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Rural Household Food Consumption in Bengkulu, Indonesia: Estimating a Demand System Based on SUSENAS Microdata

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Abstract

The paper aims to estimate the food demand of rural households in Bengkulu Province, Indonesia, using the Quadratic Almost Ideal Demand System (QUAIDS) and microdata from the SUSENAS. We aggregate food into five groups: staple food, animal food, vegetables & fruits, prepared food, and other food. The results show that demand for animal food is the most sensitive to food expenditure, whereas the demand for staple food is the most expenditure-inelastic. Staple food, animal food, vegetables & fruits, and other food are substitutes for each other. On the other hand, prepared food and staple food complement each other. Other food is the easiest to be substituted, and staple food is the most difficult to be substituted. The demographic variables, as well as prices and expenditures, impact household demand. For example, as family size increases, the demand for staple food increases, while the demand for animal food, vegetables & fruits decreases. The number of children under five years old has a positive impact on animal food demand but a negative impact on staple food and other food demand. Staple farmer households have a higher need for staple food than non-agricultural households. Due to being unmarried, divorced or bereaved, single households have a lower demand for staple food but a higher demand for prepared food. We mainly imply that the food price stabilization policy should emphasize animal food, especially beef and poultry, without increasing prices.

Keyword: demographic effects, elasticity of substitution, Quadratic Almost Ideal Demand System (QUAIDS), rural household food consumption, SUSENAS microdata

1. Introduction

Food consumption is often used as an indicator to determine the welfare of consumers and households. Modelling consumer demand has been one of the most significant trends in consumer theory literature over the last couple of decades (Note 1). Both theory and empirical approaches to demand functions have been instrumental in defining developmental and welfare policies. The Engel curve is a powerful tool for understanding consumer behaviour and household welfare. Engel's law is confirmed, given that at lower income levels, the percentage of food consumption is more significant, even though, in real terms, the absolute level of food consumption has, in most cases, been reduced (Schenkel et al., 2005). As income levels rise, consumers will seek out more expensive types of food. Many studies also prove that the relationship between consumption and income is directly related to spending. For example, research by Nicholson and Snyder (2009) and Koutsoynisnis (1982) associates consumer behaviour in consumption with commodity prices and income. Among others are Kumar, Rosegrant, and Bouis (1994), and Radhakrishna and Ravi (1990) examined the structure of food in India; Eakins and Gallagher (2003) estimated alcohol expenditure in Ireland, Zhao (2015) analyzed demand for shrimp along with beef, pork, and chicken in the US food market.

Engel curves have been applied in developing and developed countries to analyze household expenditure behaviour. Interestingly, people in developing countries spend more on household expenses on food. Clements and Si (2018) found that consumers in wealthier countries spend only 3.3% of their food budget on rice and other cereals and flours (this is part of the 14% for bread, rice, and cereals in the figure below). However, consumers in poorer countries spend 23.7% on rice, other cereals, and flour (this is part of the 29% for bread, rice, and cereals). Higher incomes bring higher quality food, but the overall elasticity is small: enhanced food quality can only be achieved with substantially higher incomes. Faharuddin et al. (2017) stated that income is another factor influencing the quality of household food consumption. The higher the income, the higher the household's ability to provide food whose consumption meets an appropriate standard of health.

Generally, most households in low and middle-income countries live in rural areas. A rural area is an open swath of land with few homes or other buildings and not very many people. Agriculture is the primary industry in most rural areas. Most people live or work on farms or ranches. Hamlets, villages, towns, and other small settlements are in or surrounded by rural areas. Nsabimana et al. (2020) estimate that about 40-48% of the population in Asia and Africa live in rural areas. In Ethiopia, a less-developed country where agricultural jobs are much more common, 87% of the people live in rural areas. Thus, there are significant discrepancies in annual expenditures between rural and urban households. The poor households merely consume food containing higher carbohydrates and starches. Further, most rural households spend almost nothing on micronutrients from animal products. A workshop report stated that consumption is changing in rural areas, blurring the distinction between urban and rural consumption and the increasing importance of the market in rural household food security. In China, the cash share of food expenditures was as high as 95% in rural parts of the Beijing municipality. It exceeded 70% in other municipalities and wealthy coastal provinces, but it was only between 40-50% for most western provinces and autonomous regions. Guizhou, one of China's poorest provinces, had the lowest cash share of expenditures, at 37% (Vorley et al., 2015).

This paper analyzes food consumption for rural households focusing on Bengkulu, one of the provinces in Indonesia, where most of the population lives in rural areas. Bengkulu Province comprises 129 sub-districts and 1,514 villages/urban villages, with the most significant number of workers in agriculture, forestry, and fisheries and the least in other sectors. The total area of Bengkulu Province reaches approximately 1,991,933 hectares, and its population in 2021 was 2.03 million people. Its area is on the west side of Sumatra Island. The eastern part is hilly with lush highlands, while the western part is a relatively narrow lowland, elongated from north to south, interspersed by bumpy areas. The west of Bengkulu is directly adjacent to the Indian Ocean on a coastline of approximately 525 km. In 2021, the locals of Bengkulu Province living in urban areas spent 43.99% of their consumption expenditure on food. In contrast, the people living in rural areas spend 56.14% (Bengkulu Statistic, 2022).

Generally, rural people spend more than half of their expenditure on food, indicating their relatively poor food security. The latest data release from Indonesian Statistics states that food took up 56.17% of the total monthly expenditure of Indonesian rural communities in 2021. This proportion was slightly higher than 55.68% in 2019. The proportion of food expenditure tends to be higher for people with low incomes. Most of the population of Bengkulu Province lives in rural areas. Bengkulu statistical data shows that only 18.58% of the population lives in urban areas. People living in rural areas are generally vulnerable to poverty. Poverty is always more prevalent in rural areas, although increases are much more significant in urban areas (Headey et al., 2022). The percentage of poor people in the Bengkulu Province in 2020 was 15.30%. This condition makes Bengkulu province the sixth poorest of the 34 provinces in Indonesia.

It is the first paper to analyze rural household food consumption in Bengkulu, Indonesia. Using the Quadratic Almost Ideal Demand System (QUAIDS; Banks, Blundell, & Lewbel, 1997), this study incorporates household demographic variables into demand analysis to better understand household food consumption. The paper intends to estimate not only expenditure elasticities, uncompensated and compensated price elasticities, and Morishima elasticities of substitution but also the effects of household demographic characteristics on household food demand. Many papers have analyzed the changes in consumer demand using the QUAIDS models. Roosen et al. (2022) estimated demand elasticities for fresh meat in Germany and the effects of taxes on consumption, welfare, and emissions. The other paper estimate price and expenditure elasticities for food commodities and nutrients in Srilanka using QUAIDS and Tobit model (Lokuge et al., 2019). The QUAIDS model also was used by Suriani et al. (2018) to analyze the effect of rice for the poor (Raskin) or subsidized rice consumption on the food demand elasticity of poor households in Aceh, Indonesia. Moreover, Poi & Lp (2012) introduce an almost-ideal demand system and the command QUAIDS in Stata Program, which obviates the need for any programming by the user.

For the Indonesian food demand, analysis at the household level has been carried out using SUSENAS data. Many previous papers used this data to estimate income elasticity and the demographic effects on food demand in Indonesia. Faharuddin et al. (2017), using SUSENAS 2013, found that expenditure elasticities of nutrients in rural areas in Indonesia are higher than those in urban areas. Skoufias et al. (2012) estimated the income elasticity of micronutrients in Indonesia using data before and after the 1997 economic crisis. The analysis finds that, although summary measures such as the income elasticity of the starchy staple ratio might not change during crises, this stability masks essential differences across individual nutrients. Jensen & Manrique (1998) analyzed demand for food commodities in Indonesia by income groups. They found that demands for low-income households were responsive to income and prices of rice and fish only. Such analysis is essential because changes in food demand can affect the effectiveness of policies for economic growth.

2. Data and Methods

2.1 Data

We use household expenditure data from the Indonesia Socio-Economic Survey (SUSENAS), a cross-section data survey collected annually by Indonesia Central Statistics Agency (BPS). We use SUSENAS in this study as secondary data. SUSENAS is a survey that collects micro data on various social issues. The data gathered includes, among others, information about one's education, health and nutrition, housing, other socio-economic activities, socio-cultural activities, household consumption and expenditures, travel, and public opinion about one's household welfare. The SUSENAS data collection system consists of a core and various modules. The function of the core system is to collect general data, covering: household members, race of household head, mortality, health, education, employment, fertility, housing, technology and information, average consumption/household expenditure, household income, agricultural land area and other socio-economic data. The module system collects specific data and is grouped into three packages: Consumption/Expenditure and Household Income Module, Socio-Cultural and Education Module, and Health and Housing Module.

In this study, we use data taken from the core and consumption modules of Bengkulu Province in March 2020, particularly data on food consumption in rural households. The number of rural households that responded to this study was 4029 households. From SUSENAS 2020, we use data on household expenditure and food prices. There are over 150 food items that Bengkulu rural households consume. To simplify the estimation of demand, we aggregate the original 13 food categories into five food groups, namely: staple food (rice, tubers), animal food (fish, meat, egg and milk), vegetables & fruits (vegetables, nuts, fruits), prepared food, and other food (seasonings, drinks, instant foods, oil and coconuts). Expenditure for food groups is calculated by adding up the expenses for food in its group. For example, the expenditure on staple food is counted by adding the expense on rice and tubers. The unit of measurement for food group expenditure is the Indonesian rupiah.

We use unit values (expenditures divided by quantities) to approximate prices because actual prices paid are not reported in The SUSENAS data. In surveys where households report expenditures and physical quantities, one can divide one by the other to obtain unit values. Expenditures and quantities were recorded at the purchase level but are here aggregated so that unit values were derived by dividing total expenditures for the household in the relevant week by total quantities in kilograms for the same week (Deaton, 1988). The missing or unreported prices are estimated using the average price of the observed data.

2.2 Variables

The model includes demographic variables to control for variations in preferences between households that are likely due to differences in their demographic characteristics. Some researchers also include household demographic variables in their demand models, such as those conducted by Ngui et al. (2011), Gostkowski (2018), Nsabimana et al. (2020), Korir et al. (2020), and Vargas-Lopez et al. (2022). Research that examines food demand in Indonesia also incorporates demographic variables (Jensen & Manrique, 1998; Faharuddin et al., 2017; Suriani et al., 2018).

Table 1 provides descriptive statistics of the variables used in the study. We use demographic and household-specific variables to account for the effects of differences in household consumption. They are the age of the household head, the schooling years of the household head, the family size, the number of children under five years old, the dependent farmers, types of a farmer based on agriculture sub-sectors, and marital statuses of the household head. The dependent farmer, types of farmer and marital statuses of household heads are dummy variables. A dependent farmer works for another farmer or agricultural company, either as a labourer or as a temporary worker, and receives daily or weekly wages. The dummy variables for the independent farmer are removed because their parameters are found to be insignificant. The baseline for the dependent farmer is the non-farmer.

There are five dummy variables for farmer types: the staple farmer, the horticulture farmer, the plantation farmer, the fish farmer, and the livestock farmer. A staple farmer cultivates food crops such as rice, potatoes, cassava, and sweet potatoes. A horticulture farmer grows vegetables, fruits, and flowers. A plantation farmer grows plants such as oil palm, rubber, tea, and coffee. A fish farmer is a person who specializes in fishing or aquaculture. A livestock farmer breeds and raises animals like cows, chickens, goats, sheep, and buffalos. The baseline for types of farmers is the non-farmer. The marital statuses of the household head consist of three dummy variables: unmarried, divorced, and bereaved. Married is the baseline for the marital status of the household head.

The selection of these variables is linked to their potential influence on household preferences and food expenditure decisions. For instance, the age variable of the household head is known to cause a household tendency to consume certain staple foods based on health needs. The education variable of the household head was chosen because he/she is generally the holder of consumption decisions and the provider of the household. The variable number of children under five years old was chosen to assume that households with children will have more diverse food needs, which is expected to influence food demand. In addition, it has been shown that household expenditure is an increasing function of family size. In this respect, we could say that as the number of family members increases, the chance to spend more on food increases. For this reason, it is necessary to determine how family size influences household food consumption.

The most interesting finding is that prepared food expenditure is higher than for other food groups. The rural households in Bengkulu spend 25.5% of their food expenditure buying prepared food. According to SUSENAS data, prepared food is ready-to-eat food that we can classify as street food. People usually buy it at food stores (known as *warung makan* or *warteg* in Indonesia), restaurants, cafes, convenience stores and food trucks. Indications of whether prepared food will serve as a substitute or complement to other food groups, particularly staple foods, will be discussed further in another section of this paper.

Table 1. Descriptive statistics

Variable	**Mean**	**Std.Dev**	**Min**	**Max**
Age of household head	47.58	13.24	14	97
Schooling years	8.458	3.445	0	18
Family size	3.618	1.445	1	12
Number of children under 5 years old	0.316	0.528	0	3
Dependent Farmer	0.068	0.252	0	1
Type of Farmer Based on Agriculture Sub-sector:				
Staple Farmer	0.104	0.306	0	1
Horticulture Farmer	0.030	0.170	0	1
Plantation Farmer	0.484	0.500	0	1
Fish Farmer	0.018	0.134	0	1
Livestock Farmer	0.005	0.070	0	1
Marital Status of Household Head:				
Unmarried	0.015	0.123	0	1
Divorced	0.030	0.170	0	1
Bereaved	0.109	0.312	0	1
Expenditure Share of Food Group:				
w_1 (Staple Food)	0.218	0.091	0	0.727
w_2 (Animal Food)	0.182	0.087	0	0.653
w_3 (Vegetables & Fruits)	0.218	0.072	0	0.539
w_4 (Prepared Food)	0.255	0.142	0	1.000
w_5 (Other Food)	0.127	0.046	0	0.366
Price of Food Group:				
p_1 (Price of Staple Food)	1.000	0.148	0.384	2.055
p_2 (Price of Animal Food)	1.000	0.781	0.146	8.036
p_3 (Price of Vegetables & Fruits)	1.000	0.226	0.263	3.308
p_4 (Price of Prepared Food)	1.000	0.516	0.215	5.207
p_5 (Price of Other Food)	1.000	1.017	0.152	20.83
y (Expenditure)	1.000	0.500	0.058	7.125

Note. Descriptive statistics for sample of 4029 observations. Price and expenditure are normalized by dividing them by their sample means.

2.3 The Method

This research estimates the price and expenditure elasticities using Quadratic Almost Ideal Demand System (QUAIDS). Let $\mathbf{p} = (p_1, \dots p_n)$ denote the nominal price vector of *n* goods and *y* denote the total expenditure on the goods (expenditure, for short) for each individual (in case, each household). The indirect utility function of QUAIDS can be specified as:

$$\log V(p,y) = \left[\left(\frac{\log y - \log a(\mathbf{p})}{b(\mathbf{p})}\right)^{-1} + c(\mathbf{p})\right]^{-1} \tag{1}$$

where, log is the natural logarithm and $a(\mathbf{p})$, $b(\mathbf{p})$, and $c(\mathbf{p})$ are distinct price aggregator functions defined as:

$$\log a(\mathbf{p}) = \alpha_0 + \sum_{i=1}^{n} \alpha_i \log p_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \gamma_{ij} \log p_i \log p_j \tag{2}$$

$$b(\mathbf{p}) = \beta_0 \prod_{i=1}^{n} p_i^{\beta_i} \tag{3}$$

$$c(\mathbf{p}) = \lambda_0 + \sum_{i=1}^{n} \lambda_i \log p_i \tag{4}$$

where, $a(\mathbf{p})$ is homogeneous of degree one and $b(\mathbf{p})$ and $c(\mathbf{p})$ are homogeneous of degree zero in $\mathbf{p}$, so that $V(\mathbf{p},y)$ is homogeneous of degree zero in $\mathbf{p}$ and y, as required. It is assumed, therefore, that the parameters meet the following restrictions,

$$\sum_{i=1}^{n} \alpha_i = 1 \text{ (adding up)} \tag{5}$$

$$\sum_{i=1}^{m} \alpha_{ih} = 0 \text{ , } h = 1, 2, \dots m \text{ (adding up)} \tag{6}$$

$$\sum_{i=1}^{n} \beta_i = 0 \text{ (adding up)} \tag{7}$$

$$\sum_{i=1}^{n} \lambda_i = 0 \text{ (adding up)} \tag{8}$$

$$\sum_{i=1}^{n} \gamma_{ij} = 0, j = 1, 2, \dots n \text{ (adding up)} \tag{9}$$

$$\sum_{j=1}^{n} \gamma_{ij} = 0, i = 1, 2, \dots n \text{ (homogeneity)} \tag{10}$$

which jointly ensure that the resulting demand system fulfills adding-up and homogeneity. Slutsky symmetry is guaranteed by the additional restriction:

$$\gamma_{ij} = \gamma_{ji}, i, j = 1, \dots n \text{ (Slutsky symetry)} \tag{11}$$

By applying the logarithmic form of Roy's identity $W_i = -\left(\partial \log V / \partial \log p_i\right) / \left(\partial \log V / \partial \log y\right)$ to Equation (1), the QUAIDS is derived as

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \log p_j + \beta_i \log \frac{y}{a(\mathbf{p})} + \frac{\lambda_i}{b(\mathbf{p})}\left(\log \frac{y}{a(\mathbf{p})}\right)^2 \tag{12}$$

where, w_i denotes the expenditure share of good *i* for each household.

In this paper, we added 13 demographic variables into the equation using the notation z_h, which is h = 1, 2, … 13. We estimate 5 food groups, so the values of i and j = 1, 2, … 5. Therefore, Equations (1) (2) and (12) are modified to be:

$$\log V(p,y,\mathbf{z}) = \left[\left(\frac{\log y - \log a(\mathbf{p},\mathbf{z})}{b(\mathbf{p})}\right)^{-1} + c(\mathbf{p})\right]^{-1} \tag{13}$$

$$\log a(\mathbf{p},\mathbf{z}) = \alpha_0 + \sum_{i=1}^{5}\left(\alpha_i + \sum_{h=1}^{13} \alpha_{ih} z\right) + \frac{1}{2}\sum_{i=1}^{5}\sum_{j=1}^{5} \gamma_{ij} \log p_i \log p_j \tag{14}$$

$$w_i = \alpha_i + \sum_{h=1}^{13} \alpha_{ih} z_h + \sum_{j=1}^{5} \gamma_{ij} \log p_j + \beta_i \log \frac{y}{a(\mathbf{p})} + \frac{\lambda_i}{b(\mathbf{p})}\left(\log \frac{y}{a(\mathbf{p})}\right)^2 \tag{15}$$

In place of $a(\mathbf{p})$, we use the log linear analogue of the Laspeyres index P^c:

$$\log P^c = \sum_{i=1}^{n} \overline{w}_i \log p_i \tag{16}$$

and, in place of $b(\mathbf{p})$, we use the composite variable P^z of Matsuda (2006):

$$\log P^z = \sum_{i=1}^{n} (w_i - \overline{w}_i) \log \frac{p_i}{\overline{p}_i} \tag{17}$$

where, $\overline{w}_i$ and $\overline{p}_i$ stand for their sample means.

To know the response of the demand for different food groups to expenditure and price changes, we calculate expenditure and uncompensated elasticities:

$$\varepsilon_i = \frac{y}{q_i}\frac{\partial q_i}{\partial y} = 1 + \frac{1}{w_i}\frac{\partial w_i}{\partial \log y} \approx 1 + \frac{\beta_i}{w_i} + \frac{2\lambda_i}{w_i P^z} \log \frac{y}{P^c},\ i = 1, 2, \dots 5 \tag{18}$$

$$\varepsilon_{ij} = \frac{p_j}{q_i}\frac{\partial q_i}{\partial p_j} = -\delta_{ij} + \frac{1}{w_i}\frac{\delta w_i}{\delta \log p_j} \approx -\delta_{ij} + \frac{\gamma_{ij}}{w_i} - \beta_i \frac{\overline{w}_i}{w_i} - \frac{\lambda_i}{w_i P^z}\left[2\overline{w}_j + \left(w_j - \overline{w}_j\right) \log \frac{y}{P^c}\right] \log \frac{y}{P^c},\ i, j = 1, 2, \dots 5 \tag{19}$$

where, δ_{ij} is the Kronecker delta, which equals one if $i = j$ and zero otherwise. However, when these elasticities are evaluated at the sample mean, where, $\overline{p}_1 = \overline{p}_2 = \dots = \overline{p}_5 = 1$ and $\overline{y} = 1$ then Equations (18) and (19) become,

$$\varepsilon_i = 1 + \frac{\beta_i}{w_i} \tag{20}$$

$$\varepsilon_{ij} \approx -\delta_{ij} + \frac{\gamma_{ij}}{w_i} - \beta_i \frac{\overline{w}_i}{w_i} \tag{21}$$

A positive value of ε_i suggests that good *i* is a normal good.

The income compensated elasticities ε_{ij}^c are obtained by the Slutsky equation:

$$\varepsilon_{ij}^c = \varepsilon_{ij} + w_j \varepsilon_i \tag{22}$$

Consumer theory suggests that the compensated own-price elasticities are always negative. Two groups of food are substitutes for each other if the compensated cross-price elasticity is positive and complements otherwise.

The Morishima Elasticity of Substitution (MES) was originally proposed by Morishima (1967) in Japanese and introduced widely by Blackorby and Russell (1975) in the production context. If the price of good *j* change, the MES in the context of consumer demand is given by

$$\sigma_{ij} = \frac{\partial \log(q_i^c/q_j^c)}{\partial \log(p_i/p_j)} = \varepsilon_{ij}^c - \varepsilon_{jj}^c \text{ , } i \neq j \tag{23}$$

which indicates the ease of substitution. Two goods are Morishima-substitutes if σ_{ij} is positive and Morishima-complements otherwise. Since ε_{jj} is negative and mostly $|\varepsilon_{ij}| < |\varepsilon_{jj}|$, σ_{ij} is likely to be positive.

3. Results and Discussion

3.1 Parameter Estimates

The five equations demand system in Table 2 are estimated by iterated three-stage least square estimation with homogeneity and Slutsky symmetry restrictions imposed. The parameter estimates are invariant to the equation dropped from the demand system estimation. Estimates of all price parameters are significant at the 1% level. The parameter estimate for vegetables & fruit expenditure is insignificant, but the quadratic estimate expenditure of them is significant at the 5% level. In several other studies (Gershon et al., 2020), (Mittal, 2010), (Elzaki et al., 2021), which also used the QUAIDS model, generally, not all the estimated parameters had a significant effect. The R2 values generated from this QUAIDS model range from 0.138 to 0.509. A low R^2 value for each estimated food share is commonly found in cross-sectional data analysis due to the large degree of stochastic variation in household survey data (Akinbode, 2015).

Table 2. Parameter estimate for price and expenditure

w_i	α_i	γ_{i1}	γ_{i2}	γ_{i3}	γ_{i4}	γ_{i5}	β_i	λ_i	R^2
Staple food	0.072***	0.132***	-0.028***	-0.036***	-0.062***	-0.006***	-0.138***	-0.019***	0.509
	(8.933)	(33.61)	(-18.34)	(-10.88)	(-26.64)	(-3.942)	(-28.86)	(-4.339)	
Animal Food	0.226***		0.058***	-0.009***	-0.017***	-0.003***	0.076***	0.018***	0.256
	(23.90)		(31.52)	(-6.227)	(-7.999)	(-3.443)	(13.65)	(3.741)	
Vegetables & Fruits	0.250***			0.065***	-0.026***	0.006***	-0.002	-0.009**	0.138
	(29.59)			(16.58)	(-10.50)	(4.345)	(-0.425)	(-2.199)	
Prepared Food	0.321***				0.122***	-0.017***	0.097***	0.026***	0.277
	(21.37)				(28.57)	(-12.06)	(10.96)	(3.194)	
Other Food	0.130***					0.019***	-0.033***	-0.016***	-
	(24.43)					(18.09)	(-10.80)	(-5.670)	

Note. *t* values in parentheses. ***, ** denote significance at 1% and 5% levels, respectively. Due to symmetry, estimates of γ_{ij} $(i > j)$ are omitted.

3.2 Elasticities

Demand elasticity is analyzed based on the value of income elasticity, own-price elasticity, and cross-price elasticity (Table 3 and Table 4). Income elasticity means the percentage change in the quantity demanded of a good due to a one per cent change in household income. In the SUSENAS data, the income value is approximated using the total value of household expenditures to buy certain commodities, while the other variables are fixed (ceteris paribus). Income elasticity is approximated by expenditure elasticity. We find that animal food has the highest expenditure elasticity, followed by prepared food, vegetables & fruits, and other food, and staple food has the lowest expenditure elasticity. Animal food demand is the most sensitive to prices for rural areas in Bengkulu. It means that, on average, a 1% increase in rural Bengkulu household income increases animal food consumption by 1.419%. It suggests that animal food is a luxury good for people living in rural areas. Previous research has stated that meat is classified as a luxury item and is very sensitive to changes in prices and income (Bett et al., 2012; Sheng et al., 2019; Elzaki et al., 2021). On the other side, demand for staple food is least responsive to expenditure in Bengkulu rural area. It means that the demand for staple food is expenditure inelastic. Therefore, staple food is included in the category of necessity goods. The findings in this study are in line with Faharuddin et al. (2017) and Lokuge et al. (2019), which prove that the demand for staple food is expenditure inelastic.

Table 3. Expenditure and uncompensated price elasticities

Quantity	Expenditure	Price				
		Staple Food	**Animal Food**	**Vegetables & Fruits**	**Prepared Food**	**Other Food**
Staple Food	0.364***	-0.256***	-0.015*	-0.025	-0.124***	0.055***
	(16.54)	(-14.16)	(-1.908)	(-1.515)	(-9.964)	(7.531)
Animal Food	1.419***	-0.248***	-0.755***	-0.145***	-0.201***	-0.071***
	(46.14)	(-22.93)	(-68.89)	(-12.97)	(-13.80)	(-10.96)
Vegetables & Fruits	0.990***	-0.161***	-0.043***	-0.701***	-0.116***	0.029***
	(42.91)	(-10.58)	(-5.486)	(-36.30)	(-9.034)	(4.128)
Prepared Food	1.382***	-0.327***	-0.136***	-0.184***	-0.618***	-0.116***
	(39.65)	(-28.03)	(-13.67)	(-14.95)	(-31.74)	(-16.28)
Other Food	0.736***	0.013	0.023***	0.107***	-0.690***	-0.810***
	(30.16)	(1.061)	(2.863)	(8.299)	(-5.268)	(-87.20)

Note. *t* values in parentheses. ***, * denote significance at 1% and 10% levels, respectively.

Table 4. Compensated price elasticities

Quantity	Price				
	Staple Food	**Animal Food**	**Vegetables & Fruits**	**Prepared Food**	**Other Food**
Staple Food	-0.176***	0.051***	0.055***	-0.031***	0.101***
	(-9.779)	(7.222)	(3.635)	(-2.859)	(15.34)
Animal Food	0.062***	-0.497***	0.165***	0.162***	0.109***
	(7.223)	(-48.81)	(19.07)	(13.79)	(21.68)
Vegetables & Fruits	0.055***	0.137***	-0.484***	0.137***	0.155***
	(3.635)	(19.07)	(-27.00)	(12.21)	(23.60)
Prepared Food	-0.026***	0.115***	0.117***	-0.265***	0.059***
	(-2.859)	(13.79)	(12.21)	(-15.82)	(10.52)
Other Food	0.173***	0.157***	0.268***	0.119***	-0.717***
	(15.34)	(21.68)	(23.60)	(10.52)	(-82.89)

Note: *t* values in parentheses. *** denotes significance at the 1% level.

The next important measure in demand analysis is compensated price elasticities. They measure how sensitive a consumer is to changes in the prices on the condition that the utility is constant. A compensated cross-price elasticity is positive when the two goods are substitutes and negative when they are complements. Signs of the elasticities are symmetric. Own-price elasticities of all food groups (Table 4) are statistically significant at the 1% level and negative as expected, which is consistent with demand theory. The results of this research indicate that most food groups are own-price inelastic. For all food groups, compensated own-price elasticities are smaller than uncompensated own-price elasticities in absolute values because the food groups are all normal goods, which ε_i are positive. It is apparent in Equation (22). Most uncompensated cross-price elasticities are negative, while most compensated cross-price elasticities are positive. It is because negative ε_{ij} along with positive $w_j\varepsilon_i$ becomes positive ε_{ij}^c in many cases. Many food groups are gross complements and substitutes for other food groups. This study found that staple food, animal food, vegetables & fruits, and other food are substitutes for each other. One of the interesting findings is that prepared food and staple food are complements while the other pairs are substitutes for each other.

Table 5 shows the result of Morishima Elasticity of Substitution (MES). All five food groups are found to be Morishima substitutes for one another. One of the outstanding findings is that other food is the easiest to substitute and that staple food is the hardest to substitute with prepared food. This finding is consistent with the compensated elasticity estimates, indicating that prepared and staple food are complements of each other.

Table 5. Morishima Elasticity of Substitution

Quantity	Price				
	Staple Food	**Animal Food**	**Vegetables & Fruits**	**Prepared Food**	**Other Food**
Staple Food	-	0.548*** (38.71)	0.539*** (17.83)	0.235*** (9.790)	0.818*** (68.91)
Animal Food	0.238*** (10.83)	-	0.649*** (29.51)	0.427*** (17.50)	0.826*** (80.13)
Vegetables & Fruits	0.231*** (7.602)	0.634*** (45.96)	-	0.403*** (16.03)	0.872*** (74.41)
Prepared Food	0.150*** (6.479)	0.612*** (39.14)	0.602*** (25.72)	-	0.776*** (65.48)
Other Food	0.349*** (14.93)	0.654*** (50.08)	0.752*** (32.48)	0.384*** (15.72)	-

Note. *t* values in parentheses. *** denotes significance at the 1% level.

3.3 Demographic Effects

Demographic characteristics have a significant impact on household food demand decisions. Table 6 shows that demographic variables significantly affect food demand. The age of the household head has a negative effect on the consumption of prepared food as older people tend to be more comfortable cooking at home than purchasing cooked food from outside the home. There is also a positive relationship with animal food, vegetables & fruits. People may become more conscious of their health as they grow.

Schooling years have a negative effect on demand for staple food and other food. It indicates that an increase in the level of education of the household head will decrease expenditure on these food groups. More educated people become more aware of the health implications of too many carbohydrates and other food (including seasonings, drinks, instant foods, oil and coconuts) in their diets. They will be reducing their consumption of these commodities. The results indicate that the consumption of animal food (meat, fish, egg and milk) as a source of protein increase with an increase in education. Another reason could be that more educated people stand the chance of earning more income and therefore can afford the relatively expensive food commodities like meat and fish. Schooling years also have a negative effect on the consumption of prepared food. People have become more educated and aware of the dangers of consuming cooked food outside the home and may prefer to cook themselves.

Family size positively affects the demand for rice and tubers as a staple food. It means that an increase in the family size will increase the households' rice consumption and tubers. It is probably because staple food is the most typical necessity good. A negative effect of family size on animal food shows that an increase in the size of the family will decrease their expenditure since animal food is relatively expensive, especially in rural areas. Family size also has a negative effect on the consumption of vegetables & fruits. Decrease in the family size will lead to more budget to purchase various vegetables & fruits on their daily food menu.

The number of children under five years old positively affects animal food demand. It is probably because the age of five or under is an important period in the growth and development of a child, so they need a lot of protein nutrition from animal food to grow and develop. The result also shows that this variable has a negative effect on demand for staple food and other food. It could be because as household heads become more aware of their children's health, they do not want their children to consume too many carbohydrates, fat, seasonings and instant food.

Table 6. Demographic effects

Variables	Age of household head	Schooling years	Family size	Number of children under 5 years old	Dependent Farmer
Staple Food	0.0002	-0.005***	0.172***	-0.091***	-0.111***
	(0.399)	(-3.062)	(28.46)	(-8.644)	(-5.760)
Animal Food	0.002***	0.015***	-0.120***	0.135***	-0.025
	(2.737)	(6.685)	(-14.23)	(9.026)	(-0.924)
Vegetables & Fruits	0.001**	-0.001	-0.061***	0.014	0.036*
	(2.394)	(-0.389)	(-9.691)	(1.223)	(1.785)
Prepared Food	-0.002***	-0.002	-0.014	-0.017	0.085***
	(-3.219)	(-0.893)	(-1.428)	(-1.003)	(2.768)
Other Food	0.0001	-0.007***	0.010	-0.025**	-0.008
	(-0.153)	(-4.182)	(1.524)	(-2.147)	(-0.355)
Variables	Type of Farmer				
	Staple Farmer	Horticulture Farmer	Plantation Farmer	Fish Farmer	Livestock Farmer
Staple Food	0.135***	0.106***	0.125***	0.020	-0.038
	(8.062)	(3.764)	(11.35)	(0.566)	(-0.577)
Animal Food	-0.017	-0.065	-0.027*	0.186***	-0.071
	(-0.725)	(-1.630)	(-1.761)	(3.692)	(-0.759)
Vegetables & Fruits	0.005	0.054*	0.047***	-0.209***	0.126*
	(0.274)	(1.836)	(4.057)	(-5.579)	(1.798)
Prepared Food	-0.137***	-0.099**	-0.167***	0.013	-0.115
	(-5.119)	(-2.203)	(-9.486)	(0.222)	(-1.072)
Other Food	0.060***	0.018	0.079***	0.033	0.183**
	(3.229)	(0.556)	(6.453)	(0.819)	(2.452)
Variables	Marital Status of Household Head				
	Unmarried	Divorced	Bereaved		
Staple Food	-0.172***	-0.063**	-0.116***		
	(-4.305)	(-2.238)	(-6.485)		
Animal Food	-0.073	-0.012	-0.003		
	(-1.291)	(-0.313)	(-0.122)		
Vegetables & Fruits	-0.211***	-0.064**	0.028		
	(-5.043)	(-2.189)	(1.516)		
Prepared Food	0.475***	0.167***	0.078***		
	(7.427)	(3.729)	(2.739)		
Other Food	-0.193***	-0.101***	-0.003		
	(-4.323)	(-3.221)	(-0.151)		

Note. *t* values in parentheses. ***, **, * denote significance at 1%, 5% and 10% levels, respectively.

The dependent farmer has a negative effect on the demand for staple food but, in contrast, has a positive effect on the demand for prepared food, vegetables & fruits. A dependent farmer works for another farmer or agricultural company and receives wages as income. Generally, a dependent farmer does not have farming land and capital to manage the farm. This condition makes them busy because they must work full-time on other people's farms. Therefore, their choice of buying prepared food is more significant than cooking at home.

Three types of farmers—a staple farmer, a horticulture farmer, and a plantation farmer—have positive effects on the demand for staple food and negative impacts on the demand for prepared food. An interesting finding is that the staple food demand in staple farmer households is 13.5% higher than in non-farmer households. This condition probably happens because, generally, the farmers in rural areas immediately sell most of their produce to the market for cash. There will not be much rice harvest for their consumption. If the rice stock at home runs out, they will buy it at the market. A plantation farmer has a negative effect on the demand for animal food, but a fish farmer has a positive impact. The demand for animal food is 18.6% higher in fish farmer households than in non-farmer households. The reason will be similar to the phenomenon in demand for staple food in staple food farmer households. A horticulture farmer, a plantation farmer, and a livestock farmer have positive effects on the demand for vegetables & fruits but have negative impacts on the demand for vegetables & fruits. It indicates that the demand for vegetables & fruits is lower for fish farmer households than non-farmer households; in contrast, it is higher for the three other types of farmers. Meanwhile, a staple farmer, a plantation farmer, and a livestock farmer positively affect the demand for other food. It means that the demand for other food is higher in the three farmer households than in non-farmer households.

The household head's marital status significantly has a negative effect on the demand for staple food; in contrast, it has a positive effect on the demand for prepared food. A head of a household who is single due to being unmarried, divorced or bereaved has a lower demand for staple food but has a higher demand for prepared food. They are generally responsible for providing for the family, so most of their time is used for work. Therefore, their opportunity to cook at home is very limited, so their demand for prepared food is higher than married heads. The results also show that the household head's marital status has a negative effect on vegetables & fruits, and other food. It could be because a single household head rarely cooks at home, so the demand for these food groups is low.

4. Conclusion

This paper uses the QUAIDS model to estimate rural household food consumption in Bengkulu Province, Indonesia, by focusing on five food groups. The rural household in Bengkulu spends an average of 25.5% of their food expenditure buying prepared food. Animal food has the highest expenditure elasticity and may be classified as a luxury good for people living in rural areas. The demand for staple foods is inelastic and has become necessity goods. This study found that staple food, animal food, vegetables & fruits, and other food are substitutes for each other. The prepared food and staple food are complemented, while the other pairs are substitutes for each other. One of the interesting findings is that other food is the easiest to substitute and that staple food is the hardest to substitute with prepared food. We have found that demographic factors, as well as prices and expenditures, significantly affect demand.

Important policy implications of this study are as follows: First, the food price stabilization policy should emphasize animal food, especially beef and poultry, without increasing prices. Rural people with lower incomes will have a more significant opportunity to consume meat if the price of meat is sold cheaper. Second, policies aimed at increasing income are essential to improve the quality of food consumption in rural Indonesia because animal food is most sensitive to income increase. Third, improving education in rural areas may improve the quality of food consumption by increasing the awareness of and demand for animal food.

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Notes

Note 1. In this paper, *demand* and *consumption* are used interchangeably.

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