*Original Research Article*

# Protein food consumption among students in a Nigerian university: A demand modelling

Oluwakemi Adeola **Obayelu**[1]*, Adebusola Iyanu **Adeyeye**[1], Abimbola Oluyemisi **Adepoju**[1], Abolupe Oluyemi **Ayanboye**[2]

[1]*Department of Agricultural Economics, University of Ibadan, Ibadan, Nigeria*
[2]*Department of Fisheries and Aquatic Resources Management, Ejigbo Campus, Osun State University, Osogbo, Nigeria*

***Correspondence to:***
**O. A. Obayelu,** Department of Agricultural Economics, University of Ibadan, Ibadan, Nigeria;
E-mail: jkemmyade@yahoo.co.uk

## Abstract

Adequate consumption of protein is indispensable for human growth and health. Nigeria has a high burden of protein deficiency with attendant loss of economic productivity and high health bills due to ill-health. Owing to paucity of information on demand for protein foods among Nigerian youths, the study assessed the demand for protein foods among students of the University of Ibadan, Ibadan, Nigeria. The data collected from 300 students through a multi-stage smapling procedure were analysed using descriptive statistics and Quadratic Almost Ideal System model (QUAIDS). The results have shown that some of the price coefficients expectedly had a negative relationship with the expenditures. The youths also spent more on beans and chicken but spent less on groundnut. Furthermore, expenditure elasticities of all protein foods were positive. Moreover, expenditure elasticities for beans, eggs, beef and goat meat showed that they were necessities goods, whereas chicken, turkey, soy milk, pork, groundnut and milk were luxury goods. Both compensated and uncompensated elasticity showed that own-price elasticities for the selected protein food items were inelastic, with the exception of goat meat. Demand for protein foods was influenced by own-prices of the protein foods, prices of other protein foods and being a male student. In order to meet their daily dietary needs within a limited budget, students should substitute expensive protein sources like chicken, goat meat, beef and turkey with cheaper ones like groundnut, soymilk, beans and eggs in their diets.

**Keywords:** Demand elasticities; household expenditure; protein foodstuff; youths; Nigeria

## INTRODUCTION

Protein is a major nutrient for the growth, upkeep and repair of all body's cells and its deficiency in the body has various negative health complications including kwashiorkor, impaired mental health, wasting and shrinkage of muscle tissues, marasmus, impaired mental health, oedema, organ failure, immune system wasting and shrinkage of muscle tissues (Khan et al., 2017). Adequate consumption of high-quality protein is indispensable for optimum and healthy human life. The Recommended Dietary Allowance (RDA) for protein is 133 mg nitrogen per kg of body weight per day, or 0·83 g protein per kg of body weight per day to meet the needs of a healthy population, irrespective of age, representing 10 to 35 percent of daily calories (WHO, 2007). Proteins are essential in the human diet needed for survival and provision of sufficient amounts of amino acids in the building block of the body (Maurya and Kushwaha, 2019). Adequate consumption of protein is essential to human growth

and health (Wu et al., 2014). Malnutrition is therefore the most important risk factor of diseases and deaths in developing countries, especially in sub-Saharan Africa region, which is the capital of nutrition insecure people in the world (Giller, 2020).

Nigeria is a populous and sundry country with the high prevalence of nutritional deficiency varying widely across its borders owing to high cost and inadequate supply of animal protein (Adekunmi et al., 2017; SPRING, 2018). As at 2019, Nigeria's per capita daily protein intake (45.4 g) was lower than both the Food and Agriculture Organization (FAO) recommended minimum per capita daily protein intake (53.8 g) and the global daily intake (64 g), indicating that the country is faced with protein deficiency (Metu et al., 2016; Akerele et al., 2017; Protein Challenge, 2020). Protein-energy malnutrition is still prevalent in Nigeria as a result of the decline in protein intake owing to scarcity and unaffordable price of animal protein food sources (De Vries-ten Have et al., 2020). A proper mix of plant and animal protein foods enhances a balanced provision of dietary protein for the young and the adult lives (Wu, 2016). However, the cost of meeting the recommended level of protein-rich foods in Nigeria is high, accounting for about 28% of the minimum total cost of diets in 2019 (Mekonnen et al., 2021). A higher proportion of Nigerian households either substitute more expensive animal proteins with plant proteins or consume a greater variety of cheap, calorie-dense cereals and starchy roots and tubers than proteins (Ecker and Hatzenbuehler, 2022).

Protein deficiency is associated with poor human capital and economic development including malnutrition, susceptibility to endemic and infectious diseases, poor cognitive development, a lowered performance in education, low productivity and increased poverty (Khan et al., 2017; Erokhin et al., 2021; Osendarp et al., 2021). Global increase in demand for protein is driven by changing socio-economic changes such as rising incomes and changing socio-demographics (Popkin et al., 2012; Suchismita and Shaik, 2018). A surge in global population and demand for food will cause changes in consumption patterns, the type of foods demanded, and their relative contribution to diets (Henchion et al., 2018). The protein intake is likely to be highest in young adults but most studies of malnutrition in developing countries have focused on early childhood malnutrition (Chernoff, 2016; Kenmogne-Domguia et al., 2016; De Vries-ten Have et al., 2020; Ibirogba and Ikhaghu, 2021; Sanusi et al., 2022). The study is therefore relevant due to relatively paucity of nutritional information on demand for protein foods among adolescents and young adults in Nigeria. The study aimed at identifying factors influencing students' demand for protein; and estimating price elasticities of demand for protein foods among the students of University of Ibadan.

### Hypotheses

$H_{01}$ = There is no significant relationship between own-price and demand for protein food items among the youths.

$H_{02}$ = There is no significant relationship between youths' socio-economic characteristics and demand for protein food items.

## MATERIALS AND METHODS

University of Ibadan, on the latitude 7.4275° N and longitude 3.8995°E; five miles (8 kilometres) from the centre of the city of Ibadan in Southwestern Nigeria, lies completely within tropical forest zone but close to the boundary between the forest and the derived savanna. It has an area of 1,032 ha and a population of 35,000 students. It has 15 faculties and a college of medicine. A two-stage simple random sampling procedure was employed in the survey; first, by taking 30% of the Hall of residences and secondly by randomly selecting 10% of its population. A total of 300 students were randomly selected from three different halls of residences, proportionate to their sizes. Some of the information obtained from the students include demographic characteristics (age of students, sex of students, income level and marital status), demand factors (price of protein foods, price of substitutes, taste and income).

Different analytical techniques used include descriptive statistics and Quadratic Almost Ideal System model (QUAIDS). The QUAIDS was used to measure the factors influencing students demand for protein, the budget share-to-protein and also the price elasticity of demand of students in the study area. The model through statistical analysis system econometric software used the iterative seemingly unrelated regressions and the ordinary least square methods to estimate income and price elasticities for eleven protein foods. The QUAIDS model employed an indirect utility demand function with budget shares linear in logarithm of total expenditure (known as PIGLOG demand system which includes AIDS) (Banks et al., 1997; Deaton and Muellbauer, 1980; Shittu et al. 2014 Obayelu et al., 2021). The QUAIDS model assumes that student's preferences belong to the following quadratic logarithmic family of:

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

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 jth protein source is specified as follows:

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

The specification of the functional forms for a (p) and b (p) in QUAIDS is sufficiently flexible to represent any arbitrary set of first and second derivatives of the cost function (Liu and He, 2016). Application of Roy's identity or Shepard's Lemma to the cost function in equation (3) gives the QUAIDS model budget shares as:

$$wi = \frac{\delta \ln a(p)}{\delta \ln Pi} + \frac{\delta \ln b(p)}{\delta \ln Pi}(\ln x) + \frac{\delta \lambda}{\delta \ln Pi}\frac{1}{b(P)}(\ln x)^2 \quad (3)$$

and the corresponding expenditure share equation is:

$$wi = \alpha_i + \sum_{j=i}^{j} Y_{ij} \ln Pj +$$

$$+ ß_i \ln\left[\frac{m}{a(p)}\right] + \frac{\lambda_i}{b(p)}\left\{\ln\left[\frac{m}{a(p)}\right]\right\}^2 + \varepsilon_i \quad (4)$$

where *w*i is the share of ith protein food expenditure; $\alpha_i$, ß, *y* and *λ* are parameters to be estimated. $\alpha_i$ is an average value of budget share in the absence of price and income effects, ß parameters determine whether protein foods are luxuries or necessities. When $ß_i > 0$, an increase in *m* leads to an increase in $w_i$ so that ith protein food is a luxury. Similarly, $ß_i < 0$ is for necessities. $P_j$ is the price of *jth* protein food, and *m* is the per capita expenditures on all commodities; $\gamma_{ij}$ represents the effects on the budget of item i of 1 percent change in the prices of items in jth protein food; $\lambda_i$ is the Lagrange multiplier (vector of non-zero element); l is a monotonically decreasing function of probability that the selected household purchased the item; Z is the vectors of other independent variables (social economics/demographic variables); $\varepsilon_i$ – is coefficient of other independent variables; and $u_i$ is the error term.

The budget share of individual food group was calculated as follows:

$$\mu_i \equiv \frac{\partial W_i}{\partial \ln m} = \beta_i + \frac{2\lambda_i}{b(P)}\left\{\ln\left[\frac{m}{a(p)}\right]\right\}, \quad (5)$$

$$\mu_{ij} \equiv \frac{\partial w_i}{\partial \ln Pj} = \gamma_{ij} - \mu_i(aj + \sum_k \gamma jk \ln Pk) - \frac{\lambda_i \beta j}{b(p)}\left\{\ln\left[\frac{m}{a(P)}\right]\right\}^2 \quad (6)$$

The budget elasticities are then given by $ei = (\mu_i / w_i) + 1$. 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.

The Marshallian demand equation was obtained from maximising utility subject to the budget constraint, while the Hicksian demand equation was derived from solving the dual problem of expenditure minimization at a certain utility level. Elasticities derived from Marshallian demand are called Marshallian or uncompensated elasticities, and elasticities derived from Hicksian demand are called Hicksian or compensated elasticities. Marshallian elasticities can be transformed into Hicksian elasticities through the Slutsky equation (Benda-Prokeinová and Hanová, 2016).

The uncompensated price elasticities are given by, where $e_{ij}^u = \mu_{ij} / (W_i - \delta_{ij})$, where $\delta_{ij}$ is Kronecker *δ*.The Slutsky equation, $e_{ij}^c = e_{ij}^u + e_i wj$, can be used to calculate the set of Hicksian compensated elasticities and to assess the symmetry and negativity conditions by examining the matrix with elements which should be symmetric and negative semi-definite in the usual way. The QUAIDS model, identified by equation (6), exhibits flexibility in the representation of income effects, being of rank three. It has the same degree of price flexibility as the usual linear AIDS and Translog models. It also has the linear AIDS model nested within it as a special case with few additional parameters over the AIDS model. The Marshallian price elasticities ($E_{ij}$) were computed by:

$$\frac{\partial wi}{\partial \ln Pj} = \gamma_{ij} - \left(aj + \sum_k \gamma k \ln Pk\right).\left(\frac{\partial wi}{\partial \ln x}\right) - \beta j \frac{\lambda_i}{b(p)} \ln\left[\frac{x}{a(p)}\right]^2 \quad (7)$$

Additivity, homogeneity and symmetry define exact linear restrictions on the parameters of the QUAIDS share equations implying the utility maximization objective.

## RESULTS AND DISCUSSION

The distribution of sexes among the respondents showed that two-thirds of the students were female (Table 1). This is against the *a priori* as males are assumed to have higher enrollment in school than females.

**Table 1.** Profiling of students by demographic characteristics

| Characteristics | Frequency | Percentage |
|---|---|---|
| **Sex** | | |
| Female | 200 | 66.67 |
| Male | 100 | 33.33 |
| **Age (in years)** | | |
| 16–20 | 86 | 28.67 |
| 21–25 | 167 | 55.67 |
| 26–30 | 36 | 12.00 |
| 31–35 | 11 | 3.67 |
| **Marital status** | | |
| Single | 284 | 94.67 |
| Married | 16 | 5.33 |
| **Time taken to walk to the market (minutes)** | | |
| <10 | 37 | 12.33 |
| 11–30 | 236 | 78.67 |
| >30 | 27 | 9.00 |
| **Time to take cab to the market (minutes)** | | |
| 0–10 | 205 | 68.33 |
| 11–20 | 88 | 29.33 |
| 21–30 | 7 | 2.33 |
| **Access to scholarship** | | |
| No | 274 | 91.33 |
| Yes | 26 | 8.67 |

**Table 2.** Monthly budget shares of respondents on protein foods

| Food items | Average monthly expenditure on food item (₦) | Budget share on food items (%) |
|---|---|---|
| Beef | 1030.50 | 10.41 |
| Beans | 1107.50 | 11.20 |
| Egg | 737.59 | 7.45 |
| Fish | 941.31 | 9.50 |
| Goat meat | 993.80 | 10.03 |
| Chicken | 1088.22 | 10.88 |
| Turkey | 1046.65 | 10.46 |
| Pork | 677.38 | 6.84 |
| Soymilk | 946.25 | 9.55 |
| Groundnut | 440.21 | 4.44 |
| Milk | 894.89 | 9.04 |

The mean age of the students was 22.08 ± 21.0 years implying that a typical student was young and less than 25 years of age. A larger proportion (55.7%) of the respondents was within 21–24 years of age whereas 3.67% were older than 30 years. A larger percentage of the students were also single (94.7%) and had no access to scholarships (91.3%). Being married and having access to scholarship are likely to increase the propensity to consume more protein. A higher proportion of students used between 21 to 30 minutes to walk to the nearest market, with an average time of 22 minutes. This time is rather long and it could discourage the student from visiting the market frequently, which could reduce the rate of purchase and consumption of protein foods. This could affect the overall well-being of the student. Moreover, a higher percentage of the respondents (68.3%) used 0–10 min to get to the nearest market in commercial vehicles, whereas 2.33% of the students spent 21 to 30 min to get to the nearest market, with an average time of 9 min using commercial vehicles. This implied that taking a cab to the market by students will help create easy access to the market.

## Budget share of protein expenditure

The budget share of each food item shows that beans (11.2%) and chicken (10.9%) had the highest budget share, whereas groundnut has the least (4.4%) (Table 2). This implies that students spent more on beans and chicken but spend less on groundnut. Owing to high cost of other proteins, beans are the most regularly consumed protein-rich food by Nigerians (NPDS, 2019). The result further buttresses the finding of De Vries-ten Have et al. (2020) that chicken and beef were frequently eaten animal proteins in Nigeria.

## Factors influencing students' demand for protein

Factors influencing students' demand for beans were own-prices of beans, prices of goat meat, turkey and pork, as well as expenditure on beans, age and being a male student (Table 3). Students' budget share on beans increased with own price due to the fact that increase in own price of other protein foods might increase the expenditure share accrued to them. However, the negative sign at the price coefficients indicated that an increase in prices of goat meat, turkey and pork will lead to a decrease in demand for beans. Being a male student with advancing age will increase in demand for beans than among younger female students. This is consistent with the findings of Olorunfemi (2013). Similarly, own-price and being a male student strongly increased the demand for groundnut, while increase in household expenditure would substantially diminish it. Furthermore, own-price strongly increased demand for soymilk, while increase in expenditure would substantially diminish it. However, when a commodity has a positive sign of expenditure and negative sign of higher order of expenditure term, this commodity is considered a luxury good at low levels of expenditure and necessity at high levels (Banks et al., 1997). The significance of expenditure squared explains the non-linear nature of demand for soy milk, that

**Table 3.** Determinants of students' demand for protein foods

| Variable | Beans | Eggs | Fish | Beef | Goat meat | Chicken | Turkey | Soymilk | Pork | Groundnut | Milk |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Constant** | **–0.166**** | **–0.066**** | **–0.112***** | **–0.175***** | **–0.219***** | **–0.150***** | **2.304***** | **–0.117***** | **–0.171***** | **–0.044***** | **–0.084**** |
| | (0.066) | (0.033) | (0.036) | (0.023) | (0.028) | (0.031) | (0.101) | (0.020) | (0.014) | (0.016) | (0.043) |
| **Price coefficients** | | | | | | | | | | | |
| **Beans** | 0.129*** | | | | | | | | | | |
| | (0.009) | | | | | | | | | | |
| **Egg** | –0.001 | 0.031*** | | | | | | | | | |
| | (0.003 | (0.003) | | | | | | | | | |
| **Fish** | –0.005 | –0.007 | 0.042*** | | | | | | | | |
| | (0.004) | (0.003) | (0.005) | | | | | | | | |
| **Beef** | –0.004 | –0.003 | –0.001 | 0.006* | | | | | | | |
| | (0.003) | (0.002) | (0.003) | (0.003) | | | | | | | |
| **Goat meat** | –0.009*** | 0.001 | 0.009*** | 0.061*** | –0.002 | | | | | | |
| | (0.003) | (0.003) | (0.003) | (0.003) | (0.004) | | | | | | |
| **Chicken** | –0.0031 | 0.000 | –0.007* | –0.002 | 0.004 | 0.068*** | | | | | |
| | (0.004) | (0.003) | (0.004) | (0.003) | (0.004) | (0.006) | | | | | |
| **Turkey** | –0.106*** | –0.024*** | –0.027*** | –0.048*** | –0.059*** | –0.042*** | –0.438*** | | | | |
| | (0.015) | (0.008) | (0.009) | (0.006) | (0.007) | (0.008) | (0.031) | | | | |
| **Soymilk** | 0.001 | 0.001 | –0.0034 | –0.001 | 0.003 | –0.006** | 0.038*** | 0.043*** | | | |
| | (0.002) | (0.002) | (0.0027) | (0.002) | (0.003) | (0.003) | (0.005) | (0.003) | | | |
| **Pork** | –0.005*** | –0.000 | 0.004* | 0.002 | –0.001 | –0.007*** | –0.047*** | –0.001 | 0.053*** | | |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.004) | (0.002) | (0.002) | | |
| **Groundnut** | –0.001 | 0.001 | –0.000 | –0.005** | –0.003 | 0.002 | –0.016*** | 0.000 | 0.001 | 0.012*** | |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.003) | (0.004) | (0.002) | (0.002) | (0.003) | |
| **Milk** | 0.004 | 0.003 | –0.003 | –0.005* | –0.005 | –0.006 | –0.029*** | 0.001 | 0.001 | 0.003 | 0.036*** |
| | (0.004) | (0.003) | (0.004) | (0.003) | (0.004) | (0.004) | (0.010) | (0.003) | (0.002) | (0.002) | (0.007) |
| **Expenditure and expenditure squared** | | | | | | | | | | | |
| **Ln Expenditure** | –0.067*** | –0.021* | –0.020 | –0.029*** | –0.047*** | –0.032*** | 0.268*** | –0.017** | –0.022*** | –0.006 | –0.008 |
| | (0.025) | (0.012) | (0.013) | (0.009) | (0.012) | (0.012) | (0.048) | (0.010) | (0.006) | (0.006) | (0.016) |
| **Ln Expenditure squared** | 0.000 | –0.000 | 0.001 | 0.000 | 0.000 | 0.002* | –0.010 | 0.001* | 0.002*** | 0.001 | 0.002 |
| | (0.002) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.005) | (0.001) | (0.001) | (0.001) | (0.001) |
| **Students' characteristics** | | | | | | | | | | | |
| **Age** | 0.004** | –0.000 | 0.000 | 0.001 | 0.003*** | 0.002 | –0.011 | 0.0002 | 0.001* | 0.000 | –0.000 |
| | (0.002) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.005) | (0.001) | (0.001) | (0.000) | (0.001) |
| **Weight** | –0.003 | –0.001 | –0.002 | –0.001 | –0.001 | –0.001 | 0.009* | –0.000 | –0.000 | 0.000 | –0.001 |
| | (0.002) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.006) | (0.001) | (0.001) | (0.000) | (0.001) |
| **Sex** | 0.004* | 0.001 | 0.002* | 0.003*** | 0.004*** | 0.002 | –0.018*** | 0.000 | 0.002** | 0.001** | –0.001 |
| | (0.002) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.006) | (0.001) | (0.001) | (0.000) | (0.001) |

***, **, * indicate level of significance at 1%, 5%, 10%, respectively. Standard errors are in parenthesis. Ln = logarithm; lnEXP = logarithm of total food expenditure: ln Exp2 = square of logarithm of total food expenditure; sex = sex of students; Age = age of students.

if a consumer is considered a necessity good at low levels of expenditure and a luxury good at high levels expenditure.

Factors influencing students' demand for eggs included its own-price, as well as price of turkey. Increase in egg expenditure will lead to a decrease in demand for egg, while an increase in price of turkey will lead to a decrease in demand for egg. Students' demand for fish was influenced by own-price, prices of goat meat, turkey, pork and chicken. Own-price of chicken also strongly increased demand for chicken, while increase in students' expenditure, prices of turkey, soymilk and pork would substantially reduce it. Furthermore, being a male student would stimulate demand for beef. The significance of expenditure squared confirms that chicken is considered a luxury good at low levels of expenditure and a necessity at high levels. However, any increase in own-price, prices of pork, groundnut and milk strongly diminished the demand for turkey, while increase in students' expenditure and price of soymilk would increase it substantially. An increase in body weight of a student and being a female student would also stimulate demand for turkey.

A positive relationship existed between the budget share of fish and own-price, price of goat meat and price of pork while a negative relationship existed between the budget share of fish and prices of chicken and turkey. This suggested that students' demand for fish increased with increase in own-price, price of goat meat and price of pork and demand decreases with increase in prices of chicken and turkey. However, male students demanded for fish more than their female counterparts. Own-price and price of goat meat strongly increased demand for beef, while increase in students' expenditure, prices of turkey, groundnut and milk would substantially diminish it. The only factor influencing the demand for milk was its own-price suggesting that any increase in price of milk would increase the demand for it. Furthermore, being a male student would stimulate demand for beef. Similarly, own-price strongly increased demand for pork, while increase in household expenditure would substantially diminish it. However, the significance of expenditure squared explains the non-linear nature of demand for pork that is considered a necessity good at low levels of expenditure and luxury at high levels. However, being a male student enhanced the demand for pork.

**Compensated and uncompensated own-price elasticity**

Expenditure elasticities for fish, chicken, turkey, pork, soymilk, groundnut and milk were greater than one; indicating that they were luxury goods (Table 4). On the other hand, expenditure elasticities for beans, eggs, beef and goat meat were less than one, indicating they were necessity goods. This suggested that beans, egg, beef and goat meat are cheap and readily available in their hostels, while fish, chicken, turkey, pork, soymilk, groundnut and dairy milk are luxury goods. Thus, the consumption patterns and income levels of the students are quite important in demand for protein foods. Groundnut had the highest elasticity of 1.9036 whereas eggs had the least elasticity of 0.3560, implying that a marginal increase in the price of groundnut will lead to a substantial decline in its consumption, which is five times decrease than eggs.

Furthermore, the Marshallian/uncompensated and Hicksian/compensated own price elasticities of the selected protein foods measure the percentage of demand changes as a result of the one percent change of the respective protein food price. The diagonal matrix indicated that some of the own-price (compensated and uncompensated) like beans, eggs, beef, goat meat and milk had negative signs and were consistent with the demand theory that the price effect on quantity demanded is negative. However, demand for fish, chicken, turkey, pork, soymilk and groundnut violated of the law of demand. Both the Marshallian and Hicksian own-price elasticities were less than zero exhibiting inelastic relationship (with absolute values less than unity) except goat meat with own-price elasticity value of -1.0616 and -1.0402, respectively. The implication of this is that, a percentage increase in the prices of all the selected protein food items will lead to a less than one percent change in their demand, with the exception of goat meat. In addition, the Marshallian cross-price elasticity as shown in the off-diagonal matrix revealed that almost all the selected protein food items have positive cross-price elasticity values exhibited more complementarity than in Hicksian cross-price.

However, uncompensated cross-price elasticities provide information on price effect between commodity groups, while compensated cross-price elasticities provide a more accurate picture of cross-price substitution between commodity groups, since they are a measure of substitution effects net of income. This is because Marshallian demand elasticities are based on constant nominal income, while Hicksian (compensated) demand elasticities are based on the assumption of constant real income. The substitutability feature of Hicksian elasticities thus creates a much larger space for policy measures (Mjeda et al., 2021). For instance, when most of the food items are substitutes, policy makers may use differentiated Value Added Taxes (VAT) to motivate consumption of healthy diets.

**Table 4.** Elasticities of demand for protein foods

| Food items | Beans | Egg | Fish | Beef | Goat meat | Chicken | Turkey | Soymilk | Pork | Groundnut | Milk |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Expenditure elasticities | 0.616 | 0.356 | 1.154 | 0.610 | 0.367 | 1.099 | 1.089 | 1.149 | 1.621 | 1.904 | 1.708 |
| Marshallian/uncompensated elasticity | | | | | | | | | | | |
| Beans | **–0.049** | –0.013 | –0.048 | –0.037 | –0.076 | –0.034 | –0.333 | –0.002 | –0.047 | –0.012 | 0.027 |
| Egg | –0.094 | **–0.270** | –0.204 | –0.114 | –0.031 | –0.039 | 0.421 | –0.012 | –0.045 | 0.009 | 0.047 |
| Fish | 0.030 | –0.111 | **0.044** | 0.038 | 0.336 | –0.087 | –1.595 | –0.030 | 0.139 | 0.003 | –0.034 |
| Beef | –0.056 | –0.062 | –0.030 | **–0.849** | 1.434 | –0.048 | –0.837 | –0.012 | 0.034 | –0.107 | –0.114 |
| Goat-meat | –0.164 | 0.010 | 0.143 | 1.031 | **–1.062** | 0.037 | –0.195 | 0.024 | –0.040 | –0.054 | –0.103 |
| Chicken | 0.089 | 0.054 | –0.061 | 0.026 | 0.152 | **0.107** | –1.445 | –0.047 | –0.052 | 0.034 | –0.058 |
| Turkey | –0.322 | –0.087 | –0.088 | –0.143 | –0.188 | –0.136 | **0.309** | –0.109 | –0.128 | –0.040 | –0.078 |
| Soymilk | 0.201 | 0.086 | –0.042 | 0.061 | 0.196 | –0.087 | –2.147 | **0.335** | 0.046 | 0.015 | 0.060 |
| Pork | 0.177 | 0.097 | 0.181 | 0.169 | 0.190 | 0.012 | –3.135 | 0.089 | **0.280** | 0.039 | 0.084 |
| Groundnut | 0.249 | 0.170 | 0.100 | –0.134 | 0.067 | 0.283 | –3.688 | 0.124 | 0.175 | **0.292** | 0.233 |
| Milk | 0.373 | 0.164 | 0.037 | 0.012 | 0.074 | 0.019 | –2.842 | 0.120 | 0.136 | 0.085 | **–0.071** |
| Hicksian/compensated elasticity | | | | | | | | | | | |
| Beans | **0.034** | 0.012 | –0.022 | –0.010 | –0.040 | 0.006 | –0.039 | 0.019 | –0.019 | –0.003 | 0.052 |
| Egg | –0.045 | **–0.255** | –0.189 | –0.099 | –0.010 | –0.015 | 0.591 | 0.000 | –0.029 | 0.015 | 0.062 |
| Fish | 0.186 | –0.064 | **0.093** | 0.088 | 0.403 | –0.012 | –1.043 | 0.009 | 0.191 | 0.021 | 0.013 |
| Beef | 0.026 | –0.037 | –0.004 | **–0.822** | 1.470 | –0.009 | –0.545 | 0.009 | 0.062 | –0.098 | –0.089 |
| Goat meat | –0.114 | 0.025 | 0.159 | 1.047 | **–1.040** | 0.061 | –0.019 | 0.037 | –0.023 | –0.049 | –0.088 |
| Chicken | 0.238 | 0.099 | –0.015 | 0.074 | 0.216 | **0.178** | –0.920 | –0.009 | –0.002 | 0.051 | –0.012 |
| Turkey | –0.174 | –0.042 | –0.042 | –0.096 | –0.125 | –0.065 | **0.831** | –0.072 | –0.079 | –0.023 | –0.033 |
| Soymilk | 0.356 | 0.133 | 0.007 | 0.111 | 0.263 | –0.012 | –1.597 | **0.374** | 0.098 | 0.033 | 0.107 |
| Pork | 0.396 | 0.163 | 0.250 | 0.239 | 0.284 | 0.118 | –2.359 | 0.144 | **0.354** | 0.064 | 0.151 |
| Groundnut | 0.506 | 0.247 | 0.180 | –0.052 | 0.178 | 0.408 | –2.777 | 0.189 | 0.262 | **0.322** | 0.312 |
| Milk | 0.604 | 0.234 | 0.108 | 0.086 | 0.174 | 0.131 | –2.024 | 0.178 | 0.213 | 0.112 | **–0.001** |

The Hicksian/compensated cross price elasticity (as evident in the off-diagonal matrix) revealed that pork, soymilk, dairy milk were substitutes to other protein food items except turkey. This is buttressed by the fact that these are luxury goods to the students. Notably, chicken and goat meat, beef and goat meat, chicken and fish were substitutes to each other. Goat meat, chicken and beef were all substitutes for eggs in meals. Groundnut is also a substitute to other protein food items except beef and turkey. However, turkey showed complementarity to all other protein food items, while fish was also a substitute for chicken, turkey and egg. Similarly, goat meat was a complement to other protein food items except egg, fish and chicken. Beans were complementary to all protein food items except egg, dairy milk and soymilk. This suggests that cheaper sources of protein like groundnut, soymilk, beans and eggs can be promoted to substitute for more expensive ones like chicken, goat meat, beef and turkey in the diets of the students.

## CONCLUSION

The study concluded that age influences the demand for soymilk and beans. Furthermore, expenditure elasticities of all protein foods were positive. Demand for protein foods was influenced by own-prices of the protein foods, prices of other protein foods and being a male student. Expenditure elasticities for beans, eggs, beef and goat meat were less than one indicating that they are necessities while the expenditure for chicken, turkey, soy milk, pork, groundnut and milk were greater than one; hence they were luxury goods. Both compensated and uncompensated elasticity showed that own-price elasticities for the selected protein food items were inelastic, with the exception of goat meat. Students in the University of Ibadan did respond to increase in some protein food prices, such

increase in food price results in low purchasing power of the students. The Hicksian cross-price elasticities showed that some of the food groups were substitutes. For every increase in the price of the commodity, expenditure share reduces. Based on the afore-going, governments should endeavour to effect price policies that will reduce the prices of essential protein foods so that it can be affordable by the students. Efforts should also be made by the institution and nutrition-related non-governmental agencies to promote the awareness of health benefits of consuming protein among the youths. In conclusion, in order to meet daily dietary needs within a limited budget, it is imperative for the youths to substitute expensive protein sources like fish, chicken, turkey, pork, soymilk, groundnut and dairy milk with cheaper ones like beans, egg, beef and goat meat in their diets.

## CONFLICT OF INTEREST

The authors declared no conflicts of interest with respect to research, authorship and publication of this article.

## ETHICAL COMPLIANCE

The authors have followed the ethical standards in conducting the research and preparing the manuscript.

## REFERENCES

Adekunmi A. O., Ayinde J. O., Ajala A. O. (2017): An assessment of animal protein consumption patterns among rural dwellers in Osun State, Nigeria. Ife Journal of Agriculture 29: 84–94.

Akerele D., Sanusi R. A., Fadare O. A., Ashaolu O. F. (2017): Factors influencing nutritional adequacy among rural households in Nigeria: How Does Dietary Diversity Stand among Influencers? Ecology of Food and Nutrition 56: 187–203. DOI: 10.1080/03670244.2017.1281127

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

Benda-Prokeinová R., Hanová M. (2016): Consumer's behavior of the foodstuff consumption in Slovakia. 19th International Conference Enterprise and Competitive Environment 2016, ECE 2016, 10–11 March 2016, Brno, Czech Republic. Procedia - Social and Behavioral Sciences 220: 21–29.

Chernoff R. (2016): Elderly: Nutrition requirements. In Encyclopedia of Food and Health, pp. 480–486.

Deaton A., Muellbauer J. (1980): An almost ideal demand system. The American Economic Review 70: 312–326.

De Vries-ten Have J., Owolabi A., Steijns J., Kudla U., Melse-Boonstra A. (2020): Protein intake adequacy among Nigerian infants, children, adolescents and women and protein quality of commonly consumed foods. Nutrition Research Reviews 33: 102–120. DOI:10.1017/S0954422419000222

Ecker O., Hatzenbuehler P. L. (2022): Food consumption–production response to agricultural policy and macroeconomic change in Nigeria. Applied Economic Perspective and Policy 44: 982-1002.–21. DOI: 10.1002/aepp.13161

Erokhin V., Diao L., Gao T., Andrei J. V., Ivolga A., Zong Y. (2021): The supply of calories, proteins, and fats in low-income countries: A four-decade retrospective study. International Journal of Environmental Research and Public Health 18: 7356. DOI: 10.3390/ijerph18147356

Giller K. E. (2020): The food security conundrum of sub-Saharan Africa. Global Food Security 26: 100431. DOI: 10.1016/j.gfs.2020.100431.

Henchion M., Hayes M., Mullen A. M., Fenelon M., Tiwari B. (2017): Future protein supply and demand: strategies and factors influencing a sustainable equilibrium. Foods 6: 53. DOI: 10.3390/foods6070053

Ibirogba F., Ikhaghu A. (2021): Poor protein intake to worsen malnutrition, disease burdens. The Guardian, 29 November 2021. https://guardian.ng/features/poor-protein-intake-to-worsen-malnutrition-disease-burdens/

Khan A., Khan S., Jan A. A., Khan M. (2017): Health complication caused by protein deficiency. Journal of Food Science and Nutrition 1: 1–2

Kenmogne-Domguia B. H., Ponka R., Fokou E. (2016): Protein-energy intakes and nutritional status of in-school adolescents in Baham, Cameroon. Journal of Nutritional Disorders Therapy 6: 186–190. DOI:10.4172/2161-0509.1000186.

Liu L., He L. (2022): The demand for road transport in China: Theoretical regularity and model selection. arXiv:1612.02656 [q-fin.EC]. Retrieved on 3 February 2022 from https://arxiv.org/pdf/1612.02656.pdf

Maurya N. K., Kushwaha R. (2019): Novel protein foods: alternative sources of protein for human consumption. In book: Research Trends in Food Technology and Nutrition. Volume 4 Edition Chapter 7: 129–142. Akinik Puplication, New Delhi.

Mekonnen D. A., Akerele D., Achterbosch T., de Lange T. Talsma E. F. (2021): Affordability of healthy

and sustainable diets in Nigeria. Frontiers in Sustainable Food Systems 5: 726773. DOI: 10.3389/fsufs.2021.726773

Metu A. G., Okeyika K. O., Maduka O. D. (2016): Achieving sustainable food security in Nigeria: Challenges and way forward. 3rd International Conference on African Development Issues (CUICADI 2016). Retrieved fromhttp://eprints.covenantuniversity.edu.ng/6653/1/icadi16pp182-187.pdf

Mjeda T., Lenz N. V. Cerović L. (2021): The microeconomic approach to food demand modelling: Empirical results for Croatian households. Economic Research-Ekonomska Istraživanja 34: 1079–1093. DOI: 10.1080/1331677X.2020.1819850

Protein Challenge (2020): Nigeria Protein Deficiency Survey Report 2019. https://proteinchallengeng.com/protein-deficiency-report-2019/

Obayelu O. A., Oshiele G. D., Ibe R. B. Akinwale E. A. (2021): Demand for selected plant-based protein among the staff of a tertiary institution in Nigeria. Future of Food: Journal on Food, Agriculture and Society 9: 1–12.

Olorunfemi S. (2013): Demand for food in Ondo state, Nigeria: Using Quadratic Almost Ideal Demand System. E3 Journal of Business Management and Economics 4: 1–19.

Osendarp S., Akuoku J. K., Black R. E., Headey D., Ruel M., Scott N., Shekar M., Walker N., Flory A., Haddad L., Laborde D., Stegmuller A., Thomas M., Heidkamp R. (2021): The COVID-19 crisis will exacerbate maternal and child undernutrition and child mortality in low- and middle-income countries. Natural Food 2: 476–484. DOI:10.1038/s43016-021-00319-4

Popkin B. M., Adair L. S., Nq S. W. (2012): Global Nutrition and the pandemic of obesity in developing countries. Nutrition Review 70: 3–21.

Sanusi R. A., Wang D., Ariyo O., Eyinla T. E., Tassy M., Eldridge A. L., Ogundero A., Leshi O., Lenighan Y. M., Ejoh, S. I. et al. (2022): Food sources of key nutrients, mealand dietary patterns among childrenaged 4–13 years in Ibadan, Nigeria: Findings from the 2019 Kids Nutrition and Health Study. Nutrients 14: 200. DOI:10.3390/nu14010200

Shittu A. M., Obayelu O. A., Salman K. K. (2015): Welfare effects of policy-induced rising food prices on farm households in Nigeria. The African Growth and Development Policy Modeling Consortium (AGRODEP) Working Paper 0010.

Suchismita R., Shaik A. H. (2018): Protein deficiency: Challenges and means to fight. Acta Scientific Nutritional Health 2: 1–2.

SPRING (2018): Assessing Drivers of Malnutrition in Nigeria: A Report on Findings from Kebbi, Niger, Benue, and Cross River to Inform Food Security Investments. Arlington, VA: Strengthening Partnerships, Results, and Innovations in Nutrition Globally (SPRING) project.

World Health Organisation (WHO) (2007): Dietary Reference Intakes for Energy, Carbohydrate, Fibre, Fat, Fatty Acids, Cholesterol, Protein and Amino Acids (Macronutrients) World Health Organisation (WHO); Geneva, Switzerland: 2007. WHO Technical Report Series 935, Report of a Joint WHO/FAO/UNU Expert Consultation.

Wu G. (2016): Dietary protein intake and human health. Food Function 7: 1251–1265.

Wu G., Fanzo J., Miller D. D., Pingali P., Post M., Steiner J. L., Thalacker-Mercer A. E. (2014): Production and supply of high-quality food protein for human consumption: sustainability, challenges, and innovations. Annals of the New York Academy of Sciences 1321: 1–19. DOI: 10.1111/nyas.12500

*Received: September 25, 2021*
*Accepted after revisions: June 7, 2022*