-0.0010 (0.0026)	0.0291* (0.0030)	-0.0006 (0.0025)	-0.0121* (0.0024)	0.0062 (0.0047)	0.0123** (0.0049)
LNEXP	-0.1642* (0.0077)	-0.0425 (0.0101)	0.1467* (0.0073)	0.0218 (0.0070)	-0.0689 (0.0088)	0.0613 (0.0067)	0.0464* (0.0044)
$LNEXP^2$	-0.0142* (0.0005)	-0.0030* (0.0006)	0.0152* (0.0004)	0.0004* (0.0003)	-0.0033* (0.0005)	0.0029* (0.0004)	0.0020* (0.0002)
Age	-0.0003** (0.0002)	0.0002 (0.0001)	0.0004*** (0.0002)	-0.0001** ($8.67e^{-04}$)	-0.0006* 0.0001	0.0004* ($8.74e^{-04}$)	0.0002* ($5.61e^{-04}$)
Sex	-0.0004 (0.0007)	-0.0004 (0.0006)	0.0001 (0.0008)	-0.0001 (0.0004)	0.0008*** (0.0005)	0.0002 (0.0003)	-0.0002 (0.0002)
House-hold size	0.0002** ($8.33e^{-05}$)	0.0004* ($7.4e^{-05}$)	-0.0002** (0.0001)	-00001 (4.43^{e-05})	-0.0003 (5.38^{e-05})	-0.0001* (4.19^{e-05})	4.99^{e-06} ($2.67e^{-05}$)
Educa-tional sta-tus	0.0019* (0.0006)	0.0018* (0.0005)	0.0015** (0.0007)	0.0023* (0.0003)	0.0021* (0.0004)	0.0007** (0.0003)	0.0001 (0.0002)
Sector	0.0052* (0.0008)	0.0005 (0.0007)	0.0047* (0.0009)	-0.0038* (0.0004)	-0.0035* (0.0006)	-0.0020* (0.0005)	-0.0011* (0.0004)
Zone	-0.0003 (0.0006)	-0.0057* (0.0005)	0.0082* (0.0006)	-0.0011* (0.0003)	-0.0008** (0.0004)	0.0011* (0.0003)	-0.0014* (0.00018)

Source: Author's estimations.

*,**,*** indicate level of significance at 1%,5% and 10%, respectively. Standard errors are in parenthesis. All prices are in logarithms, PTOMA=price of tomatoes, PPEPR=price of pepper, PONION= price of onion, PBANA=price of banana, POKRA=price of okra, PCITRU= price of citrus, PPINE= price of pineapple. LNEXP= logarithm of total food expenditure,
$LNEXP^2$= square of logarithm of total food expenditure

Nearly every item's demand is positively and significantly affected by educational status. Education improves the understanding of the health advantages of fruits and vegetables. The results show that being educated increases the consumption of pepper ($p<0.01$), onions ($p<0.05$), tomatoes ($p<0.01$), banana ($p<0.01$), okra ($p<0.01$) and citrus ($p<0.05$) by 0.0019, 0.0018, 0.0015, 0.0023, 0.0021, and 0.0007 respectively. Furthermore, urban households demand more fruits and vegetables than their rural counterparts. This might be due to higher poverty rate in rural Nigeria.

The expenditure elasticities of demand

The expenditure elasticity of demand reveals the relationship between percentage change in good's demand and the percentage change in income. Table 4 lists the expenditure elasticities for the various vegetables and fruits. Since every FV has positive elasticity, they are all considered to be normal goods. This

Table 04: Expenditure elasticities

FV types	Elasticities
Tomatoes	1.14
Pepper	0.98
Onion	0.61
Banana	1.70
Okra	1.01
Citrus	1.49
Pineapple	2.09

FV means Fruits and Vegetables

conclusion is in line with that of Fashogbon and Oni (2013) and Obisesan (2019) that vegetables and fruits are normal goods in Ondo state, Nigeria and urban Nigeria respectively. For banana, okra, citrus, tomatoes and pineapples, the expenditure elasticities are greater than unity, but less than unity for onions and pepper. The results indicate that onions and pepper are expenditure inelastic while others are expenditure elastic. A 10% rise in income will increase demand for banana and citrus by 17.0% and 14.9% respectively. Pineapple's high expenditure elasticity (2.09) indicates that it is a more desired fruits variety.

Expenditure elasticity across income quartiles and sectors

Considering the expenditure elasticity across the income quartiles, Table 5 shows similar but reducing expenditure elasticity for the different fruits and vegetables. In contrast to pepper and onion, which are inelastic across all the income groups, okra, tomatoes, banana, citrus and pineapple are expenditure elastic. Furthermore, the table reports similar fruits and vegetables responsiveness to expenditure increases across sector (rural and urban) and zone (north and south). However, the demand for okra (1.0606) is expenditure elastic in the rural Nigeria while it is inelastic in urban (though close to unity). In the same vein, okra (1.0727) and pepper (1.0345) are expenditure elastic in the north while they are inelastic in the south.

Own- and cross-price elasticities of vegetables and fruits in Nigeria

The compensated (Hicksian) and uncompensated (Marshallian) expenditure elasticities estimates are presented in Tables 6 & 7 respectively. The estimations on the diagonal represent the various fruits and vegetables' individual price elasticity. Negative estimates are observed for both compensated and uncompensated own-price elasticities. This demonstrates that they adhere to the demand theory. All fruits and vegetables, with the exception of pineapple, have own-price elastic demand, according to estimations of uncompensated price elasticity. According to the findings, the quantity demanded for tomatoes, peppers, and onions will decrease by 1.20,1.05, and 1.04 accordingly for every 1% increase in price. Compared to the uncompensated own-price elasticities, the compensated ones have lower absolute values (Table 6). The degree to which demand for all fruits and vegetables responds to changes in their prices is significantly influenced by income.

The Marshallian cross price elasticities of fruits and vegetables revealed a combination of complementary and substitution relationships. For instance, pepper and tomatoes have a complimentary connection (-0.74), meaning that for every 1 percent increase in tomato price, there will be a 0.74 percent fall in pepper demand.

Table 05: Expenditure elasticities across income quartiles

FV items	I	II	III	IV	ALL
Tomatoes	1.2977	1.1800	1.1777	1.0691	1.1449
Pepper	0.9848	0.9833	0.9434	0.8970	0.9801
Onion	0.6491	0.6075	0.6382	0.6677	0.6152
Banana	1.6867	1.6310	1.5781	1.5097	1.7020
Okra	1.1185	1.0527	1.0119	1.0112	1.0162
Citrus	1.6770	1.3292	1.3444	1.3191	1.4923
Pineapple	2.0421	1.9550	1.9440	1.7617	2.0935
Expenditure	**Elasticity by**	**Region**			
	Rural	**Urban**		**North**	**South**
Tomatoes	1.2377	1.0076		1.1679	1.1246
Pepper	0.9907	0.9211		1.0345	0.9183
Onion	0.5935	0.6951		0.6336	0.5869
Banana	1.7349	1.7257		1.8265	1.7068
Okra	1.0606	0.9433		1.0727	0.9387
Citrus	1.4498	1.4859		1.5525	1.4400
Pineapple	2.2104	2.0476		2.1914	2.2083

Source: Author's estimations.
The Roman numerals indicate income quartiles in ascending order from lowest income to highest income quartile

Table 06: The Marshallian / uncompensated elasticity of demand

FV	Tomatoes	Pepper	Onion	Banana	Okro	Citrus	Pineap-ple
Tomatoes	**-1.20**	-0.74	0.33	0.05	0.04	-0.01	0.01
Pepper	-0.05	**-1.05**	-0.09	-0.02	-0.05	0.05	0.04
Onion	-0.21	-0.16	**-1.04**	0.01	-0.02	0.05	0.02
Banana	0.23	-0.27	-0.27	**-1.43**	0.14	0.13	-0.23
Okro	0.18	-0.12	-0.17	0.08	**-1.01**	0.04	-0.02
Citrus	-0.17	0.16	0.14	0.14	0.05	**-1.60**	0.21
Pineap-ple	-0.29	0.53	0.14	0.74	-0.24	0.68	**-0.82**

Source: Author's estimations

Table 07: Hicksian /compensated elasticities of demand

FV	Tomatoes	Pepper	Onion	Banana	Okro	Citrus	Pineapple
Tomatoes	**-0.84**	0.19	0.35	0.10	0.15	0.04	0.02
Pepper	0.25	**-0.83**	0.36	0.02	0.05	0.09	0.06
Onion	0.40	0.30	**-0.87**	0.03	0.04	0.08	0.03
Banana	0.76	0.11	0.20	**-1.36**	0.30	0.20	-0.20
Okra	0.49	0.11	0.11	0.13	**-0.91**	0.08	-0.004
Citrus	0.29	0.50	0.54	0.20	0.19	**-1.54**	-0.19
Pineapple	0.36	1.00	0.71	-0.65	-0.03	-0.59	**-0.80**

Source: Author's estimations

CONCLUSIONS

The study used data from the three waves of the LSMS-ISA namely 2010/11, 2012/13 and 2015/16, to analyze Nigerian households' demand for fruits and vegetables using QUAIDS. Bananas, pineapples, citrus, tomatoes, onions, fresh okra, and pepper are the fruits and vegetables taken into consideration. Relative price changes are accompanied by a strong quantity response. Every fruit and vegetable taken into consideration are normal items. Onion and pepper are necessity goods in the households, whereas tomatoes, okra, bananas, citrus, and pineapple are luxury commodities. Households' demographic factors affect demand for fruits and vegetables in Nigeria. There is high sensitivity to price changes especially among low-income groups. Expenditure elasticity for the different fruits and vegetables was similar though reducing across the income quartiles. Although pepper and onion are inelastic across all income groups, tomatoes, okra, banana, citrus, and pineapple are expenditure elastic. There is similar fruits and vegetables responsiveness to expenditure increases across sector (rural and urban) and zone (north and south). The demand theory is supported by the fact that all own-price elasticities, both compensated and uncompensated, are negative. Changes in the price of fruits and vegetables are met with a greater-than-proportional response from Nigerian households. Fruits and vegetables have a mix of substitutive and complimentary relationships. The response of demand for all fruits and vegetables to changing prices is significantly influenced by income. The study suggests interventions that stabilize prices and boost income in Nigeria. Prompt attention should be given to enhancing households' income in Nigeria especially among the low-income groups. Consumption of fruits should be included in the school feeding programme. The study further suggests more attention on nutrition- sensitive food system that can promote and sustain healthy and diverse diets.

ACKNOWLEDGMENTS

The author appreciates Dr. Saweda Liverpool-Tasie who initiated the AAEA Africa Early Career Scholarship mentoring programme and her mentors, Prof. Derek Byelee and Dr. Tewoja Mogues for their immense contributions to the study.

AUTHOR CONTRIBUTION

OAA designed the study, collated the data, analyzed the data and discussed the results.

REFERENCES

Akinleye SO 2009 Food demand in Northern Nigeria: Implications for food policy. Journal of Social Science, 18: 209–215.

Banks J, Blundell R and Lewbel A 1997 Quadratic engel curves and consumer demand. The Review of Economics and Statistics, 79: 527–539.

Bundi MK, Nzuma J and Mbatia OLE 2013 Urban demand for smallholder crops: the Case of fruits and vegetables in Nairobi, Kenya. https.// www.ageconsearch. umn.edu/ record/ 161469.

Fashogbon AE and Oni OA 2013 Heterogeneity in rural household food demand and its determinants in Ondo state, Nigeria: an application of quadratic almost ideal demand system. Journal of Agricultural Science 5: 169-177.

FAO (Food and Agriculture Organization of the United Nations) 2015 The state of food insecurity in the world: strengthening the enabling environment for food security and nutrition, Rome: FAO. https: //www.fao.org/ publications/2015/.

Food and Agriculture Organization 2020 The state of food security and nutrition in the world 2020. https: //www.fao.org/ publications/sofi/2020/.

Food and Agricultural Organization (FAO), International Fund For Agricultural Development (IFAD),United Nations International Children's Emergency Fund (UNICEF), World Food Programme (WFP), World Health Organization WHO 2020. The state of food security and nutrition in the world 2020. Transforming food systems for affordable healthy diets, Rome FAO. https:doi.org/10.4060/ca 9692 en/.

Global Food Policy Report 2015 Reshaping the global food system for sustainable development. https:// dx.doi.org/10.249999780896295827/.

Hall JN, Moore S and Lynch W 2009 Global variability in fruits and vegetables consumption. American Journal of Preventive Medicine, 36:402-409.

Heien D and Wessells C 1990 Demand systems estimation with microdata: a censored regression approach. Journal of Business & Economic Statistics, 8: 365-371.

Khaliukova O 2013 Demand analysis for tomato, onion, peppers, and fresh okra in Nigeria. University of Tennessee, Knoxville Trace: Tennessee Research and Creative Exchange. https:// core.ac.uk/display/268804398/.

Liu RH 2003 Health benefits of fruit and vegetables are from additive and synergistic combinations of phytochemicals. American Journal Clinical Nutrition, 78: 517–520.

Loy S, Marhazlina M, Azwany YN and Jan JMH 2011 Higher intake of fruits and vegetables in pregnancy is associated with birth size. Southeast Asian Journal Tropical Medical Public Health, 42: 1214-1223.

Luchuo EB, Paschal KA, Nga G, Njam PK, Yelene S, Nsah B and Ajue TT (2013) Malnutrition in sub-saharan africa: burden, causes and prospects. Pan African Medical Journal, 15:120-132. doi:10.11604/pamj.2013.15.120.2535.

Meyerhoefer CD, Ranney CK and Sahn DE 2005 Consistent estimation of censored demand systems using panel data. American Journal of Agricultural Economics, 87: 660-672.

Mikkelsen TB, Osler M, Orozova-Bekkevold I, Knudsen VK and Olsen SF 2006 Association between fruit and vegetable consumption and birth weight: a prospective study among Danish women. Scandinavian Journal Public Health, 34: 616-622.

Mutuc MEM, Pan S and Rejesus RM 2007 Household vegetable demand in the Philippines. Is there an urban-rural divide? Agribusiness, 23: 511–527.

Obayelu AE, Okoruwa VO and Ajani OIY 2009 Crosssectional analysis of food demand in the North central, Nigeria: the quadratic almost ideal demand system approach. China Agricultural Economic Review, 1: 173–193.

Obisesan AA 2019 Households' demand for fruits and vegetables in urban Nigeria. Pacific Journal of Science and Technology, 20:173-181.

Ogundari K and Arifalo SF 2013 Determinants of household demand for fresh fruit and vegetable in Nigeria: a double hurdle approach. Quarterly Journal of International Agriculture, 52: 199-216.

Otunaiya AO and Shittu AM 2014 Complete household demand system of vegeta-

bles in Ogun State, Nigeria. Agricultural Econonomics–Czech, 60: 509–516.

Poi B 2012 Easy demand system estimation with QUAIDS. The Stata Journal, 12: 433-446.

Rao S, Yajnik CS, Kanade A, Fall CH, Margetts BM, Jackson AA, Shier R, Joshi S, Rege S, Lubree H, Desai B 2001 Intake of micronutrient-rich foods in rural Indian mothers is associated wit the size of their babies at birth. Pune Maternal Nutrition Study. Journal of Nutrition, 131 (4): 1217-24. Doi: 10.1093.jn/131.4.1217.PMID: 11285330.

Tafere K, Taffesse AS, Tamiru S, Tefera N and Paulos N 2011 Food demand elasticities in Ethiopia: estimates using household income consumption expenditure (HICE) survey data. Development Strategy and Governance Division, International Food Policy Research Institute: Discussion Paper No. ESSP2011.https://media. africaportal.org/ documents/ ESSP Discussion Paper _ 011.pdf.

Tey YS, Mad Nasir S, Zainalabidin M, Jinap S and Abdul Gariff R 2009 Demand for quality vegetable in Malaysia. International Food Research Journal, 16: 315-329.

Tsegai DW and Kormawa PM 2009 The determinants of urban households' demand for cassava and cassava products in Kaduna, Northern Nigeria: An application of the AIDS model. European Journal of Development Research, 21: 435–447.

World Bank 2017 Living standards measurement study. Retrieved from https:/ www. worldbank. org/en/lsms/ initiatives/lsms-ISA.

World Food Programme 2020 Global report of food crises. https://www.wfp.org/ publications /2020.

World Health Organization (WHO) 2020 Double burden of malnutrition. https:// www. who. int /nutrition /double-burden-malnutrition/en/.