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Households' demand for fruits and vegetables in Nigeria: Panel QUAIDS approach

by Adekemi Obisesan

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Abstract

The study analyzed households' demand for fruits and vegetables in Nigeria using data from the three waves of Living Standard Measurement Survey-Integrated Survey on Agriculture (LSMS-ISA) namely 2010/11, 2012/13 and 2015/16. The Quadratic Almost Ideal Demand System (QUAIDS) was employed to analyze the demand for bananas, citrus, pineapples, tomatoes, onions, fresh okra and pepper. Nigerian households consumed more vegetables than fruits from 2010-2015 Tomatoes, onions and pepper are important vegetables among Nigerian households across the different zones of the country. High quantity response to movements in relative prices was observed. All the fruits and vegetables were normal goods. Tomatoes, okra, banana, citrus and pineapple were luxury goods while onion and pepper were necessity goods. There is similar fruits and vegetables responsiveness to expenditure increases across sector (rural and urban). All the own-price elasticities (compensated and uncompensated) were negative conforming to demand theory. Nigerian households' response to changes in the prices of fruits and vegetables is more than proportionate. More consideration should be given to intensifying production of fruits and vegetables in technology development and investment to make them available and affordable.

Keywords: Food; demand elasticity; healthy diets; income; nutrition security; price; income effect

INTRODUCTION

Food and nutrition insecurity are common challenges across the globe. Regardless of projects and programmes targeted towards increasing food security and nutrition, close to 690 million people in the world remains hungry. Two billion people lack regular access to safe, nutritious and sufficient food in 2019 (Food and Agriculture Organization [FAO], 2020). The burden of malnutrition in all its forms remains a global challenge (World Health Organization [WHO], 2020). Malnutrition contributes significantly to high mortality rate of children worldwide (Luchuo *et al.,* 2013). According to current estimates, 21.3 percent (144.0 million) of children under 5 years of age were stunted, 6.9 percent (47.0 million) wasted and 5.6 percent (38.3 million) overweight in 2019 (World Food Programme [WFP], 2020).

Many African countries are characterized by deteriorating nutrition as 19.1 percent of the population is undernourished (FAO, 2020). In Sub-Saharan African (SSA), over twenty three percent of the total population (two hundred and ten million) are undernourished and poor nutrition is responsible for forty-five percent of death especially in children under five (FAO, 2015). In SSA, more than half of the population cannot afford a healthy diet (WFP, 2020).

Fruits and Vegetables (FV) are vital constituents 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 intake of fruits and vegetables prevents chronic diseases such as heart diseases and certain types of cancer (Key *et al*., 2002; Hu, 2003), and is associated with an increase in many birth size parameters (Rao *et al.*, 2001; Mikkelsen *et al,* 2006; Loy *et al.,* 2011).

In spite of the enormous benefits of fruits and vegetables, their consumption in Africa is low compared to the recommended daily intake (Hall *et al.,* 2009). In Sub-Saharan Africa, estimates of fruits and vegetables consumption range from 70 to 312 g per person per day (Ruel *et al.*, 2004). Low income countries (including Nigeria) rely more on staple foods and less on fruits and vegetables compared to high-income countries (FAO *et. al*., 2020). According to Global Food Policy (2015), Nigeria has the highest number of stunted children in Africa. Therefore, with 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 FV at a disaggregated level 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 investigates households' demand of selected fruits and vegetables in Nigeria. The study proffers answer to the following research questions:

1. How does the households' demand for fruits and vegetables respond to changes in prices and income?
2. What are the household's demographic factors influencing fruits and vegetables demand 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, Oyekale (2000), Tsegai and Kormawa (2002), Akinleye (2009), Ogundari and Arifalo, (2013), Otunaiya and Shittu (2014) have conducted studies on food demand in Nigeria employing 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 except

Ogundari & Arifalo (2013), Khaliukova (2013) and Obisesan (2019) considered the whole food basket and treated FV as an aggregate food item in the demand system. Therefore, this study complements previous studies on fruits and vegetables demand in Nigeria by using panel data from 2010 to 2016. It employs Quadratic Almost Ideal Demand System (QUAIDS) within a panel framework to estimate the income and price elasticities of different fruits and vegetables across zones in Nigeria following (Banks *et al.,* 1997). Estimation of demand elasticity of fruits and vegetables at more disaggregated levels is essential in order to have more meaningful analysis of the consumption impacts of domestic food policy interventions (Mutuc *et al.,* 2007).

Empirical review of Literatures on fruits and vegetables demand in Nigeria

Previous Studies	**Study description**	**Analytical approach**	**Results**
Mutuc *et al.*, 2007. Household vegetable demand in Phillipines: is there an urban –rural divide?	Examined price, income, and cross-price elasticities of commonly consumed Philippine vegetables. In addition, effects of socio-demographic factors and urban/rural dummy variables on vegetable food demand were	Three-step estimation method and a Nonlinear Quadratic Almost Ideal Demand System (NQAIDS)	Most of the expen-diture and own-price elasticities of the vegetables are near or larger than unitary in both rural and urban areas. Only demand for cabbage and tomatoes in the urban areas tend to be statistically

	also explored.		different compared to rural areas.
Bundi *et al*., 2013 Urban demand for smallholder crops: the case of fruits and vegetables in Nairobi, Kenya.	Described the consumption patterns and assess the responsiveness of Nairobi households to changes in fruit and vegetable commodity prices, as well as assess the effect of demographic characteristics on the demand for these commodities using dataset of about 760 households. Kales, tomato, cabbage and onion, banana, mango, oranges and avocado, were selected for the	Almost Ideal Demand System (AIDS)	Kale and tomato were important vegetables in the diets of households in Nairobi. The expenditure elasticities for some vegetables and fruits are high. The expenditure elasticities range between 0.699 and 1.350. Households' demographic characteristics influenced the demand for fruits and vegetables.

	analysis.		
Otunaiya and Shittu, 2014. Complete household demand system for vegetables in Ogun state, Nigeria	Estimated the price and income (expenditure) elasticities of demand for the commonly consumed vegetables among households in Ogun State, Southwest Nigeria. Data were collected with the use of a well-structured questionnaire administered to one hundred and twenty households that were randomly selected using a multi-stage sampling procedure.	Nonlinear Quadratic Almost Ideal Demand System	Income elasticity of demand for Bitter leave and the Eggplant are elastic, while income elasticity of demand for Tomato to which about one-third of vegetables' expenditure are devoted, is inelastic. Own-price elasticities of demand have the expected negative signs for all the vegetables and are generally inelastic. Estimates of cross price elasticities show the dominance of substitutability among the vegetables with

			only few cases of complementarities.
Tey *et al.*, 2009. Demand for vegetables in Malaysia	Estimated the price and income elasticities for the six categories of vege-tables that are commonly found and consumed in Malaysia using the Household Expenditure Survey 2004/05 data.	Multi-stage demand system'	Income elasticity for various vegetable categories are positive, indicating that they are generally normal goods. Malaysian consumers are likely to increase their expenditure on aggregated vegetables and the various vegetable categories in line with income growth. This, however, may not be so certain if there are positive adjustments in vegetable prices as suggested by the

			estimated own-price elasticities.
Ogundari and Arifalo, 2013. Determinants of Household demand for fresh fruit and vegetable in Nigeria: A Double Hurdle Approach	Investigated separately demand characteristics of fresh fruits and vegetables using the 2003/2004 Nigeria Living Standard Survey (NLSS) data	Double Hurdle	Households in the low and high-income groups considered the demand for fresh fruit to be necessity and luxury-goods, respectively. Fresh vegetables are luxury good. The demand for fruits and vegetables was higher among households with younger members, compared to households with older members. Regional differences in the demand for fruits and vegetables were also evident in the study.

Khaliukova (2013). Demand analysis for Tomato, Onion, Peppers and fresh Okra in Nigeria	Examined the demand analysis for onion, peppers, fresh okra and tomato in Nigeria using General Household Survey data collected by the World Bank and the Nigeria National Bureau of Statistics in 2010-2011.	Two stage estimation procedure and Linear Approximation Almost Ideal Demand System	Not all of the vegetables are normal goods, okra is an inferior good. Demographic characteristics affect consumption. Marshallian cross price elasticities suggested that the food items are mix of gross substitutes and complements, however, positive values of Hicksian cross-price elasticities indicate that all vegetables are net substitutes

MATERIALS AND METHODS

Data

The study employed secondary data from the three waves of the Living Standard Measurement Survey-Integrated Survey on Agriculture (LSMS-ISA) namely 2010/11, 2012/13 and 2015/16. Based on the agricultural seasons, each year had two visits (post-planting, September-November, and post-harvest, February-April). Detailed information were collected in the survey on the quantities of household food consumption from own production, purchases, and gifts. The household's weekly expenditure on purchased food items 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 household consumption of fruits and vegetables, household food expenditure, prices, age, household size, sex, marital status, educational status. The fruits and vegetables considered as contained in the data set are: bananas, orange/tangerine, pineapples for fruits and; tomatoes, onions, fresh okra and pepper for vegetables. Recall information on food consumption (purchased and auto-consumption) over a week period was collected.

The Quadratic Almost Ideal Demand System

The almost ideal demand system (AIDS) of Deaton and Muellbauer (1980) has been a popular functional form to model demand behavior during the past two decades. The AIDS model has budget shares that are linear functions of log total expenditure. AIDS is a member of the Price-Independent Generalized Logarithmic (PIGLOG) class of demand models (Muellbauer, 1976), which are derived from indirect utility functions that are themselves linear in log total

expenditure. However, there is a body of literature providing evidence on the importance of allowing for non-linearity in the budget share equations (Lewbel, 1991; Banks *et al*., 1997).

The Quadratic Almost Ideal Demand System can better approximate non-linear Engel curves in empirical analysis than other demand system analysis. Furthermore, the study used a modified routine of Poi (2012) which allows the inclusion of demographic variables to the model using the method of Ray (1983), 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 quadratic almost ideal demand system (QUAIDS) model developed by Banks *et al*. (1997), which has budget shares that are quadratic in log total expenditure, is an example of the empirical demand systems that have been developed to allow for this expenditure nonlinearity. The QUAIDS model is a generalization of PIGLOG preferences based on the following indirect utility (V) function:

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

where x is total expenditure, $\mathbf{p}$ is a vector of prices, $a(\mathbf{p})$ is a function that is homogenous of degree one in prices, and $b(\mathbf{p})$ and $\lambda(\mathbf{p})$ are functions that are homogeneous of degree zero in prices. As in the original AIDS model, ln $a(\mathbf{p})$ and ln $b(\mathbf{p})$ are specified as the translog and Cobb-Douglas equations:

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

$$b(p) = \prod_{i=1}^{K} p_i^{\beta_i} \text{.....(3)}$$

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

$$\lambda(p) = \sum_{i=1}^{K} \lambda_i \ln p_i \quad \text{.....(4)}$$

Where,

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

Application of Roy's identity to (1) gives the QUAIDS budget share equations. To control for varying preference structures and heterogeneity across households, demographic variables (**z**) will be incorporated into the QUAIDS model through the linear demographic translating method (Pollak and Wales, 1981). This leads to the following empirical specification of the QUAIDS budget share equations:

$$w_i = \alpha_i + \sum_{j=1}^{K} \gamma_{ij} \ln p_j + \beta_i \ln\left[\frac{x}{a(p)}\right] + \frac{\lambda_i}{b(p)}\left\{\ln\left[\frac{x}{a(p)}\right]\right\}^2 + \sum_{s=1}^{L} \delta_{is} z_s \text{.....(5)}$$

where $z_s = (z_1, ..., z_L)$ is a set of demographic variables. Formulas for the QUAIDS expenditure and price elasticities are derived by differentiating the budget share equations with respect to ln *x* and ln *pj*, respectively.

A probit regression analysis is done in order to estimate the probability that a given household consumes the individual fruit and vegetable in question. This regression is then used to yield the Inverse Mills Ratio (IMR) for each household in order to correct the possible bias created by the presence of zero consumption (Heien and Wessels, 1990).

$$w_i = \alpha_i + \sum_{j=1}^{K} \gamma_{ij} \ln p_j + \beta_i \ln\left[\frac{x}{a(p)}\right] + \frac{\lambda_i}{b(p)}\left\{\ln\left[\frac{x}{a(p)}\right]\right\}^2 + \sum_{s=1}^{L} \delta_{is} z_s \text{.....} + IMR_i \text{(6)}$$

Following Banks *et al*. (1997), the expressions for the elasticity formulas is simplified by using the intermediate results:

$$\mu_i \equiv \frac{\partial w_i}{\partial \ln x} = \beta_i + \frac{2\lambda_i}{b(p)}\left\{\ln\left[\frac{x}{a(p)}\right]\right\} \quad \text{.....(7)}$$

$$\mu_{ij} \equiv \frac{\partial w_i}{\partial \ln p_j} = \gamma_{ij} - \mu_i\left(\alpha_j + \sum_{l=1}^{K}\gamma_{jl}\ln p_i\right) - \frac{\lambda_i\beta_j}{b(p)}\left\{\ln\left[\frac{x}{a(p)}\right]\right\}^2 \quad \text{.....(8)}$$

In terms of the μ_i, the formula for expenditure elasticities can be written as:

$$e_i = 1 + \frac{\mu_i}{w_i} \quad \text{.....(9)}$$

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

$$e_i = \frac{\mu_{ij}}{w_i} - \delta_{ij} \quad \text{.....(10)}$$

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

$$e_{ij}^{c} = e_{ij}^{u} + w_j e_i \quad \text{.....(11)}$$

Variables definition

The independent variables included in the model are prices of tomatoes, pepper, onion, okra, banana, pineapples and citrus; household's expenditure on fruits and vegetables. 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).

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). Consumption of fruits and vegetables was more in the urban than rural Nigeria. 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, pepper 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 (1.64 kg) 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) was higher in the urban sector than rural irrespective of the fact that their production is more concentrated in the rural areas.

Table 1. 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 estimations from the LSMS-ISA 2010, 2012 and 2015 data.
The shares reported are only of households consuming fruits and vegetables in a 7 days period. Households can consume more than one type of fruits and vegetables.

Table 2. Households consuming fruits and vegetables in Nigeria by FV Type(%)

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 from the LSMS-ISA 2010, 2012 and 2015 data.
The shares reported are only of households consuming fruits and vegetables. The shares reported are only of households consuming fruits and vegetables in a 7 days period. Households can consume more than one type of fruits and vegetables.

Estimated parameters of the QUAIDS model

Some households in the LSMS-ISA data used in the study recorded zero expenditure in the survey. According to literature, three main factors could be responsible for zero expenditures in household level data: it is possible for households that they never consume the commodity of

interest; limited survey periods can record zero consumption of the commodity among some households while some households may fail to report consuming the commodity due to the fact that it is not an optimal decision at a particular time subject to the set of prices they face and income (Meyerhoefer *et al.,* 2005; Tafere *et al.,* 2011). This problem was solved using a two stage estimation procedure. In the first stage, a probit regression was estimated to represent a decision by household (h) to demand the particular commodity (i) or not. The estimate of the maximum likelihood was later used to construct the Inverse Mills Ratio (IMR) for each household. The IMR was used in the second stage as an explanatory variable to incorporate the censoring latent variable in the regression (Heins and Wessels, 1990; Bundi *et al.,* 2013) see eq. 6.

The estimated parameters of the QUAIDS model are presented in Table 3. Seventeen out of the 28 price effects are significant, reflecting high quantity response to movements in relative prices among Nigerian households. This might be due to the disaggregation of the fruits and vegetables which gives better understanding of households' sensitivity to price changes than when aggregated.

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 tests whether the AIDS model fits the data better than the QUAIDS. From the results, the coefficients of (λ) for the different fruits and vegetables considered are significant suggesting that the QUAIDS model fits the data better than the AIDS. The implication is that, the response of the demand for all the fruits and vegetables to increase in total expenditure is non-

linear, strongly supports the rejection of the hypothesis that the quadratic expenditure term is zero. This reveals the suitability of the QUAIDS model over the traditional AIDS model.

Furthermore, Table 3 revealed the effects of demographic factors on the household demand of the different fruits and vegetables. More than half (thirty out of forty-two) of the demographic variables are statistically different from zero. Age of the household head has positive and significant influence on the demand for onion ($p<0.01$), citrus ($p<0.1$) 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 due to the fact that almost all the other food groups are consumed with pepper and tomatoes stew in Nigeria. However, this is not in tandem with Khaliukova (2013) who opined that the more the household size, the less the consumption of tomatoes and pepper in Nigeria. 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.

Educational status has positive and significant influence on the demand for almost all the items. Education enhances the understanding of the nutritional benefits of fruits and vegetables. The results show that being educated increases the consumption of tomatoes ($p<0.01$), pepper ($p<0.01$), onions ($p<0.05$), 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.

Table 3. Estimated parameters of the QUAIDS model

Variables	Tomatoes	Pepper	Onion	Banana	Okra	Citrus	Pineapple
Constant	-0.3362*	-0.0110	0.5097*	0.3046*	-0.1241*	0.3915*	0.2656*
	(0.3319)	(0.0451)	(0.0350)	(0.0309)	(0.0387)	(0.0295)	(0.1894)
PTOMA	0.1138*						
	(0.0125)						
PPEPR	0.0303*	0.0008					
	(0.0079)	(0.0057)					
PONION	-0.1166*	-0.0132*	0.1001*				
	(0.0080)	(0.0068)	(0.0089)				
PBANA	-0.0036	-0.0128*	0.0063	-0.0084*			
	(0.0059)	(0.0030)	(0.0047)	(0.0038)			
POKRA	0.0608*	0.00078	-0.0508*	0.0008	0.1183**		
	(0.0067)	(0.0034)	(0.0060)	(0.0031)	(0.0051)		
PCITRU	-0.0507*	-0.0048	0.0450*	0.1834*	-0.0113*	0.0028	
	(0.0059)	(0.0039)	(0.0045)	(0.0032)	(0.0036)	(0.0061)	
PPINE	-0.0340*	-0.0010	0.0291*	-0.0006	-0.0121*	0.0062	0.0123**
	(0.0038)	(0.0026)	(0.0030)	(0.0025)	(0.0024)	(0.0047)	(0.0049)
LNEXP	-0.1642*	-0.0425	0.1467*	0.0218	-0.0689	0.0613	0.0464*
	(0.0077)	(0.0101)	(0.0073)	(0.0070)	(0.0088)	(0.0067)	(0.0044)
LNEXP^2	-0.0142*	-0.0030*	0.0152*	0.0004*	-0.0033*	0.0029*	0.0020*
	(0.0005)	(0.0006)	(0.0004)	(0.0003)	(0.0005)	(0.0004)	(0.0002)
Age	-0.0003**	0.0002	0.0004***	-0.0001**	-0.0006*	0.0004*	0.0002*

	(0.0002)	(0.0001)	(0.0002)	(8.67e^{-04})	0.0001	(8.74e^{-04})	(5.61e^{-04})
Sex	-0.0004	-0.0004	0.0001	-0.0001	0.0008***	0.0002	-0.0002
	(0.0007)	(0.0006)	(0.0008)	(0.0004)	(0.0005)	(0.0003)	(0.0002)
Household	0.0002**	0.0004*	-0.0002**	-00001	-0.0003	-0.0001*	4.99^{e-06}
size	(8.33e^{-05})	(7.4e^{-05})	(0.0001)	(4.43^{e-05})	(5.38^{e-05})	(4.19^{e-05})	(2.67e^{-05})
Educational	0.0019*	0.0018*	0.0015**	0.0023*	0.0021*	0.0007**	0.0001
status	(0.0006)	(0.0005)	(0.0007)	(0.0003)	(0.0004)	(0.0003)	(0.0002)
Sector	0.0052*	0.0005	0.0047*	-0.0038*	-0.0035*	-0.0020*	-0.0011*
	(0.0008)	(0.0007)	(0.0009)	(0.0004)	(0.0006)	(0.0005)	(0.0004)
Zone	-0.0003	-0.0057*	0.0082*	-0.0011*	-0.0008**	0.0011*	-0.0014*
	(0.0006)	(0.0005)	(0.0006)	(0.0003)	(0.0004)	(0.0003)	(0.00018)

Source: Author's estimations from the LSMS-ISA 2010, 2012 and 2015 data.
*,**,*** 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

Expenditure Elasticities of demand

The expenditure elasticities for the different fruits and vegetables are reported in Table 4. All elasticities are positive indicating that all the FV are normal goods. This finding is consistent with Fashogbon and Oni (2013) and Obisesan (2019) that fruits and vegetables are normal goods in Ondo state, Nigeria and urban Nigeria respectively. The expenditure elasticities are greater than unity for tomatoes, okra, banana, citrus and pineapple while they are less than unity for onions and pepper. The results indicate that onions and pepper are expenditure inelastic while others are expenditure elastic. Ten percent increase in income will increase demand for banana

and citrus by 17.0% and 14.9% respectively. The high expenditure elasticity for pineapple (2.09) shows that it is a more desired form of fruits.

Table 4. Expenditure elasticities

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

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

The study further examines the own and cross price elasticities of fruits and vegetables. Estimates of the Marshallian (uncompensated) expenditure elasticities and Hicksian (compensated) expenditure elasticities are presented in Tables 5 & 6 respectively. The estimates

on the diagonal are the own price elasticities of the different fruits and vegetables. The compensated and uncompensated own-price elasticities are negative. This shows they follow the demand theory. The uncompensated price elasticity estimates reveal that the demand for all the fruits and vegetables except pineapple are own-price elastic. From the results, a one percent increase in the prices of tomatoes, pepper and onion will lead to 1.20, 1.05 and 1.04 decrease in the quantity demanded, respectively. The compensated own-price elasticities are smaller in their absolute value than the uncompensated (Table 6). There is a significant income effect in the responsiveness of all the fruits and vegetables demand to changes in their prices.

A mix of complementary and substitution relationship was observed among the fruits and vegetables from the Marshallian cross price elasticities. For instance, pepper has a complementary relationship with tomatoes (-0.74), that is, 1% increase in the price of tomatoes will decrease the quantity of pepper demanded by 0.74.

Table 5. The Marshallian / uncompensated elasticity of demand

FV	Tomatoes	Pepper	Onion	Banana	Okro	Citrus	Pineapple
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
Pineapple	-0.29	0.53	0.14	0.74	-0.24	0.68	**-0.82**

Source: Author's estimations from the LSMS-ISA 2010, 2012 and 2015 data

Table 6. 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 from the LSMS-ISA 2010, 2012 and 2015 data

CONCLUSION AND RECOMMENDATIONS

The study employed QUAIDS in analyzing households' fruits and vegetables demand in Nigeria using data from the three waves of LSMS-ISA namely 2010/11, 2012/13 and 2015/16. The fruits and vegetables considered are: bananas, citrus, pineapples, tomatoes, onions, fresh okra and pepper. There is high quantity response to movements in relative prices. All the fruits and vegetables considered are normal goods. Tomatoes, okra, banana, citrus and pineapple are luxury items while onion and pepper are necessity items in the households. Households' demographic factors affect demand for fruits and vegetables in Nigeria. All the own-price

elasticities (compensated and uncompensated) are negative, hence, conforming to the demand theory. Nigerian households respond more than proportionately to changes in the prices of the fruits and vegetables. A mix of complementary and substitution relationship exist among the fruits and vegetables. There is a significant income effect in the responsiveness of all the fruits and vegetables demand to changing fruits and vegetable prices. The study recommends interventions that stabilize prices and boost income in Nigeria. 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.

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