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Demand for selected plant-based protein among the staff of a tertiary institution in Nigeria

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Increasing demand for animal protein has negative consequences on human health and the environment. Thus, the need for a replacement of animal protein with plant-based protein in the human diet is necessary. Therefore, the demand for selected plant-based protein (PBPs) (soybean, mushroom, potato, and cowpea) was assessed. Data collected from 343 staffers from the University of Ibadan were analysed using descriptive statistics and Quadratic Almost Ideal Demand System. Mushroom and soybean were luxury goods, but demand for mushrooms was more elastic than soybean. Potato was considered a necessary good. Expenditure elasticity for cowpea was, however, found to be just unitary. The selected plant-based proteins were normal goods.
Furthermore, all the compensated own-price elasticities (except mushroom) were less than one (in absolute terms), indicating that they are price-inelastic. They ranged between (-0.14) for soybean and (-0.62) for potato. Hicksian elasticities showed that mushroom was a substitute for cowpea and potato. Cowpea and potato were also substitutes for each other. Socio-economic factors influencing demand were years of schooling, access to market, prices of the PBPs and marital status of the respondent.

1. Introduction

Red meat is an important protein source, but it negatively affects health and can be substituted with plant-based protein foods (Martha *et al.*, 2019). These plant-based protein foods can be in modern forms, designed in such a way that satisfies the need of the consumer in terms of texture and flavour that are desirable; and can be made of soybeans and other protein-rich crops, including grass (Linnemann and Dijkstra, 2000). Food safety and health concerns have become crucial factors for a constantly growing number of consumers when purchasing food products (Zhu *et al.*, 2006). Thus, changing attitudes towards food consumption increases demand for meat substitutes or meat alternatives (Zhu and van Ierland, 2005; Zhu *et al.*, 2006).

Increased consumption and production of animal proteins is linked to increased greenhouse gas emissions and overutilization of water, which leads to rapid depletion of the Ozone layer; thereby causing climate change, global warming and ultimately, posing a threat to human existence (Wu *et al.*, 2014; Aiking, 2014). Arguably, the best solution to reduce problems associated with meat consumption would be to replace meat with plant-based protein foods (Markiewicz, 2010). One of the key drivers of meat-alternative product choice is the growing interest in healthy eating, including incorporating more plant-based foods into the diet and expectations of higher quality meat-alternative products (Sadler, 2004). The protein content of pulses (beans, peas and lentils) is higher than that of meat, fish, eggs or fresh milk, while cereals have intermediate content of proteins (Grigg, 1995). Although the differences in protein content in foods are significant, it is important to remember that malnutrition is caused by the lack of proteins in the diet and insufficient calorie intake (Aiking, 2011). A plant-based diet can also provide the essential amino acids when combined correctly with cereals and pulses.

Adherence to plant-based diets offers an advantage over animal-based diets concerning promoting longevity and prevention and management of chronic diseases, including heart disease and type2 diabetes (Ashaye *et al.*, 2012; Tuso *et al.*, 2013; McMacken and Shah 2017; Lynch *et al.*, 2018). A plant-based diet, including the plants of interest for this study, is rich in health-promoting nutrients and compounds like vitamins, minerals, fibre, and phytochemicals, even whilst providing the body with protein. Plant-based sources of protein of interest in this study- potato, cowpea, soy, and mushroom- are rich in vitamins, energy, non-essential amino acids, and most of all, protein. They are also low in cholesterol, unlike their counterpart animal-based protein foods. Cowpea (*Vigna unguiculata*) is the most consumed legume in Nigeria, and it combines the benefit of being a pulse with being a legume containing 21.1-29.9% protein and rich in essential and nonessential amino acids but low in fat content (1.2-1.8%) (Horax *et al.*, 2004; Onimawo 2010; Ajeigbe *et al.*, 2008). On the other hand, mushrooms and soybean are considered complete proteins, as they both contain all essential amino acids and possess 3.1-36g of protein in every 100g, respectively (United States Department of Agriculture, 2019). Soybeans are the only vegetable food that contains all eight essential amino acids with no cholesterol and are low in saturated fat (Lindsay & Claywell, 1998; Dudek, 2001). Furthermore, potato (Solanum tuberosum) protein is one of the most valuable non-animal proteins containing about 75 per cent water-soluble essential amino acids, and its nutritional value for humans equals that of a whole egg (Kowalczewski 2019). The average protein content of potatoes is 2% on a fresh weight basis (USDA, 2019). Although its protein is the least among the four selected plant-based proteins, its dry weight protein content is similar to that of cereals and is very high compared to other roots and tubers (FAO, 2008).

Nigeria ranks amongst the top potato producers in terms of area of land cultivated and production generally. In potato production, Nigeria is the fourth biggest producer in sub-Saharan Africa and has almost as much land for potato farming as Germany (Ugonna *et al.*, 2013). Abba (2013) stated that Nigeria is the largest producer of cowpea in Africa, with increasing demand over the last decade. A FAOSTAT report in 2014 listed Nigeria as the highest producer of cowpea in the world. Plant-based protein may be a cost-effective way to improve diet quality at all income levels (Aggarwal *et al.*, 2019). The plant-based protein sources of interest in this study are available all year round and are well adapted to the Nigerian climatic condition.

Relevant literature on demand and consumption for animal protein sources, other than plant sources, abound (Abdulai, 2004; Bielik and Šajbidorová, 2009; Ogunniyi *et al.*, 2012; Lusk and Tonsor, 2016). Although Wild *et al.* (2014) worked on a plant-based alternative to meat and its global acceptance, there is a dearth of empirical studies on demand for plant-based protein sources, especially in Nigeria. This study differs from related studies in that it estimated elasticities of selected plant-based protein foods, which is scarce in the literature.

2. Methodology

Primary data was used to collect information from 400 members of the University of Ibadan in 2019, using a questionnaire. The selection was made through a multi-stage sampling procedure (Figure 1). At the first stage, thirty per cent of each faculty (13) and the administrative units (18) were selected. This resulted in four (4) faculties and five (5) administrative units, respectively. At the second stage, 50 per cent of Departments in each chosen faculty were randomly selected. Then, the questionnaire was administered to 30 per cent of their academic staff and 50 per cent of their non-academic staff. For the administrative units, 30 per cent of senior staff and 10 per cent junior staff

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were randomly selected proportionate to size. Information on socio-economic factors such as age, sex, income, household size, etc., per capita expenditure on the selected crops and their expenditure on other food and non-food items were obtained from the respondents.

Descriptive statistics (mean, standard deviation, frequency and percentage) were employed to describe socioeconomic and other relevant variables considered in this study. The complete food demand estimation was carried out using Quadratic Almost Ideal System (QUAIDS) model. The QUAIDS model assumes that household preferences belong to the following quadratic logarithmic family of expenditure functions:

$$\ln c(u \cdot p) = lna(p) + \frac{ub(p)}{1 - \lambda(p)b(p)u} \quad (1)$$

Where u is utility, *p* is a vector of prices, *a(p)* is a function that is homogenous of degree one in prices, *b(p)* and *λ(p)* are functions that are homogeneous of degree zero in prices. The corresponding indirect utility *(V)* function for the plant-based protein of interest is specified as follows:

$$\ln V = \{[\frac{\ln m - lna(p)}{b(p)}]^{-1} + \lambda(p)\}^{-1} \quad (2)$$

Where m is the total expenditure, ln *a(p)* is the price index having the translog form expressed as:

$$lna(\mathbf{p}) = \alpha_0 + \sum_{i=1}^{j} \alpha_1 lnp_i + \frac{1}{2}\sum_{i=1}^{j}\sum_{i=1}^{j} \gamma_{ij} \ln p_i \ln p_j \quad (3)$$

b(**p**), which is Cobb-Douglas price aggregator takes the following specific flexible functional form:

$$b(\mathbf{p}) = \prod_{i=1}^{j} p_{i^{B}i} \quad (4)$$

$$\lambda(\mathbf{p}) = \sum_{i=1}^{j} \lambda \ln p_i \text{ where } \sum_{i=1}^{j} \lambda_i = 0 \quad (5)$$

Where *i*=1; and j denotes the number of plant-based protein inputted into the demand model. Deaton and Muellbauer (1980) proposed an AIDS model has an indirect utility function given by equation (1), but with $\lambda(\mathbf{p})$ set to zero. The specification of the functional forms for $a(\mathbf{p})$ and $b(\mathbf{p})$ in QUAIDS is similar to their specification in AIDS, in which they are made to be sufficiently flexible to represent any arbitrary set of first and second derivatives of the cost function (Bopape, 2006). Application of Roy's identity or Shepard's Lemma to the cost function in equation (5) gives the QUAIDS model budget shares as:

$$w_i \frac{\partial lna(\mathbf{p})}{\partial lnp_i} + \frac{\partial lnb(\mathbf{p})}{\partial lnp_i} (\ln x) + \frac{\partial \lambda}{\partial \ln p_i} \frac{1}{b(\mathbf{p})} (lnx)^2 \quad (6)$$

The corresponding expenditure share equation is:

$$w_i = \alpha_i + \sum_{j=1}^{j} \gamma_{ij} \ln p_j + \beta_i \ln\left[\frac{m}{a(\mathbf{p})}\right] + \frac{\lambda_i}{b(\mathbf{p})}\{\ln\left[\frac{m}{a(\mathbf{p})}\right]\}^2 + Z_i + \varepsilon_i \quad (7)$$

Where w_i is the budget share, allocated to the plant-based proteins i (potatoes (P), soybean (S), cowpea (C), mushroom (M); and m is the per capita expenditures on all commodities; γ_{ij} is the effects on the budget of item *i* (individual plant-based protein) of one per cent change in the prices of other crops in the basket *j* (all the plant-based protein of interest in the study); λ_i is lagrange multiplier (vector of non-zero element) is a monotonically decreasing function of probability that the selected household purchased the plant-based protein; m is household's total expenditure on food; Z is a vector of other independent variables described in Appendix I (including age, gender, highest educational attainment, distance to market, staff category, and staff level); ε_i is the error term; and α_i, β_i, and λ_i are parameters to be estimated. α_i is an average value of budget share in the absence of price and income effects, β parameters determines whether the individual crops are perceived as luxuries or necessities. When $\beta_i > 0$, an increase in m, leads to an increase in w_i, so that good i is a luxury. Similarly, $\beta_i < 0$ for necessities p_j is the price of each of the plant-based protein of interest in the study.

The budget share of individual food group was calculated thus:

$$W_{Pi} = (P_{P_b i} \cdot Q_{P_b i})/X_{P_b}$$

Where W_{Pi} is the budget share of the *ith* crop in the basket of plant-based protein (P_b), relative to total expenditure in the basket; and QPbi is the basket of ith plant-based protein (i = 1, 2, . . . , N) in order to overcome the problem of adding up different quantity of food consumed which are not of the same form; P_{Pbi} and Q_{Pbi} are the price and quantity of *i-th* food in basket P_b, respectively.

$$W_{Pi} = \frac{X_{P_b}}{X} = \textit{The budget share of basket } P_{bi}, \quad (8)$$

$$X_{P_b} = \sum P_{P_b i} Q_{p_b i} = \textit{total expenditure in basket } P_b \quad (9)$$

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Differentiating equation (6) with respect to ln m and ln pj, respectively, give:

$$\mu_i = \frac{\partial w_i}{\partial \ln m} = \beta_i + \frac{2\lambda_i}{b(\mathbf{p})} \left\{ \ln \left[\frac{m}{a(\boldsymbol{p})} \right] \right\} \quad (10)$$

$$\mu_{ij} = \frac{\partial w_i}{\partial \ln P_I} = \gamma_{ij} - \mu_i \left(\alpha_j + \sum_k \gamma_{jk} ln\, P_k \right) - \frac{\lambda_i \beta_j}{b(\mathbf{p})} \left\{ \ln \left[\frac{m}{a(\boldsymbol{p})} \right] \right\}^2 \quad (11)$$

The budget elasticities are then given by $e_i = (\mu_i / w_i)$. With a positive β and a negative λ , the budget elasticities will appear to be larger than unity at low levels of expenditure and less than unity as the total expenditure increases. Commodities have the features of luxuries at low levels of total expenditure and necessities at high levels.

3. Results and Discussion

Distribution of the consumers showed a male-dominated (67.6%) workforce with a modal age group of 41-50 years and a household size of five to eight members (Table 1). The mean age and household sizes were 44.7±8.95 years and 5±1.51, respectively (Appendix II), depicting an active working population in the university. A typical worker was a married (93.0 %) non-teaching staffer with post-secondary educational attainment, which is likely to increase awareness of the importance of plant-based protein foods in the human diet. The mean income stood at N180,635.20±142,540.60 ($501.76 ±395.95) per month (Table 4.2). The highest proportion of the respondents (35.9 per cent) earned between N100,001 - N200,000 ($277.78 – $555.56) monthly income, while only 27.7 per cent earned below $277.78. This suggests low remuneration of staff in the institution, which can suppress the demand for white meat.

Level of demand for plant-based proteins

Cowpea had the highest expenditure share (₦243.81), while mushroom (₦1.46) had the least (Table 2). This suggested that demand for cowpea was highest amongst the selected plant-based proteins, while the least was mushroom.

Determinants of demand for selected plant-based protein foods

Results showed that the coefficients of the squared per capita expenditure (lnEXPD2) on plant-based protein foods (soybean, mushroom, potato, cowpea) were significant (Table 3) for all the equations indicating that the staff's response of their demand to increase in expenditure was non-linear. Thus, supporting the rejection of the null hypothesis that the quadratic expenditure term is zero. This unveils the suitability of the QUAIDS model over the traditional AIDS model.

The years of schooling of staff and staff categories positively affected the demand for soybean (Table 3). These results imply that as the frontiers of knowledge of the respondents are broadened, staff tended to demand more soybean owing to exposure to the numerous benefits that can be acquired from soybean consumption. Furthermore, an academic staff member was more likely to increase demand for soybeans than a non-academic staff member. Similarly, being a senior staff will also increase the demand for soybean than being a junior staff. The staff category and staff level further showed that as consumers' education increased and they attained higher ranks in their respective careers, their demand for mushrooms also increased.

Furthermore, marital status negatively affected mushroom demand, while household size, distance to market, years of education, staff category, and level had a positive effect on mushroom demand. This inferred that being married, with additional mouths to feed, reduced the demand for mushrooms. This may be due to the assumption that the consumer is rational and replaced the consumption of luxury goods with necessities, increasing expenditure on necessities for the household. Similarly, an increase in distance to market will not limit respondents' demand for mushroom, indicating that they were willing to go to any length to ensure that their demand for mushroom was met.

The price of mushroom had positive effect on its budget share, while the prices of potato and cowpea had negative effect on their respective budget shares. This implied that the budget share of mushroom increased with increase in its own-price, while the budget shares of potato and cowpea decreased with increase in their respective own-prices. In the same vein, demand for mushroom increased with educational attainment, suggesting that education opens the gate of awareness and enlightenment for the con-

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sumer about the importance of highly plant-based protein foods, such as mushroom in the human diet.

Demand for potato increased with an increase in own-price and distance to market but decreased with an increase in the price of cowpea. However, it was lower among married respondents than among their unmarried counterparts. This showed the complementary nature of the two food items, implicitly hinting that potato consumers consumed it with cowpea. Furthermore, demand for cowpea increased with its own-price, owing to the fact that an increase in own-price of cowpea might increase the expenditure share accrued to it. Also, the result implied that demand for

Table 1. Socioeconomic distribution of the respondents

Socio-economic variables	Frequency	Per cent
Sex of respondent		
Female	111	32.4
Male	232	67.6
Age of respondent		
<31	15	4.4
31-40	107	31.2
41-50	135	39.4
51-60	79	23.0
>60	7	2.0
Marital status respondent		
Others	24	7.0
Married	319	93.0
Highest education attainment		
Primary	1	0.3
Secondary	8	2.3
Certificate/Diploma	25	7.3
Bachelors' degree	120	35.0
Master's degree	64	18.7
Ph.D.	125	36.4
Monthly income of respondents		
≤ 100,000	95	27.7
100,001-200,000	123	35.86
200,001-300,000	59	17.2
300,001-400,000	31	9.04
>400,000	35	10.2
Household size		
1- 4	129	37.5
5 – 8	207	60.5
>8	7	2
Staff category		
Non-academic	167	48.69
Academic	176	51.31
Staff level		
Senior staff	223	65.0
Junior staff	120	35.0

cowpea was higher among married individuals, probably because married households tend to have large household sizes. Conversely, household size, distance to market, years of education, staff category, and level had an inverse relationship with cowpea demand indicating a reduction in demand for cowpea whenever there was an increase in any of these variables. Household size having a negative effect on food demand is consistent with the findings of Ashagidigbi *et al.* (2012).

Elasticity of demand for the selected plant-based protein

Expenditure elasticity for soybean, and mushroom, estimated at sample means, had a greater than one value, indicating that they were both elastic commodities. However, mushroom had a higher value, suggesting that it was more elastic than soybean. Besides, both mushroom and soybean were both luxury goods (Table 4). Expenditure elasticity for potato was less than one but greater than zero, signifying that potato is a necessary good; thus, a unit increase in the income of respondents will lead to a less than proportionate increase in the demand for potato. This finding is similar to the findings of Huq *et al.* (2004) for potatoes in Bangladesh. Conversely, expenditure elasticity for cowpea was found to be unitary (1.03), indicating that there will be almost an equal increase in demand for cowpea as the consumer income/expenditure increases by a unit.

Compensated and uncompensated own-price elasticities of demand for selected plant-based proteins

The diagonal matrix showed that all own-price elasticities of the selected food items (except that of soybean) had negative signs, implying that they were normal goods, whose demand declined when their prices increased (Table 5). The positive own-price elasticity for soybean indicated that it was a 'giffen' good, whose demand increased with a proportionate increase in own-price. Estimates of the uncompensated own-price elasticities of demand for soybean, cowpea, and potato were inelastic in absolute terms. However, mushroom was highly elastic in absolute terms, suggesting that it was highly responsive to changes in own-prices.

In addition, all the compensated own-price elasticities in the diagonal matrix carried the expected negative sign implying that the food items were normal goods whose demand declines when their prices increase. However, the elasticities were smaller in magnitude (except for soybean) than the uncompensated/ Marshallian own-price elasticities. This implied that price responsiveness of the different plant-based protein items was dependent on expenditure. When expenditure was held constant (that is, not a constraint in the decision process), consumers tended to be less responsive to prices of these items. Furthermore, all the compensated own-price elasticities (except mushroom) were less than one (in absolute terms) indicating that they were price-inelastic, ranging from (-0.14) for soybean and (-0.62) for potato. Similar to uncompensated own-price elasticities, the compensated own-price elasticities for mushroom (-2.0324) were found to be larger in magnitude than others. This implied that the mushroom is more responsive to change in own-prices than other plant-based protein foods.

The uncompensated or the Marshallian cross-price elasticity of demand for the selected plant-based pro-

Table 2. Expenditure share of plant-based proteins

Variable	share	Mean	Std. Dev.
w1	17.78	0.051843	0.14
w2	1.46	0.004255	0.03
w3	79.95	0.233088	0.28
w4	243.81	0.710814	0.30

w1= Expenditure share of soybean; w2= Expenditure share of mushroom; w3= Expenditure share of potato; w4= Expenditure share of cowpea. (prices per kilogram were used in computing the expenditure share)

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Table 3. Determinants of demand for Plant-based Proteins

Variable	Soybean	Mushroom	Potato	Cowpea
Constant	0. .0082 (0.2074)	0.3463*** (0.0548)	1.7574*** (0.3059)	-1.1120*** (0.3471)
		Price coefficients		
ln price of soybean	0.0688 (0.0545)			
ln Price of Mushroom	-0.0141 (0.0146)	0.0137* (0.0081)		
Ln Price of Potato	-0.0738 (0.0732)	-0.0974*** (0.0187)	0.5608*** (0.1646)	
ln Price of Cowpea	0.0191 (0.0815)	-0.0970*** (0.0243)	-0.5845*** (0.1726)	0.6623*** (0.2139)
		Expenditure and Expenditure squared		
lnEXPD	-0.1010* (0.0530)	0.0651*** (0.0129)	0.3854*** (0.0713)	-0.3495*** (0.0813)
$\ln EXPD^2$	-0.0050* (0.0030)	0.0038*** (0.0007)	0.0269*** (0.0032)	-0.0257*** (0.0040)
		Socio-economic Characteristics		
Age	0.0002 (0.0002)	0.00004 (0.00003)	0.0004 (0.0004)	-0.0006 (0.0004)
MAR_STATUS	-0.0041 (0.0051)	-0.0016* (0.0009)	-0.0372*** (0.0118)	0.0430*** (0.0121)
HHSIZE	0.0016 (0.0010)	0.0004** (0.0002)	0.0022 (0.0023)	-0.0042* (0.0006)
DIST_MARKET	-0.00002 (0.0001)	0.0001*** (0.0000)	0.0004* (0.0002)	-0.0004** (0.0002)
Highest_Edu	0.0017*** (0.0006)	0.0002** (0.0001)	0.0002 (0.0012)	-0.0021* (0.0012)
STAFF_CAT	0.0102** (0.0046)	0.0022*** (0.0008)	0.0121 (0.0104)	-0.0245** (0.0107)
STAFF_LEVEL	0.0090** (0.0042)	0.0027*** (0.0007)	0.0109 (0.0095)	-0.0226** (0.0098)

(Figures in parenthesis represent the standard error). *, ** and *** represent levels of significance at 10¸ 5, and 1 percent, respectively.
Age: The age of respondent; MAR_STATUS: marital status of the respondent; HHSIZE: household size of the respondent; DIST_MARKET: distance to market from respondent; Highest_Edu: the highest educational attainment of respondent measured in years of formal education; STAFF_CAT: Staff category of respondent, whether academic or non-academic; STAFF_LEVEL: The respondents rank/level in their job.

teins shows the percentage change in the demand or consumption of an individual selected plant-based protein when the price is increased with respect to any of the selected food items in the study. The uncompensated cross-price elasticities were mainly negative, indicating a complementary relationship among the food items. For example, the cross-price elasticity for soybean and mushroom (-1.4986) indicated that both food items were complements (Table 5). This means that a percentage rise in the soybean price would lead to a less than proportionate decrease (1.5) in the quantity of mushroom demanded. Other pairs of food items having a complementary relationship are soybean and potato (-0.0375), soybean and cowpea (-0.0542), and potato and cowpea (-0.0455).

On the other hand, the uncompensated cross-price elasticity of demand between mushroom and potato (0.0152), mushroom and cowpea (0.0096), cowpea and potato (0.1377) indicated that they were substitutes. Thus, a percentage increase in the price of one pair would lead to a less or greater than proportionate increase in the demand for the other. For example, a per cent increase in the price of cowpea would cause a less than proportionate increase (0.13%) in demand for potato. On the other hand, the compensated or Hicksian cross-price elasticities were mostly positive, indicating substitutions among the food items. Mushroom was considered a substitute for all other food items except soybean, implying that when the price of mushroom increases, there would be a greater than proportionate increase in the quantity demanded of potato and cowpea, respectively. Likewise, cowpea and potato (0.14) were substitutes.

4. Conclusion

This study provides empirical evidence on demand for plant-based protein foods among the staff of a tertiary institution in Southwest using QUAIDS model. Results showed that the consumers spent more on cowpea than the selected plant-based protein foods, while mushroom was the least consumed. However, mushroom and soybean were luxury goods, while cowpea, potatoes and soybean were necessities. Low-income earners were less likely to choose mushroom and soybean but were more likely to choose cowpea. All the food items except mushroom were price inelastic. From the foregoing, there is a need for increased production of the selected plant-based proteins, especially cowpea, as it is the most demanded among the selected plant-based proteins. The high level of demand for cowpea in the study area also leads to higher market prices. Agricultural and nutritional policymakers should intensify efforts for public enlightenment on the numerous benefits of plant-based protein, especially mushroom and soybean, which were the least demanded plant-protein foods. Increased demand for these food items will reduce the price of cowpea and potatoes, which were their substitutes.

Furthermore, government intervention towards the marketing and pricing of mushroom and soybean is recommended to take it from 'luxury good' status to 'necessity good' status, thereby increasing the demand for these food items. Conclusively, the "one cap fits all" policy cannot be prescribed to promote the selected PBPs' consumption among consumers. However, an integrated food policy that takes into account the socioeconomics of consumers, such as increasing their years of schooling, access to market and income, would increase consumers' demand for plant-based protein foods.

Conflict of interest

Authors declare no conflicts of interest.

Table 4. Expenditure elasticity of plant-based proteins

Food items	Elasticity
Soybean	2.00
Mushroom	2.73
Potato	0.66
Cowpea	1.03

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Table 5. Uncompensated and compensated elasticities of demand

Food Items	Soybean	Mushroom	Potato	Cowpea
Marshallian/uncompensated Elasticity				
Soybean	**0.0353**	-1.4986	-0.0375	-0.0542
Mushroom	-1.1424	**-2.0440**	0.0152	0.0096
Potato	-0.4488	0.5155	**-0.7708**	-0.0455
Cowpea	-1.4676	0.2999	0.1377	**-0.9399**
Hicksian/compensated Elasticity				
Soybean	**0.1388**	-1.3572	-0.0035	-0.0008
Mushroom	-0.1057	**-2.0324**	0.0180	0.0140
Potato	0.0163	1.1512	**-0.6180**	0.1946
Cowpea	-0.0493	2.2384	0.6036	**-0.2077**

Source: Computed from QUAIDS (All quantities are standardized kilogram, and prices are per kilogram).

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Appendix I. Description and a priori expectations of explanatory

VARIABLE	DESCRIPTION	SIGN			REFERENCE
Age	Age of respondent (in years)	+ -			Lloyd *et al.* 2014 Chinda *et al.* 2018
Age^2	The square of the respondent's age (in years)	+			Kaiser *et al.* 2000
Gender	Sex of the respondent (1 if male, 0 otherwise)	+			Obayelu *et al.* 2018
Marital status	Marital status of respondent; Dummy, 1 if married, and 0 otherwise	+			Chinda *et al.* 2018
Educational level	Highest educational attainment of respondent	+			Lloyd *et al.* 2013, Chinda *et al.* 2018
Household size	Household size of the respondent	+			Chinda *et al.* 2018
Income	The income earned per month by the respondent (in naira)	+			Obayelu O.A. *et al.* 2018; Rampal P. 2018
Price	The price at which the food items of interest are purchased (in naira per kg)	-			Rampal 2018; Williamson, and Shah 1981
Expenditure share	The share of expenditure of the respondent for each of the plant-based protein of interest in the study (in naira per week), and given as the total amount spent on individual food item / total amount expended on all plant based protein	+			Rampal 2018; Williamson and Shah, 1981

Appendix II. Summary statistics of variablesvariables

Variable	Definition of variable	Obs	Mean	Std. Dev.	Min	Max
Age	Age of respondents(in years)	343	44.69679	8.950231	20	65
Agesq	The square of age of respondents(in years)	343	2077.676	802.6305	400	4225
Highest_Edu	Highest educational attainment of the respondent (number of years of formal education)	343	19.2828	3.379318	6	23
HHSIZE	Household size of the respondent	343	4.912536	1.536473	1	10
INCOME	Monthly income of respondent (in naira)	343	180635.2	142540.6	10000	800000
QTY_SOYBEA	Quantity of Soybean purchased weekly by the consumer	343	0.215743	0.6341523	0	5
QTY_MUSHROOM	Quantity of Mushroom purchased weekly by the consumer	343	0.065598	0.4774875	0	5
QTY_POTATO	Quantity of potato purchased weekly by the consumer	343	1.268222	1.485627	0	10

Continue Appendix II. Summary statistics of variablesvariables

Variable	Definition of variable	Obs	Mean	Std. Dev.	Min	Max
QTY_COWPEA	Quantity of cowpea purchased weekly by the consumer	343	1.95481	1.707011	0	15
ACT_PRICE_SOYBEAN	Actual price consumer purchases soybean	343	398.7172	50.91518	350	800
ACT_PRICE_MUSHROOM	Actual price consumer purchases mushroom	343	156.7638	27.45586	100	350
ACT_PRICE_POTATO	Actual price consumer purchases potato	343	181.3703	38.01185	100	375
ACT_PRICE_COWPEA	Actual price consumer purchases cowpea	343	408.3382	63.24099	300	600
EXP_SOY	Consumer weekly expenditure on soybean	343	86.73469	251.7706	0	2000
EXP_MUSHROOM	Consumer weekly expenditure on mushroom	343	11.1516	74.97895	0	850
EXP_POTATO	Consumer weekly expenditure on potato	343	221.7201	250.0271	0	1500
EXP_COWPEA	Consumer weekly expenditure on cowpea	343	796.8513	684.9691	0	6000
TEXP_PLANT	Total weekly expenditure of consumer on plant-based protein of interest	343	1116.458	826.0829	150	6000

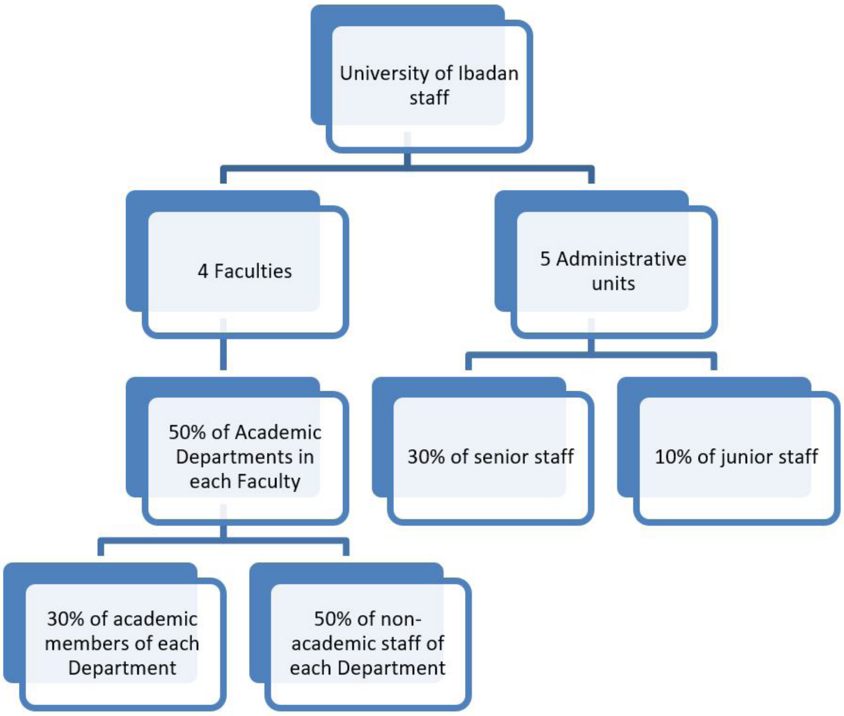

Figure 1. Sampling procedure

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