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Household Demand for Plant-Based Protein Foods During the COVID-19 Pandemic

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RESEARCH ARTICLE

Abstract

This study was conducted to investigate the demand for plant-based protein foods among households during the COVID-19 pandemic. A multistage sampling technique was used to select 1000 households from ten Local Government Areas in Lagos State, Nigeria. The data collected were analyzed using descriptive statistics and a censored Quadratic Almost Ideal Demand System model. Households were categorized into non-poor, moderately-poor and core-poor using the FGT index. The study found that during the COVID-19 pandemic, though non-poor households had a higher expenditure on plant protein foods than both the moderately-poor and core-poor households, the moderately-poor and core-poor households, however allocated higher shares of their total food expenditure share on plant protein foods than the non-poor households. The result also showed that, while cowpea and groundnut were considered to be necessities for all households, soybean, lentils, and pigeon pea, were necessities for the core-poor households. The study therefore recommended that during periods of crisis, soybean, lentils, and pigeon pea should be made available for core-poor households because these households consider them to be very important in their diet and thus, will still purchase them even in the face of price shock.

Keywords: plant protein, households, elasticities, COVID-19, expenditure

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INTRODUCTION

Protein, a macronutrient needed by humans, is central to good health (Baum and Rodibaugh, 2014). Proteins play many critical roles in the human body and are essential for maintaining and regulating tissues and organs (Tomar *et al*., 2021). They contain various amounts of amino acids which are essential for human health, growth, reproduction, development, lactation and survival (Wu, 2013; Food and Agriculture Organization (FAO), 2013). Dietary protein can be obtained from both plant and animal sources (Baum *et al*., 2020; Andreoli *et al*., 2021). Aiking (2014), Machovina *et al*. (2015), and Swain *et al*. (2018), however submitted that animal-derived foods have severe consequences for the sustainability of the environment, while their consumption had also been linked to obesity and other pathologies (Richi *et al*., 2015; Henneberg, 2016). In addition, several studies have shown that consuming vegetal foods have numerous advantages to human health as well as the environment (Tilman and Clark, 2014; Springmann *et al*., 2016; Chai *et al*., 2019; Aiking and de Boer, 2020). Therefore, a transition from animal- to plant-based protein food may be desirable for numerous reasons such as maintaining environmental stability, ethical reasons, food affordability, greater food safety, fulfilling higher consumer demand, and combating protein-energy malnutrition (Langyan *et al*., 2022). Furthermore, plant-derived protein foods have numerous economic advantages and uses which can help increase the income and living standard of both producers and marketers alike, and can consequently increase the Gross Domestic Product (GDP) of any nation. Plant-derived proteins have numerous industrial applications – they can be used as food ingredients/supplements, as edible coating/films for food packaging so as to prevent spoilage, as bioactive peptides/protein hydrolysates for protecting animals against a plethora of microbes amongst other functions, as stabilizers/emulsifiers, as hydrogels for use in tissue engineering or regenerative medicines or biomedical implants or food additives or pharmaceuticals or wound dressings, and as eco-friendly wood adhesives (Kumar *et al*., 2022; Li *et al*., 2019; Varaprasad *et al*., 2017; Raghavendra *et al*., 2015; Tang *et al*., 2014; Laftah *et al*., 2011). In addition, increasing the consumption of protein, particularly, protein from plant sources had been associated with the achievement of food security in developing countries, Nigeria inclusive (Speedy, 2003; Drewnowski and Poulain, 2018).

The novel COVID-19 pandemic, however disrupted the distribution of foods and further threatened the actualization of food security in many economies, including the Nigeria economy (FAO, 2020; Torero, 2020; Zurayk, 2020). The surging inflation rate which characterized the period caused a reduction in the real purchasing power of many households (National Bureau of Statistics (NBS), 2020). Prices of food items during this period skyrocketed while the income of many households fell significantly. This adversely affected different households' demand and purchase of nutritious and proteinous food items (Balana *et al*., 2020; Obayelu *et al*., 2021). Different studies had also shown that households' demand and consumption of plant protein foods significantly reduced during the COVID-19 pandemic when compared with the pre-COVID-19 period in the country (Madzorera *et al*., 2021). Furthermore, Global Alliance for Improved Nutrition (GAIN) (2021) and Ogundahunsi *et al*. (2020) confirmed a lesser consumption of healthy proteinous food, such as legumes during the COVID-19 pandemic among households. This, according to the latter, may be detrimental as these foods aid immunity and are natural sources of ascorbic acid that may help reverse some of the damage that COVID-19 could cause.

Food prices and household income – the major elements affected by the COVID-19 pandemic (Laborde *et al*., 2020; World Bank and NBS, 2020; Yu *et al*., 2020), are according to Chern *et al*. (2002) the major drivers of demand. The increasing prices of protein food, particularly plant protein foods as well as the falling household income significantly reduced households' purchases and/or consumption of these food items (Madzorera *et al*., 2021). This had contributed to the already increasing rate of food insecurity, malnutrition and nutritional deficiencies reported in the country (Amare *et al*., 2020; Andam *et al*., 2020; Balana *et al*., 2020). While households with large income were able to afford healthy proteinous food items, those with low income were however unable to do so and this can have a negative effect on their diet. There is therefore a need to understand how households responded to their changing income and prices of these plant protein foods. Understanding this is necessary to finding different measures to increase the demand for plant-based protein, which are known to be healthier (Andreoli *et al*., 2021), especially during periods of crisis.

Moreover, while there are different studies on the impact of COVID-19 on food security and/or nutrition (Madzorera *et al*., 2021; Obayelu *et al*., 2021), there is however limited information on how different households responded to changing income and prices of plant protein foods during the pandemic. Doing this will be vital to understanding how income and prices of plant protein foods affected households' demand for these foods during the pandemic which is necessary to help policy makers not only plan for periods of crisis, but also for the future. This is because elasticities obtained from demand can assist in predicting future demand for food items which can help overcome the cost of welfare attributable to changing income and prices, and thus improve both the dietary needs and welfare status of households. This study thus contributes to the existing body of knowledge on plant protein foods as well as the demand for them by households. Moreover, the results will help understand what proportion of food expenditure different households allocated to plant protein foods. It will also give an insight on how households responded to shocks posed by changing prices and income. It is against this background that this study addressed the demand for plant protein foods among households during the COVID-19 pandemic.

MATERIALS AND METHODS

Study area

This study was carried out in Lagos State, Nigeria. The State, which consists of 20 Local Government Areas (LGAs), and 57 Local Council Development Areas (LCDAs), has an estimated population of 15,388,000 (Macrotrends, 2022). It lies in the southwestern geopolitical zone of the country, and is located between the latitude 60^{0} 22′ and 60^{0} 2′ north of the equator and longitude 20^{0} 42′ north and 32^{0} 2′ east of the meridian. It is bounded on the north and east by Ogun State. In the west, it shares boundaries with the Republic of Benin and stretches over 180 kilometers along the Guinea Coast of the Bight of Benin on the Atlantic Ocean. Its southern borders are with the Atlantic Ocean. It covers an area of 358,862 hectares or 3,577 square kilometres. Lagos State has many markets where different plant protein foods are being sold by marketers and purchased by households for consumption.

Data collection

A multi-stage sampling technique was used to obtain data for this study. The first stage involved a simple random sampling of ten LGAs from the twenty LGAs in the State. The ten LGAs randomly selected were Alimosho (with 6 LCDAs), Badagry (with 3 LCDAs), Epe (with 3 LCDAs), Eti-Osa (with 4 LCDAs), Ifako-Ijaiye (with 2 LCDAs), Ikorodu (with 6 LCDAs), Mushin (with 2 LCDAs), Oshodi/Isolo (with 3 LCDAs), Ojo (with 3 LCDAs) and Surulere (with 3 LCDAs). In the second stage, two (2) LCDAs were randomly selected from each LGA. In the third stage, 50 houses were systematically selected from each LCDA, while the fourth stage involved a simple random sampling of one household from each house to arrive at a sample size of 1000 households. The sampling formula provided by Yamane (1967) was used to determine the sample size for each selected LGA. The sample size is given in the formula below:

$$n = \frac{N}{1 + N(e)^2} \tag{1}$$

where n is the sample size to be determined, N is the population size for an LGA, and e is the level of precision, which is taken to be 10%.

Primary data were collected using a structured questionnaire and were administered through interview schedule. The questionnaire which was administered between December, 2021 and January, 2022 followed the 30-day recall approach. Specifically, data were collected from household heads on their socio-economic characteristics, expenditures on all items (food and non-food) and prices of different plant protein foods. The plant protein foods selected for this study were based on preliminary survey which showed them as the mostly consumed plant protein foods by households. The selected plant protein foods include: cowpea, soybean, groundnut, lentils, peas, and pigeon pea. For ease of identification, samples of the selected plant protein foods were shown to households.

Methods of data analysis

Descriptive statistics such as frequency and percentages were used to describe the socio-economic characteristics of households, and also profile the expenditure share on plant protein foods while the censored Quadratic Almost Ideal Demand System (QUAIDS) model was used to determine the response of households to income and price changes with respect to the plant protein foods. Furthermore, for ease of discussion of the socio-economic characteristics of households, the F-test of significance was used to test the differences among the means of the different categories of households.

Classification of households

This study classified households according to their living conditions. This is because differences in food demand across poverty or income categories at a point in time can help provide clues to the changes in demand that could result into sustained economic growth (Deaton, 1997; Akinleye and Rahji, 2007). For this reason, households were divided into non-poor, moderately-poor and core-poor. For this to be done, households' mean *per* adult equivalent consumption expenditure was computed and used to classify households into non-poor, moderately-poor and core-poor. The poverty line was set at $\frac{1}{3}$ and $\frac{2}{3}$ of the mean *per* adult equivalent household consumption expenditure. The classifications of the poverty status are as follows:

- Non-poor: These are households whose *per* adult equivalent consumption expenditure was above two-thirds of the poverty line, that is, $P > \frac{2}{3}$ of the mean expenditure per month;
- Moderately-poor: These are households whose *per* adult equivalent consumption expenditure was greater than one-third but less or equal to two-thirds of the poverty line, that is, $\frac{1}{3} < P \leq \frac{2}{3}$ of the mean expenditure per month;
- Core-poor: These are households whose *per* adult equivalent consumption expenditure was below or equal to one-third of the poverty line, that is, $P \leq \frac{1}{3}$ of the mean expenditure per month.

Separability of food items

Consumption of food is assumed to be weakly separable from the non-food consumption and the consumption of plant protein foods is assumed to be weakly separable from other food consumption. This procedure of separability assumes that the consumer's utility maximization decision can be decomposed into three separate stages. In the first stage, the total expenditures are allocated over the food and non-food items. In the second stage, food expenditures are then allocated over plant protein foods and other food items. In the third stage, the expenditures on plant protein foods are allocated over the following foods: Cowpea, Soybean, Groundnut, Lentils, Peas, and Pigeon Pea.

Analytical model

Multivariate probit regression model

Households are characterized as economic agents that maximize utility, U_j, subject to a budget constraint. For this study, it was assumed that a household has already made a decision on the amount of income to spend on food. Given this income and a vector of food items in the market, a household makes a decision on whether to spend on given food item *j,* if the utility realized from consumption of food item *j* is greater than that of reallocating the same expenditure on a different food item. As a result, it is common to frequently find zero per item expenditure in household surveys. Irrespective of the preference, household may also report zero expenditures on some food item due to non-affordability, permanent non-consumers, and/or non-consumers during the survey period.

Whatever the reason for zero expenditure, inclusion of such expenditures as zeros in the demand estimation results in biased estimates. This requires a technique that escapes sample selection arising due to zero expenditure. The popular procedure involves estimation of several probit models independently. However, it is important to notice that the data for the different plant protein foods was collected from one individual at a given point in time. This may bring endogeneity within the data set, that is, the error terms between the equations of different plant protein foods might be correlated since data is being collected from the same household whose decision on a particular plant protein food may affect the probability of selecting another plant protein food. To overcome this problem, this study adopted the approach used by Maganga *et al.* (2014) by employing multivariate probit model. Following Cappellari and Jenkins, (2003) the multivariate probit model is structured as follows:

$$y_{im}^{*} = \beta_m{}'X_{im} + \epsilon_{im}, m = 1, \dots, M$$
$$y_{im}^{*} = 1 \text{ if } y_{im}^{*} > 0 \text{ and } 0 \text{ otherwise} \quad (2)$$

ϵ_{im}, $m = 1, \dots, M$ are error terms distributed as multivariate normal, each with a mean of zero, and variance-covariance matrix V, where V has value of 1 on the leading diagonal and correlations $\rho_{jk} = \rho_{kj}$ as off-diagonal elements. The multivariate probit model has a structure like the Seemingly Unrelated Regression (SUR), except that the dependent variables are binary indicators. The y_{im} might represent outcomes for *M* different choices at the same point in time, for example, whether an household purchases *M* plant protein foods. The X_{im} is a vector of explanatory variables and β_m are unknown parameters to be estimated. The probability function of the probit model is usually the standard normal density which provides predicted values within the range (0, 1).

A censored Quadratic Almost Ideal Demand System (QUAIDS) model

A censored QUAIDS model was used to examine the determinants of households' demand for plant protein foods. For this to be done, an Inverse Mills Ratio (IMR) was obtained from the multivariate probit regression model and then included as an independent variable in the QUAIDS model so as to account and correct for zero observations.

The QUAIDS model was used to estimate the effect of households' income (proxied by total expenditure), and the prices of different plant protein foods on the consumption expenditure of the different plant protein foods. Thus in the model, households' budget share on the different plant protein foods served as the dependent variables. The QUAIDS model is expressed as follows:

According to Poi (2012), the household's expenditure share for good *i*, that is, ω_i is defined as:

$$\omega_i = \frac{p_i q_i}{y} \quad (3)$$

where ω_i is the budget share for the plant protein food *i*, p_i is the price per kg for plant protein food *i*, q_i is the quantity of plant protein food *i* consumed, and y is the total expenditure on all plant protein foods in the demand system. With this definition of y,

$$\sum_{i=1}^{k} \omega_i = 1 \quad (4)$$

where k is the total number of plant protein foods in the demand system. The equation (4) assumes that budget share of an individual household on plant protein foods must sum to 1.

The fact that $\sum_i \omega_i = 1$ is often called the adding up condition and this condition is satisfied if the following hold, that is, if:

$$\sum_{i=1}^{k} \alpha_i = 1; \ \sum_{i=1}^{k} \beta_i = 0; \ \sum_{i=1}^{k} \lambda_i = 0 \ and \ \sum_{i=1}^{k} \gamma_{ii} = 0 \ \forall i \quad (5)$$

The QUAIDS model was specified by applying Roy's identity and the independent variables were incorporated as suggested in Poi (2012) using the scaling technique introduced by Ray (1983) as follows:

$$\omega_i = \propto_i + \sum_{j=1}^{k} \gamma_{ij} \ln p_j + (\beta_i + \eta_j{}'\mathbf{z}) \ln\left\{\frac{y}{\overline{y_0}(\mathbf{z})\, a(\mathbf{p})}\right\} + \frac{\lambda_i}{b(\mathbf{p})c(\mathbf{p},\mathbf{z})} \left[\ln\left\{\frac{y}{\overline{y_0}(\mathbf{z})\, a(\mathbf{p})}\right\}\right]^2 \quad (6)$$

When $\lambda_i = 0$ for all i, the quadratic term in each expenditure share equation drops out, the model thus resembles the Deaton and Muellbauer's (1980) original AIDS model. Including the IMR, the QUAIDS model then becomes:

$$w_i = \widehat{\Phi}\left[\alpha_i + \sum_{i=1}^{J} \gamma_{ij}\, lnp_j + \beta_i \ln\left[\frac{x}{a(p)}\right] + \frac{\lambda_i}{b(p)}\left\{ln\left[\frac{x}{a(p)}\right]\right\}^2\right] + \delta\widehat{\emptyset} + \varepsilon_{ih} \quad (7)$$

where, w_i is expenditure share for plant protein food i, p_j is the price of plant protein food j, x is the household expenditure, α_i, γ_{ij}, β_i and λ_i are parameters to be estimated, a(p) is a transcendental logarithm price index, $\widehat{\Phi}$ and $\widehat{\emptyset}$ are cumulative distribution and probability density functions respectively and ε_{ih} is a residual assumed to be multivariate normally distributed with zero mean and a finite variance-covariance matrix. The demand theory requires that the above system to be estimated under restrictions of adding up, homogeneity and symmetry. The adding-up is satisfied if $\sum_{i=1}^{J} \omega_i = 1$ for all x and p which requires:

Adding-up $\sum_{i=1}^{J} \propto_i = 1,\ \sum_{i=1}^{J} \beta_i = 0,\ \sum_{i=1}^{J} \gamma_{ij} = 0, \sum_{i=1}^{J} \lambda_i = 0$ (8)

Homogeneity in prices

$$\sum_{i=1}^{J} \gamma_{ij} = 0 \quad (9)$$

Slutsky Symmetry $\gamma_{ij} = \gamma_{ji}$ (10)

The QUAIDS methodology has two stages. The first stage consists of estimating a model using the data from the household survey. This model explains how the expenditure on plant protein foods depended on the household income, and price of the plant protein foods; while in the second stage, the elasticities of demand were estimated using results from the computed QUAIDS model. The expenditure and uncompensated (Marshallian) price elasticities were obtained using equations (11) and (12), respectively.

$$\epsilon_i = \frac{\eta_i}{w_i^*} + 1 = \frac{\Phi}{w_i}\left(\beta_i + \frac{2\lambda_i}{b(p)}\left\{ln\left[\frac{x}{a(p)}\right]\right\}\right) + 1 \quad (11)$$

$$\epsilon_{ij}^{u} = \frac{\eta_{ij}}{w_i^*} - \vartheta_{ij} = \frac{\Phi}{w_i^*}\left(\gamma_{ij} - \eta_i\left(\alpha_j + \sum_{k=1}^{J} \gamma_{ij}\, lnp_k\right) - \frac{2\lambda_i\beta_j}{b(2)}\left\{ln\left[\frac{x}{a(p)}\right]^2\right\}\right) - \vartheta_{ij} \quad (12)$$

where, ϑ_{ij} is the Kronecker delta equating one when $i = j$, and zero otherwise.

RESULTS AND DISCUSSIONS

Socio-economic characteristics of household heads

The results of the socio-economic analysis of household heads as presented on Table 1 showed that the mean age of household heads in the study area was approximately 47±10 years. This result indicates that household heads in the study area are active, productive and should be able to make vital decisions as it concerns their households. The test of significance result showed that there is a significant difference in the mean ages of at least one of the categories of household heads. The result also showed that majority (88.8%) of the household heads were males, who were mostly married (79.1%). The predominance of males as household heads, according to Ojedokun and Yesufu (2021) is a result of the peculiar nature of African societies where males are mostly the breadwinner of their homes and as such must provide for their households. The result also showed that the mean household size by adult equivalent for all household heads in the study area was approximately 3±1 member. The test of significance results however showed that there is a significant difference in the mean adult equivalent household size of at least one of the categories of household heads.

The result further revealed that majority (96.4%) of household heads in the study area had formal education, and had spent an average of 14±4 years in attaining formal education. This implies that these household heads can not only read and/or write, but are expected to know the nutritional components of the different food that they consume. This is because the years that an individual spent in attaining formal education can help shapen the individual's dietary and nutritional choice. The test of significance results however showed that there is a significant difference in the mean years of household head education of at least one of the categories of household heads. The result further revealed that majority (56.8%) of household heads in the study area are classified as salary earners (civil servants, private salary workers and pensioners).

Table 1: Socio-economic characteristics of household heads

Socio-economic characteristics	Pooled (1000)	Non-Poor (564)	Moderately-Poor (310)	Core-Poor (126)	Test of Significance
	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	
Age of household head					
20 – 29	55 (5.5)	45 (8.0)	5 (1.6)	5 (4.0)	7.130*** (0.001)
30 – 39	189 (18.9)	119 (21.1)	48 (15.5)	22 (17.5)	
40 – 49	336 (33.6)	189 (33.5)	108 (34.8)	39 (31.0)	
50 – 59	309 (30.9)	149 (26.4)	118 (38.1)	42 (33.3)	
60 – 69	92 (9.2)	49 (8.7)	31 (10.0)	15 (11.9)	
70 – 79	17 (1.7)	11 (2.0)	0 (0.0)	3 (2.4)	
80 – 89	2 (0.2)	2 (0.4)	0 (0.0)	0 (0.0)	
Mean (Standard deviation)	46.82 (10.461)	45.73 (11.261)	48.26 (8.762)	48.16 (10.064)	
Sex of household head					
Male	888 (88.8)	490 (86.9)	284 (91.6)	114 (90.5)	
Female	112 (11.2)	74 (13.1)	26 (8.4)	12 (9.5)	
Marital status					
Married	791 (79.1)	413 (73.2)	275 (88.7)	103 (81.7)	
Single	209 (20.9)	151 (26.8)	35 (11.3)	23 (18.3)	
Adult equivalent					
1 – 4.99	950 (95.0)	540 (95.7)	294 (94.8)	116 (92.1)	
5 – 8.99	50 (5.0)	24 (4.3)	16 (5.2)	10 (7.9)	26.134*** (0.000)
Mean (Standard deviation)	3.17 (0.970)	2.98 (1.011)	3.42 (0.824)	3.42 (0.928)	
Education of household head					
No formal education	36 (3.6)	14 (2.5)	11 (3.5)	11 (8.7)	
Primary education	72 (7.2)	31 (5.5)	26 (8.4)	15 (11.9)	
Secondary education	268 (26.8)	152 (27.0)	91 (29.4)	25 (19.8)	
Tertiary education	624 (62.4)	367 (65.1)	182 (58.7)	75 (59.5)	
Years of formal education					
1 – 5	1 (0.1)	0 (0.0)	1 (0.3)	0 (0.0)	
6 – 10	72 (7.2)	30 (5.3)	26 (8.4)	16 (12.7)	3.699** (0.025)
11 – 15	318 (31.8)	180 (31.9)	107 (34.5)	31 (24.6)	
16 – 20	567 (56.7)	340 (60.3)	165 (53.2)	62 (49.2)	
21 – 25	6 (0.6)	0 (0.0)	0 (0.0)	6 (4.8)	
Mean (Standard deviation)	13.81 (4.147)	14.12 (3.618)	13.45 (4.128)	13.34 (5.949)	
Primary occupation of household head					
Civil servant	235 (23.5)	127 (22.5)	69 (22.3)	39 (31.0)	
Artisan	184 (18.4)	110 (19.5)	52 (16.8)	22 (17.5)	
Private salary worker	308 (30.8)	184 (32.6)	96 (31.0)	28 (22.2)	
Trader	217 (21.7)	116 (20.6)	70 (22.6)	31 (24.6)	
Pensioner	25 (2.5)	17 (3.0)	5 (1.6)	3 (2.4)	
Transporter	18 (1.8)	9 (1.6)	8 (2.6)	1 (0.8)	
Clergy	7 (0.7)	1 (0.2)	5 (1.6)	1 (0.8)	
Farmer	6 (0.6)	0 (0.0)	5 (1.6)	1 (0.8)	
Secondary occupation of household head					
None	631 (63.1)	347 (61.5)	191 (61.6)	93 (73.8)	
Artisan	85 (8.5)	53 (9.4)	22 (7.1)	10 (7.9)	
Private salary worker	38 (3.8)	17 (3.0)	20 (6.5)	1 (0.8)	
Trader	239 (23.9)	144 (25.5)	74 (23.9)	21 (16.7)	
Businessman	4 (0.4)	2 (0.4)	2 (0.6)	0 (0.0)	
Transporter	2 (0.2)	1 (0.2)	0 (0.0)	1 (0.8)	
Farming	1 (0.1)	0 (0.0)	1 (0.3)	0 (0.0)	
Consume plant protein foods*					
Cowpea	961 (96.1)	544 (96.5)	302 (97.4)	115 (91.3)	
Soy Bean	195 (19.5)	121 (21.5)	58 (18.7)	16 (12.7)	
Groundnut	898 (89.8)	516 (91.5)	270 (87.1)	112 (88.9)	
Lentils	72 (7.2)	53 (9.4)	15 (4.8)	4 (3.2)	
Peas	294 (29.4)	199 (35.3)	78 (25.2)	17 (13.5)	
Pigeon pea	119 (11.9)	66 (11.7)	43 (13.9)	10 (7.9)	

Note: * represents multiple responses; Source: Data Analysis, 2022

The type of occupation of an individual can have an impact on their disposable income, and consequently their demand for nutritious foods. The result further showed that few (36.9%) household heads in the study area had secondary occupation aside their primary occupation. The implication of this result is that household heads with secondary occupation are expected to have more disposable income which can be spread across the different expenditures within the household. The fact that some household heads have other occupation asides their primary occupation could be a coping mechanism as the income they get from their primary occupation may not be enough to adequately cater for their households' expenses. Finally, the result revealed that households in the study area mostly consume cowpea (96.1%) and groundnut (89.8%). Households, mostly consuming cowpea and groundnut could be due to their availability and accessibility. This is because Maziya-Dixon *et al* (2004) submitted that cowpea and groundnut are the most available legumes.

Expenditure share on plant protein foods among households

The results of the expenditure on plant protein foods by per adult equivalent among households is presented on Table 2. The result showed that for all households, cowpea had the largest share of expenditure in the total plant protein foods' budget relative to other plant protein foods. The result showed that households allocated 64.8% of their plant protein foods budget share on cowpea, thus signifying its importance in their diet. Cowpea, having the highest share of expenditure among other plant protein foods could be due to its availability as well as its versatility in diets. The assertion of its versatility in preparing different dishes can be attributed to Ojedokun and Yesufu (2021), who in their study on different varieties of cowpea confirmed that cowpea can be used to prepare different delicious dishes such as pudding (*Moin Moin*), porridge, bean cake (*Akara*), white bean pudding (*Ekuru*) and bean soup (*Gbegiri*). Also, the result revealed that while the non-poor households allocated about 64% of its total plant protein foods' expenditure share on cowpea, the moderately-poor and core-poor households allocated about 67% and 68% of their total plant protein foods' expenditure share on cowpea, respectively.

Moreover, the result showed that the total expenditure share on plant protein foods by per adult equivalent for all households in the study area was 8%. This implies that households only allocated 8% of their total food budget share on plant protein foods. This showed that households during the pandemic allocated a very small portion of their total budget share on plant protein foods. This result may be because households during periods of crisis were more inclined towards meeting their hunger needs and not necessarily their nutritional needs (Obayelu *et al*., 2021). Furthermore, in line with *a priori* expectation, the result showed that though non-poor households during the pandemic had a higher expenditure on plant protein foods (₦1,308,082 or $3,087.14) than both the moderately-poor (₦379,876.5 or $896.53) and core-poor households (₦116,007.7 or $273.78), the moderately-poor and core-poor households, however allocated higher shares (that is, 9% and 13%) of their total food expenditure share on plant protein foods than the non-poor households. This, thus shows the significance of plant protein foods in the diets of households in the lower rung of the income ladder. This result mirrors those of Ojedokun and Yesufu (2021), Alene (2017) and Mfikwa and Kilima (2014) who in their different studies opined that while non-poor households have a higher average household expenditure on cowpea, poor households had a higher proportion of their expenditure on cowpea. Non-poor households allocating lesser expenditure share on plant protein foods is however due to the fact that these households can obtain their protein requirement from other sources, particularly, animal source. According to Ahnen *et al*. (2019), in spite of the efforts to boost increased intake of dietary protein from plant-based sources, most consumers still significantly meet their protein needs by consuming meat and meat products. However, this may not be the case for core-poor households, who are most likely to be affected by higher prices of animal products and whose income are likely to be affected by price fluctuations.

Table 2. Expenditure on Plant Protein Foods by Per Adult Equivalent

Food item	Pooled	Non-Poor	Moderately-Poor	Core-Poor
	Expenditure (₦)	**Expenditure (₦)**	**Expenditure (₦)**	**Expenditure (₦)**
Cowpea	1,169,407 (0.648)	834,733 (0.638)	255,957.5 (0.674)	78,716.29 (0.679)
Soy Bean	101,709.7 (0.056)	76,519.46 (0.058)	19,301.89 (0.051)	5,888.32 (0.051)
Groundnut	392,446.5 (0.218)	290,124.2 (0.222)	77,020.5 (0.203)	25,321.76 (0.218)
Lentils	22,273.98 (0.012)	16,901.25 (0.013)	4,569.93 (0.012)	802.80 (0.007)
Peas	83,799.77 (0.046)	66,428.91 (0.051)	14,505.11 (0.038)	2,865.75 (0.025)
Pigeon pea	34,309.54 (0.019)	23,375.21 (0.018)	8,521.55 (0.022)	2,412.77 (0.021)
Total	**1,803,966**	**1,308,082**	**379,876.5**	**116,007.7**
Plant protein foods	1,803,966 (0.079)	1,308,082 (0.074)	379,876.5 (0.091)	116,007.7 (0.125)
Other food items	21,049,243 (0.921)	16,441,092 (0.926)	3,797,537 (0.909)	810,614.6 (0.875)
Total	**22,853,210**	**17,749,174**	**4,177,413.5**	**926,622.3**

Source: Data Analysis, 2022

Note: The figures in parentheses are the percentages and $1 $\approx$ 423.72

Income elasticity of demand for plant protein foods among households

The results of the estimated income elasticity of demand for plant protein foods among households is shown on Table 3. The positive sign on the coefficients of the plant protein foods imply that all the plant protein foods considered are normal goods. The plant protein foods being normal goods imply that an increase in the income of households caused an increase in their demand. The result revealed that cowpea (0.955) and groundnut (0.964) were considered to be necessities while soybean (1.282), lentils (1.659), peas (1.424), and pigeon pea (1.109) were considered to be luxuries. The necessities imply that households demanded for them regardless of their income, while the luxuries imply that households demanded for them only when their income increased. This result therefore showed the importance of cowpea and groundnut in the diets of households and that households forgone the other plant protein foods for cowpea and groundnut as a result of a fall in income during the pandemic. This is because with a fall in income, households still demanded for cowpea and groundnut. This could be due to households' usage of cowpea and groundnut, because while cowpea and groundnut have several uses (Janila *et al*., 2013; Ojedokun and Yesufu, 2021), the other plant protein foods can only be consumed in fewer forms.

This result also showed that the plant protein foods are normal goods for all categories of households, however their degree of response to income shock differs. The result revealed that for non-poor households, soybean (1.168), lentils (1.227) and peas (1.378) were luxuries while cowpea (0.995), groundnut (0.896) and pigeon pea (0.997) were necessities. The result showed that when non-poor households were faced with income shock, they still demanded for cowpea, groundnut and pigeon pea. Also, the result showed that soybean (1.128), groundnut (1.228), lentils (3.836) and pigeon pea (2.494) were considered to be luxuries for moderately-poor households, while cowpea (0.808) and peas (0.945) were considered to be necessities. This result showed that during the pandemic, moderately-poor households still demanded for cowpea and peas when faced with income shock.

Table 3. Expenditure (Income) Elasticity of Demand for Plant Protein Foods among Different Categories of Households

Food item	All Households		Non-poor Households		Moderately-poor Households		Core-poor Households	
	Elasticity	Decision	Elasticity	Decision	Elasticity	Decision	Elasticity	Decision
Cowpea	0.955*** (0.015)	Necessity	0.995*** (0.025)	Necessity	0.808*** (0.066)	Necessity	1.003*** (0.104)	Luxury
Soy Bean	1.282*** (0.102)	Luxury	1.168*** (0.157)	Luxury	1.128** (0.470)	Luxury	0.795 (0.864)	Necessity
Groundnut	0.964*** (0.033)	Necessity	0.896*** (0.057)	Necessity	1.228*** (0.132)	Luxury	1.051*** (0.226)	Luxury
Lentils	1.659*** (0.195)	Luxury	1.227*** (0.260)	Luxury	3.836*** (1.083)	Luxury	0.010 (1.371)	Necessity
Peas	1.424*** (0.087)	Luxury	1.378*** (0.117)	Luxury	0.945** (0.430)	Necessity	1.416* (0.858)	Luxury
Pigeon pea	1.109*** (0.141)	Luxury	0.997*** (0.217)	Necessity	2.494*** (0.576)	Luxury	0.129 (0.940)	Necessity

Source: Data Analysis, 2022

*, **, and *** denotes 10%, 5% and 1% level of significance respectively

Note: The figures in parentheses are the standard errors

However, cowpea (1.003), groundnut (1.051) and peas (1.461) were considered to be luxuries, while soybean (0.795), lentils (0.010), and pigeon pea (0.129) were considered to be necessities by the core-poor households. This result showed that core-poor households still demanded for soybean, lentils and pigeon pea when faced with income shock. This result for the core-poor households could be due to the lower prices of soybean, lentils, and pigeon pea when compared with others. The results of the income elasticity of demand for plant protein foods among households thus showed that while all households considered cowpea and groundnut as necessities, probably due to their availability and accessibility, the core-poor households considered soybean, lentils, and pigeon pea as necessities, probably because of their lower prices.

Own- and Cross-price elasticities of demand for plant protein foods among households

The results of the own- and cross-price elasticities of demand for plant protein foods among households is presented on Table 4. The results in bold, that is, the results on the on-diagonal represents the own-price elasticities, while those on the off-diagonal represents the cross-price elasticities. The results of the own-price elasticities showed that for all households, the elasticities were all statistically significant and in conformity with the law of demand, that is, they all have the expected negative signs. This implies that for all households, an increase in the price of the plant protein foods during the pandemic resulted in a decrease in the quantity that was demanded, and vice-versa. The results also showed that the demand for some of the plant protein foods were price-elastic, while for others, it was price-inelastic. The price-elasticity indicates that a change in the price resulted in a substantial change in the quantity demanded, while the price-inelasticity indicates that a change in the price caused a small change in the quantity demanded. The results further revealed that during the pandemic, the demand for cowpea and groundnut were price-inelastic for all households. These results are therefore consistent with these plant protein foods being necessities (see Table 3). The results further showed that while all own-price elasticities were statistically significant for both the non-poor and moderately-poor households, not all own-price elasticities were however statistically significant for the core-poor households.

For non-poor households, the results showed that only the demand for groundnut was price-inelastic, implying that an increase in the price of groundnut caused a small change in the quantity of groundnut that was demanded. This showed that during the pandemic, non-poor households were less responsive to a price shock with respect to groundnut, but responded more to a price shock with respect to cowpea, soybean, lentils, peas and pigeon pea. In addition, the results showed that for the moderately-poor households, the demand for cowpea was price-inelastic, that is, an increase in the price of cowpea caused a small change in the quantity of cowpea that moderately-poor households demanded. These results showed that moderately-poor households in the face of price shock were less responsive to the demand for cowpea. The results however showed that only three own-price elasticities were statistically significant for the core-poor households. The results revealed that for core-poor households, none of the plant protein foods were price-inelastic. A critical examination of these results showed that during the pandemic, core-poor households were more affected by a price shock than other categories of households, and as such were more responsive to the impact of increases in prices of plant protein foods than the non-poor and moderately-poor households.

The results of the cross-price elasticities of demand on Table 4 showed that some of the plant protein foods exhibited competitive or substitutive behavior because of the positive sign on their coefficients, while some others exhibited complementary behavior because of the negative coefficients' sign. The substitutive behavior indicates that an increase in the price of one food led to an increase in the demand for another, while the complementary behavior implies that an increase in the price of one food caused a reduction in the demand for another. The results showed that for all households, cowpea exhibited substitutive behavior with lentils and peas. The implication of this is that an increase in the price of cowpea caused households to demand more of lentils and peas. The results also showed that soybean only showed substitutive behavior with lentils and peas, indicating that an increase in the price of soybean led to an increase in the demand for lentils and peas. In addition, the results showed that groundnut, lentils and peas showed substitutive behavior with pigeon pea. This implies that an increase in the price of these plant protein foods (groundnut, lentils and peas) caused households to increase their demand for pigeon pea. The results further revealed that for non-poor households, cowpea and soybean exhibited substitutive behavior with lentils and peas. This implies that as the prices of cowpea and soybean increased, non-poor households increased their demand for lentils and peas. The results further showed that groundnut showed substitutive behavior with pigeon pea, indicating that as the price of groundnut increased, non-poor households increased their demand for pigeon pea. Also, the results revealed that lentils showed substitutive behavior with peas. This implies that when the price of lentils increased, non-poor households increased their demand for peas. For the moderately-poor households, the results showed that cowpea and soybean showed substitutive behavior with lentils. This implies that an increase in the prices of cowpea and soybean caused moderately-poor households to increase their demand for lentils. The results further showed that groundnut showed substitutive behavior with pigeon pea, which indicates that as the price of groundnut increased, moderately-poor households increased their demand for pigeon pea.

Finally, it is noteworthy to understand that the substitutive and complementary relationship observed among some of the plant protein foods has serious implications. The substitutive relationship exhibited by some of the plant protein foods could be associated with their identical nutritional profiles and similar texture when cooked. Also, some of these plant protein foods are rich in fibre and contain low level of fat and as such can substitute for themselves. However, the complementary relationship observed shows that these plant protein foods can be consumed together in the quest to provide complete protein for households (Flinn, 2021). This is because many of these plant protein foods are incomplete protein source. In addition, the complementary pairing observed according to Bruso (2018), is better than that of grains and legumes. Bruso (2018), further pointed out that the complementary pairing does not necessarily imply that they are consumed in the same meal but the same day.

Table 4: Own- and Cross-Price Elasticity of Demand for Plant Protein Foods among Different Categories of Households

Food item	Category	Cowpea	Soybean	Groundnut	Lentils	Pea	Pigeon Pea
Cowpea	All	**-0.954*** (0.069)**	0.022 (0.040)	-0.187*** (0.058)	0.086*** (0.017)	0.056** (0.026)	0.023 (0.022)
	Non-Poor	**-1.087*** (0.094)**	0.062 (0.056)	-0.174** (0.078)	0.112*** (0.023)	0.076** (0.037)	0.015 (0.028)
	Moderately-Poor	**-0.830*** (0.109)**	0.029 (0.071)	-0.227** (0.093)	0.123*** (0.032)	0.039 (0.041)	0.058 (0.044)
	Core-Poor	**-1.118*** (0.223)**	0.092 (0.124)	0.042 (0.226)	0.015 (0.031)	-0.016 (0.072)	-0.016 (0.062)
Soy Bean	All	0.078 (0.526)	**-2.153*** (0.592)**	-0.894 (0.651)	0.916*** (0.214)	0.655* (0.338)	0.116 (0.265)
	Non-Poor	0.656 (0.656)	**-2.374*** (0.738)**	-0.641 (0.746)	0.442* (0.243)	0.677* (0.401)	0.072 (0.290)
	Moderately-Poor	0.156 (0.835)	**-2.166** (1.105)**	-0.667 (1.121)	1.229*** (0.437)	0.766 (0.568)	-0.445 (0.550)
	Core-Poor	2.062 (2.370)	**-3.327 (2.601)**	-0.952 (3.192)	0.990 (0.686)	0.072 (1.528)	0.359 (1.198)
Groundnut	All	-0.483*** (0.144)	-0.157 (0.125)	**-0.930*** (0.300)**	0.038 (0.084)	0.096 (0.147)	0.472*** (0.094)
	Non-Poor	-0.391** (0.200)	-0.121 (0.159)	**-0.665* (0.365)**	0.130 (0.105)	-0.166 (0.190)	0.316*** (0.116)
	Moderately-Poor	-0.863*** (0.217)	-0.138 (0.222)	**-1.394*** (0.448)**	0.036 (0.147)	0.292 (0.206)	0.839*** (0.167)
	Core-Poor	0.060 (0.465)	-0.110 (0.340)	**-2.063** (0.980)**	-0.044 (0.165)	0.687 (0.430)	0.419 (0.278)
Lentils	All	5.292*** (1.081)	4.597*** (1.078)	0.836 (2.203)	**-9.105*** (1.165)**	1.690 (1.125)	-4.968*** (0.862)
	Non-Poor	6.345*** (1.279)	2.074* (1.148)	2.815 (2.335)	**-10.863*** (1.375)**	2.696** (1.287)	-4.294*** (0.947)
	Moderately-Poor	7.045*** (2.064)	6.593*** (2.409)	0.387 (4.059)	**-10.334*** (2.568)**	-0.698 (2.009)	-6.830*** (1.938)
	Core-Poor	2.729 (3.760)	6.432 (4.430)	-2.402 (9.997)	**-3.887 (3.367)**	0.429 (4.736)	-3.310 (3.902)
Peas	All	0.635 (0.424)	0.817* (0.426)	0.521 (0.967)	0.423 (0.281)	**-2.818*** (0.554)**	-1.002*** (0.312)
	Non-Poor	0.824 (0.503)	0.753* (0.456)	-1.005 (1.016)	0.646** (0.310)	**-2.383*** (0.629)**	-0.213 (0.342)
	Moderately-Poor	0.694 (0.749)	1.149 (0.849)	2.274 (1.556)	-0.165 (0.544)	**-1.969** (0.899)**	-2.927*** (0.602)
	Core-Poor	-0.861 (2.286)	0.099 (2.574)	10.684 (6.806)	0.109 (1.235)	**-7.498** (3.505)**	-3.948** (1.946)
Pigeon pea	All	0.673 (0.703)	0.296 (0.657)	6.058*** (1.212)	-2.437*** (0.423)	-1.960*** (0.614)	**-3.740*** (0.639)**
	Non-Poor	0.577 (1.000)	0.231 (0.891)	4.554*** (1.667)	-2.794*** (0.617)	-0.559 (0.926)	**-3.005*** (0.875)**
	Moderately-Poor	0.402 (0.979)	-0.915 (1.034)	7.657*** (1.591)	-2.322*** (0.659)	-3.725*** (0.756)	**-3.591*** (1.043)**
	Core-Poor	-0.113 (2.471)	0.787 (2.514)	8.401 (5.443)	-1.078 (1.265)	-4.900** (2.421)	**-3.225 (2.754)**

Note: The figures in parentheses are the standard errors; Source: Data Analysis, 2022; *, **, and *** denotes 10%, 5% and 1% level of significance respectively;

CONCLUSIONS

This study was conducted to investigate the demand for plant-based protein foods among different categories of households. This is necessary to drive policy towards the fulfilment of improved nutritional security and also the actualization of the Sustainable Development Goal (SDG) on good health and wellbeing. Households were divided into non-poor, moderately-poor and core-poor. This study concluded that during the COVID-19 pandemic, the most consumed plant protein foods by households were cowpea and groundnut. In addition, the study concluded that the result showed that, though non-poor households during the pandemic had a higher expenditure on plant protein foods than both the moderately-poor and core-poor households, the moderately-poor and core-poor households, however allocated higher shares of their total food expenditure share on plant protein foods than the non-poor households. The study further concluded that though cowpea and groundnut were considered to be necessities for all households, the following plant protein foods – soybean, lentils, and pigeon pea, were necessities for the core-poor households. The study concluded that if the core-poor households were given financial aid during the period of crisis, they will demand for soybean, lentils, and pigeon pea. Moreover, the result concluded that for all households, the demand for cowpea and groundnut were price-inelastic, and as such, a change in the price of cowpea and groundnut during the pandemic resulted in a small change in the quantity demanded for cowpea and groundnut.

This study has shown that the fall in income and the rise in prices of plant protein foods affected households though in different degrees. Hence, policy makers should endeavor that households, particularly the poorer segments of the society are protected through the introduction of different interventions or schemes during periods of crisis. This can be done through the introduction of relief packages to this section of the society. Also, during periods of crisis, soybean, lentils, and pigeon pea should be made available for core-poor households because these households consider them to be very important in their diet and thus, will still purchase them even in the face of price shock. In addition, when some plant protein foods, such as cowpea and groundnut are not available, some others like lentils, peas and pigeon pea should be provided for households.

Finally, this study only focused on some plant protein foods and was conducted in a particular geographical setting, it is therefore suggested that further studies conduct a nation-wide analysis of household demand across different plant-based protein foods.

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Conflicts of Interest

The authors declare that they do not have any conflict of interest.

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