agriculture

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Underutilised Indigenous Vegetables for Household Dietary Diversity in Southwest Nigeria

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Citation: Tanimonure, V.A.; Naziri, D.; Codjoe, S.N.A.; Ayanwale, A.B. Underutilised Indigenous Vegetables for Household Dietary Diversity in Southwest Nigeria. *Agriculture* **2021**, *11*, 1064. https://doi.org/10.3390/agriculture11111064

Academic Editors: David Oscar Yawson and Sanzidur Rahman

Received: 24 May 2021
Accepted: 3 September 2021
Published: 28 October 2021

Abstract: The diets of many households in developing countries are monotonous and starch-based. Integrating underutilised indigenous vegetables (UIVs) to cropping systems can contribute to both crop and dietary diversities, thereby improving rural households' nutrition and boosting food security. Therefore, this study established a link between the UIVs' diversity and the household dietary diversity (HDD) of the UIVs producers in the rural area of Southwest Nigeria. A multistage sampling technique was used to select 191 UIV-producing households in the region. Their HDD was measured based on the 12 unique food groups consumed by households over a 7-day reference period preceding the survey, and negative binomial Poisson regression analysis was used to determine the relationship between UIV diversities, other sociodemographic characteristics, and the HDD score of the UIV-producing households in the area. The results showed that only about four groups of food contributed greatly to the HDD score. The result of the negative binomial Poisson regression analysis showed UIVs diversity as a significant variable that increased the HDD score in the study area. Other factors that determined the HDD score of UIV-producing households were the marital status of the household head, farm distance from the home, UIVs land area, off-farm income, UIVs gross margin, per capita food expenditure, and Oyo location. The study concluded that the inclusion of diverse underutilised indigenous vegetables into cropping systems in rural areas and vegetable home gardening practices in the rural and urban areas of developing countries could alleviate the challenge of nutrition insecurity.

Keywords: underutilised indigenous vegetables; vegetable diversity; household dietary diversity; rural areas

1. Introduction

There are links between the promotion of diversity in food crops, indigenous vegetables, and optimum nutritional status [1]. Households with high agricultural production diversity are likely to have a high household dietary diversity score (HDDS), and this is likely to impact positively on their nutrition security [2]. However, researchers still advocate for more research to be done to better understand the role that agro-biodiversity plays on nutrition and dietary outcomes [1].

Meanwhile, it is unfortunate that food production approaches to date have culminated in increasing dependence on a small number of crops. This has been linked to poorer nutrition, especially in developing countries [3–5], where the household food demand pattern is monotonous and mainly dependent on a handful of starch-based foods like yam, cassava, maize, and rice, which are believed to be cheaper compared with micronutrient-dense foods. Less demand is usually placed on micronutrient-based food sources like vegetables and protein [6,7]. This is probably because many people in rural areas are poor and, as such, cannot afford to pay for more nutritious food items.

Therefore, there is a need to harness agro-biodiversity in our food systems in order to enhance traditional food systems that make use of it. Sadly, only 30 crops provide 90 percent of the world's food energy intake, and only four, rice, wheat, maize, and potatoes, supply 50 percent of the world's food energy needs [8]; additionally, only 150 crops are commercialized on a significant global scale. This has led to a narrowed food base, which is a global phenomenon and a worst-case scenario in Africa [8]. This has also been pinpointed as an important factor affecting dietary diversity in developing countries [3].

Meanwhile, ethnobotanics surveys estimated 300,000 plant species worldwide, out of which only 3.3 percent have been used for human food since agriculture started approximately 7000 years ago [8]. These species are an enormous wealth of agrobiodiversity and have great potential for contributing to improved incomes, dietary diversity, and food security and nutrition and for combating the "hidden hunger" caused by micronutrient (vitamin and mineral) deficiencies. However, they are underutilised [4].

The term "underutilised" is applied to a wide range of different crop species that are recognized as being used to a relatively small degree of their potential. Underutilised indigenous vegetables (UIVs) are, therefore, vegetables that were once grown more widely or intensively but which are falling into disuse for a variety of agronomic, genetic, economic, and cultural reasons—they are species whose potentials have not been fully realized [5].

Until recently, the importance of UIVs has been largely unrecognized and unacknowledged by agricultural policy- and decision-makers, technology providers, researchers, extension agents, and donor organizations. This is because, generally, UIVs have very limited commercial appeal, and, as such, they are less competitive when compared with other species in the agricultural environment. They are associated with subsistence farming and are limited to household consumption and informal trading systems [9].

In the intervening time, a number of studies have drawn the attention of the larger society to the roles that UIVs play in more sustainable local livelihoods. There is a growing recognition of the role of underutilised crops in maintaining biodiversity, contributing to incomes in rural communities, and serving as an important safety net for resource-poor smallholder farmers as these crops need fewer inputs for their production. They are often naturally resistant to the pests and diseases of the local agro-ecology as they are uniquely adapted to the environment they grow in [9–15].

Another main attribute of these UIV plant species, about which many researchers are in consonance with, is their contribution towards more balanced diets. They provide micronutrients and vitamins in developing countries whose diets are predominantly based on starchy staples that include little or no animal product and few fruits and vegetables [16–23]. Numerous studies have shown that consuming a diverse diet (diverse vegetables) is related to a better-quality diet and proper nutrition around the world [18,24–27]. Therefore, the diversity of diet could be related to the diet quality, which could lead to good health and can be used as an instrument to measure food security [28,29].

A large number of studies exist on the association between DD and nutritional security. A significant number of them focused on the relationship between dietary diversity and associated factors such as child growth, child malnutrition, nutrient adequacy, and nutrient quality [30–32]. Most of these studies established a positive and significant relationship between the consumption of more diverse diets and the associated factors.

In recent times, studies have made attempts to establish causality between crop diversity and the HDD of farming households. For instance, [33] measures the effects that crop diversification, identified by the number of crops produced by rural households has on the HDD and the amount of crop income from eight developing countries. They found that the link between the number of crops produced and dietary diversity indicators is positive and significant and therefore concluded that crop diversification has a double role: it has impact on HDD and also increases agricultural revenue.

Akerele [34] posed the question of whether food production diversity can influence farm households' dietary diversity. Their findings suggested that the linkage between farm production diversity and dietary diversity is complex because of other variables such as food prices, which may come into play. This notwithstanding, more diverse production systems substantially stimulate consumption of varied diets.

Demeke [35] used household survey data to investigate associations between farm-level production diversity and household-level dietary diversity in seven counties of Kenya. The HDDS were calculated by first aggregating foods that the respondents reported consuming in the seven days prior to the interview into 12 equally weighted groups. The results showed that there was a significant association between production diversification and household dietary diversity.

Further, Rajendran [27] examined the causality between crop diversity and DD at the household level in Sub-Saharan Africa. The study was aimed at exploring whether an increase in the diversity of crops in farmers' fields will lead to increased HDD. Simpson's Index [36] was used to measure the crop diversity, and the study established a relationship that is positive and non-linear between crop diversity and HDD. The study suggested further research studies on the contribution of vegetables to nutrient adequacy (HDD) since vegetables are good sources of micronutrients in household diets.

Huluka [37] also considered the determinants of HDD in the Yayo biosphere reserve of Ethiopia. The study used three different regression models to establish consistency in their results and found that livelihood strategies such as farm production diversity and non-farm income and livelihood outcomes such as meal frequency and household wealth status had a positive influence on HDD in the study area.

Cordero-Ahiman et al. [38] analysed the factors that determine the household dietary diversity score (HDDS) in the rural area of the Paute River Basin, Azuay Province, Ecuador. The HDDS was measured through 12 food groups consumed over a recall period of 7 days, and a Poisson regression model was used to determine the relationship between the HDDS and sociodemographic variables. The results showed that the most consumed food groups were cereals, roots and tubers, fruits, and sugar/honey. The determinants that best explain the HDDS in the predictive model were housing size, household size, per capita food expenditure, area of cultivated land, level of education, and marital status of the head of the household.

This study, therefore, was integrated into the NICANVEG project. The study envisaged that the integration of UIVs production in the subsistence farming sector in Southwest Nigeria can contribute to household dietary diversity, thereby improving rural household nutrition and boosting nutrition security in the area. The main objective of this study was to investigate whether UIV diversity through cultivation in the field results in a high dietary diversity of the producers' households or otherwise. Further, the question of whether dietary diversity is linked to the socioeconomic status of the household cultivating UIVs was also verified.

2. Material and Methods

2.1. Study Area

The study was carried out in southwestern Nigeria, where UIV cultivation was promoted under the NICANVEG project. Southwestern Nigeria is located approximately between coordinates 20,311 to 60,001 East longitude and 60,211 to 80,371 North latitude, with a total land area of 77,818 km^2 and a population of 14,840,360 in 2016. The region is distinctly divided into three major agroecological zones (a rain forest zone, a swamp forest zone, and a derived savanna zone) with varying climatic conditions. The forest agroecological zone has an annual rainfall in the range of 1600 to 2400 mm, with cropping seasons between April and November and dry spells from December to March. On the other hand, the derived savannah ecosystem has a mean annual rainfall ranging from 800 to 1500 mm with cropping seasons between April and November. This research was purposefully carried out in two (rain forest and derived savanna) of the three agroecological zones where the NICANVEG project was implemented [39]. The project was carried out in the rain forest zone and the derived savannah zone where agriculture is widely practised without any threat of flood. These two agroecological zones comprised four states, namely, Ekiti, Ondo, Osun, and Oyo. The study area map is presented in Figure 1.

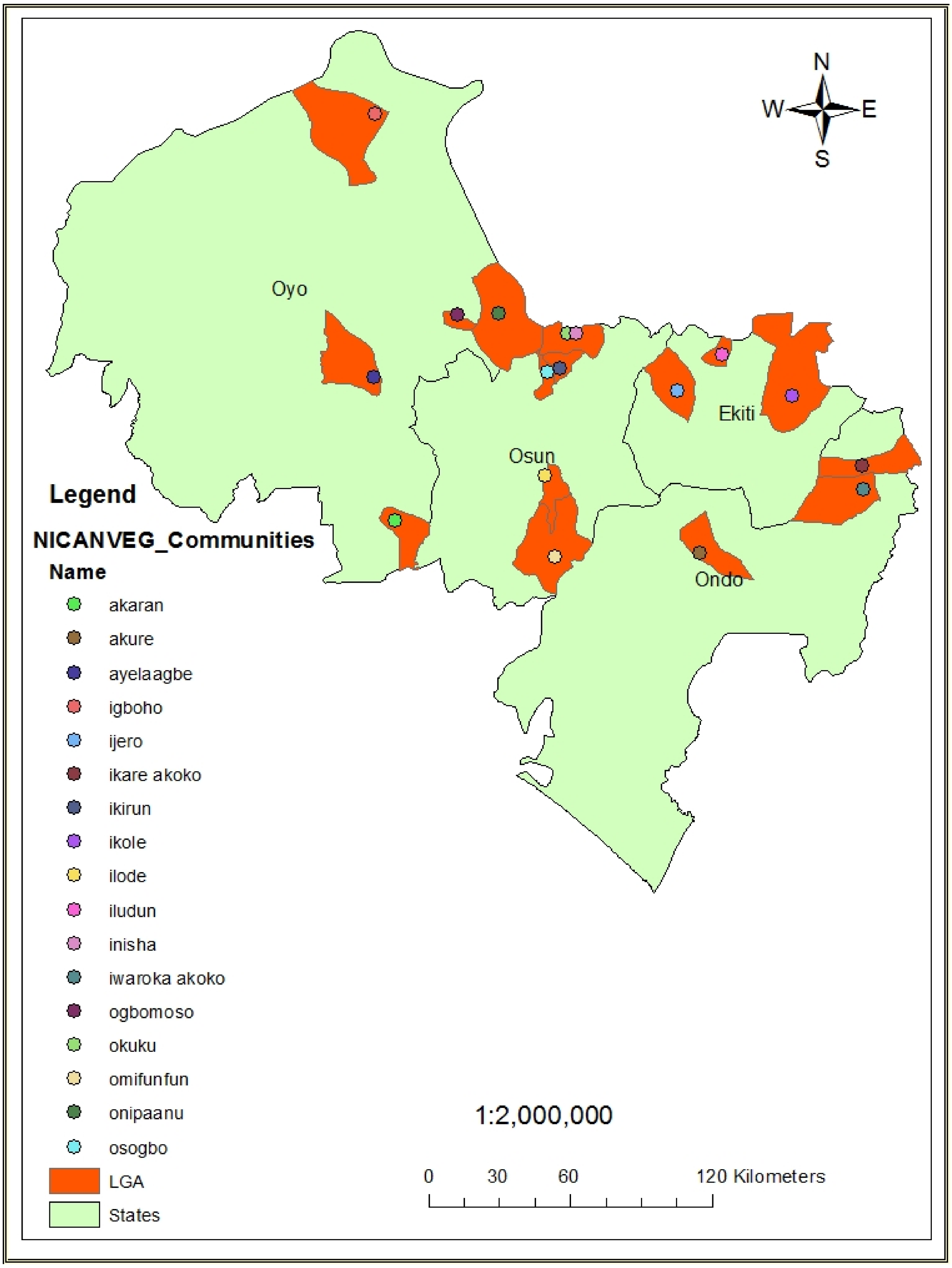

Figure 1. Map of the study area.

2.2. Study Design and Participants

This involved complete selection of all the 17 NICANVEG communities in sixteen local government areas (LGAs) of the four (Ekiti, Ondo, Osun, and Oyo) states. The selection was purposive and was based on the implementation of the NICANVEG project in the selected communities. The sampling procedure ensured representativeness and, due to a limited budget, a simplified formula (Equation (1)) developed by Kothari [40] was employed to calculate the sample size of the respondents at the community level. A 95% confidence level, a 5% estimated percentage, and p = 0.5 were assumed in the equations.

$$n = \frac{Z^2\ x\ p\ x\ q\ x\ N}{e^2 x\ (N-1) + Z^2\ x\ p\ x\ q} \tag{1}$$

where n is the sample size, N is the population size, e is the estimated proportion, p is the sample proportion, $q = 1 - p$, and z is the value of the standard variate at a given confidence level to be worked out from the table showing the area under a normal curve.

Based on this formula, the respondent sample size was approximately 191 (about 50% of the direct beneficiaries of the NICANVEG project in the study area). At each NICANVEG site, 50% of the total farmers were randomly selected using NICANVEG farmers' lists. This proportionate sampling procedure was necessary because the number of farmers in each community or site differs.

2.3. Data Collection

Face-to-face interviews using a structured questionnaire was conducted by trained postgraduate students of Obafemi Awolowo University. The interviewers were supervised by the first author during the data collection. Phones were used for the data collection; the questions were coded on the phone using the open data kit (ODK) in order to minimize errors that could emanate during data collection and entry. Information obtained from the respondents included socioeconomic data such as age, sex, level of education, income from UIVs enterprise, household size, among others. Data on UIVs production were adequately collected, including the number of UIVs cultivated by the household (this was used to calculate the UIVs diversity) and input and output data on UIVs production. Data on the dietary diversity of the household were obtained as well, and this included the frequency of food group consumption over a 7-day reference period preceding the survey. The reference period was chosen according to the Food and Agriculture Organization (FAO) guidelines for measuring household and individual dietary diversity [41].

2.4. Analytical Techniques

2.4.1. Measuring Dietary Diversity of the Household

This study employed a dietary diversity scoring system proposed by Hoddinoth [24] and also used in Mozambique by Rose [42]. This involved the use of a weighting system, that is, a weighted sum of the number of individual foods per group of food consumed over a reference period of 24 h [43]. Usually, the reference period varies depending on the focus of the study, but, generally, the previous day or week was used by [24,25,43]. This study adopted a 7-day reference period preceding the survey following [38,41]. Fourteen different standardized food groups were included in the questionnaire for scoring (Table 1). Following FAO [8], food groups 3 and 4 (legume, nut and seed) and 7 and 8 (meat) were aggregated to create dietary diversity scores (DDS) of the households, which ranged between 0 and 12, as summarised in Table 1. It should be noted that there is no international consensus on which food groups to include in the scores; rather, the selection of food groups should be driven by the specific purpose that the dietary diversity indicator is to be used for [8,18]. Each food group has a range of food items that are consumed in the study area for which the households have to indicate the frequency of eating in the last 7 days preceding the survey.

Table 1. Food groups included in the study.

No	Food Group Plant Origin	Foods within the Group
1	Cereals and grain products	Maize, millet, rice, sorghum, wheat (incl. eko, akamu/ogi, semo, etc.)
2	Starchy roots, tubers, and fruit	Cassava, plantain, potato, sweet potato, cocoyam, yam (incl. eba, amala from yam and plantain, iyan, etc.)
3	Grain legumes and legume products	Bean, chickpea, cowpea, pigeon pea, soybean (incl. akara, moinmoin, etc.)
4	Nuts and seeds	Cashew nut, groundnut, coconut (and products, e.g., milk), groundnut, melon seeds, pumpkin seeds, etc.
5	Vegetables and vegetable products	Bulbs (onion, leek, garlic), exotic vegetables (cabbages, cucumber, lettuce) indigenous vegetables (*woorowo*, *teteabalaye*, *ugu*, *odu*, *igbagba*, *ogunmo*, etc.) conventional leafy vegetables (green, corchorus, etc.), mushrooms, root vegetables (carrot), okra, pumpkin fruit, tomato, pepper, etc.
6	Fruits	Banana, mango, orange, lemon, pawpaw, pear, pineapple, tangerine, watermelon, wild fruits
	Animal origin	
7	Meat	Beef, goat, mutton, pork, bush meat, etc.
8	Poultry	Chicken, duck, bush fowl
9	Eggs	Eggs (from chicken)
10	Fish and fish products	Fish (frozen or dry fish), freshwater fish, etc.
11	Milk and milk products	Milk (cow, goat), soy milk
	Others	
12	Oils and fats	Palm oil, vegetable oil, groundnut oil, animal fat, margarine, etc.
13	Spices, condiment and beverages	Carbonated soft drinks, non-alcoholic hot drinks (tea, coffee)
14	Sweets	Sugar, honey, sweetened soda, or sweetened juice drinks

Source: adapted from [41].

2.4.2. Empirical Model

The essence of this study was to analyse the role of UIVs diversity on the dietary diversity of the households. It was envisaged that cultivation of diverse UIVs will increase the vegetable intake of the household and also that the income generated from the UIVs could be used to purchase other food items not produced by the house to enhance nutrition. For instance, a UIV farming household can sell UIVs and, in turn, purchase food items to meet the food requirement of the members, thereby increasing the household dietary diversity. The dietary diversity of the household, therefore, is a function of UIVs diversity and other household characteristics [2].

In order to examine the effect of UIVs diversity on HDD in southwestern Nigeria, the nature of the dependent variable (HDD) was considered. In this study, the dependent variable was a count datum, and three forms of count data regression models could be carried out. These included normal Poisson regression, negative binomial regression, and zero-truncated Poisson. However, negative binomial regression was considered. Negative binomial regression models do not assume an equal mean and variance and particularly correct for over-dispersion in the data, which is when the variance is greater than the conditional mean [44–46]. It could be considered as a generalization of Poisson regression since it has the same mean structure as Poisson regression, and it has an extra parameter to model the over-dispersion. If the conditional distribution of the outcome variable is over-dispersed, the confidence intervals for the negative binomial regression are likely to be narrower as compared to those from a Poisson regression model.

In negative binomial regression, the mean of y is determined by the exposure time t and a set of k regressor variables (the xs). The expression relating these quantities is Equation (2):

$$\mu_i = \exp(\ln(t_i) + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots + \beta_k x_{ki}) \tag{2}$$

Often, $X1 \equiv 1$, in which case $\beta 1$ is called the intercept. The regression coefficients $\beta 1$, $\beta 2, \ldots, \beta k$ are unknown parameters that are estimated from a set of data. Their estimates are symbolized as b1, b2, . . . , bk. Using this notation, the fundamental negative binomial regression model for an observation *i* is Equation (3), written as:

$$\Pr(Y = y_i \backslash \mu_i,\ \alpha) = \frac{\Gamma\left(y_i + \alpha^{-1}\right)}{\Gamma(\alpha^{-1})\Gamma(y_i + 1)}\left(\frac{1}{1 + \alpha\mu_i}\right)^{\alpha^{-1}}\left(\frac{\alpha\mu_i}{1 + \alpha\mu_i}\right)^{y_i} \quad (3)$$

The source of data was from a cross-sectional survey conducted among the underutilised indigenous vegetables producers, who participated in a Nigeria–Canada vegetable project in Southwest Nigeria. The dependent variable, household dietary diversity was the weighted sum of the number of individual foods per group of food consumed over a reference period of 7 days. Explanatory variables included demographic and socioeconomic characteristics of the UIVs farmers. The variables included were UIVs diversity (number of UIVs cultivated), age of the head of the household (years), years of formal education of the head of household, marital status of the head of household (the marital status of the head of household was registered according to the options: single, married), number of UIVs farm plots, farm distance from home (km), area of cultivated land to UIVs (ha), access to extension agent (yes or no), off-farm income in naira, gross margin generated from UIVs in naira (gross margin from immediate past UIVs cultivated before the survey), monthly food expenditure per capita, location (Oyo, Ondo, and Ekiti). Therefore, 12 explanatory variables were selected for the estimation of the model following [2,38]. The parameters and values chosen to rule that an association is or is not statistically significant were realized according the significance levels: * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$. The model parameter vector was estimated through the maximum likelihood method (MLE).

3. Results

3.1. Description of Variables

Table 2 presents the summary statistics for variables used in the analysis. From the table, each household cultivated, on average, two types of UIVs. The main UIVs cultivated by the households include *Amaranthus viridis, Solanecio biafrae, Solanum scarbum, Solanum nigum*, *Telfairia occidentalis,* and *Solanum macrocarpon*. The mean gross margin from the immediate past UIVs production cycle was ₦ 119,211.03 (USD 600) (at the prevailing exchange rate of 198.53 per U.S. dollar when the data were collected). The average UIVs cultivated land area was 0.21 ha, and the average distance of the UIVs farm to homestead was 2.14 km. On average, the distance of the UIVs farm to the main road was 6.96 km, which was about a 10-min drive from the main road. Each household, on average, consumed about 11% of the UIVs cultivated in the immediate past production cycle. About 63% of the sample households were headed by a male, and their average age was 48.16 years with an average of 9 years of formal education. The average household size was 8 persons. About 63% belonged to a farmers' association, and only about 23% had access to a loan during the immediate past production cycle before the data collection. On average, each household spent a sum of ₦ 31,067.47 (USD 156.49) on food items per month.

3.2. Frequency of Food Group Consumption Per Reference Period

The frequency of food group consumption over a reference period of 7 days is presented in Figure 2. The results showed that the frequently consumed food groups were spices and condiments (16.2), vegetables (14.9), cereals (14.5) and legumes, and nuts and seeds (14.2) within the seven-day reference period. It was worth noting that the frequency of consumption of more nutritious food groups such as eggs (1.5), milk and dairy products (2.1), fish and other seafoods (5.5), and meats (5.7) compared relatively low to other food groups.

3.3. Household Dietary Diversity Score Distribution

The HDD score for the study is presented in Table 3; the result revealed that the HDD of the sample respondents was low. Most (70.16%) respondents had an HDD score between 2 and 3.99.

Table 2. Descriptive statistics and variable definitions.

Variable	Description	Number	Mean	SD
UIVs diversity	Number of UIVs cultivated by household	191	2.2408	1.1492
Gross margin	Gross margin from the immediate last production cycle prior to data collection in naira	191	119,211.03	225,829.77
UIVs land area	Area of land cultivated to UIVs in ha	191	0.2058	0.4543
Distance to farm from home	The distance to the farm from home in km	191	2.1376	3.2080
Distance of farm to main road	Distance to a main motorable road in km	191	6.9590	3.7431
UIVs consumed	Percentage of UIVs consumed in the immediate past production cycle	191	10.8764	8.8202
Gender of household head	Dummy variable = 1 if the respondent is a male and 0 otherwise	191	0.9424	0.2335
Age of household head	Age of household head in years	191	48.1571	14.3386
Formal education	Number of years of formal education	191	9.2094	4.6857
Household size	Number of members eating in the same pot	191	7.7120	4.5498
Group membership	Dummy variable = 1 if the respondent is a member of group and 0 otherwise	191	0.6283	0.4853
Access to loan	Access to a loan during the immediate past production cycle. Dummy variable = 1 if has access to loan and 0 otherwise	191	0.2251	0.4187
Total food expenditure	Total expenses spent on food in the previous month prior to data collection in naira	191	31,067.47	26,277.49

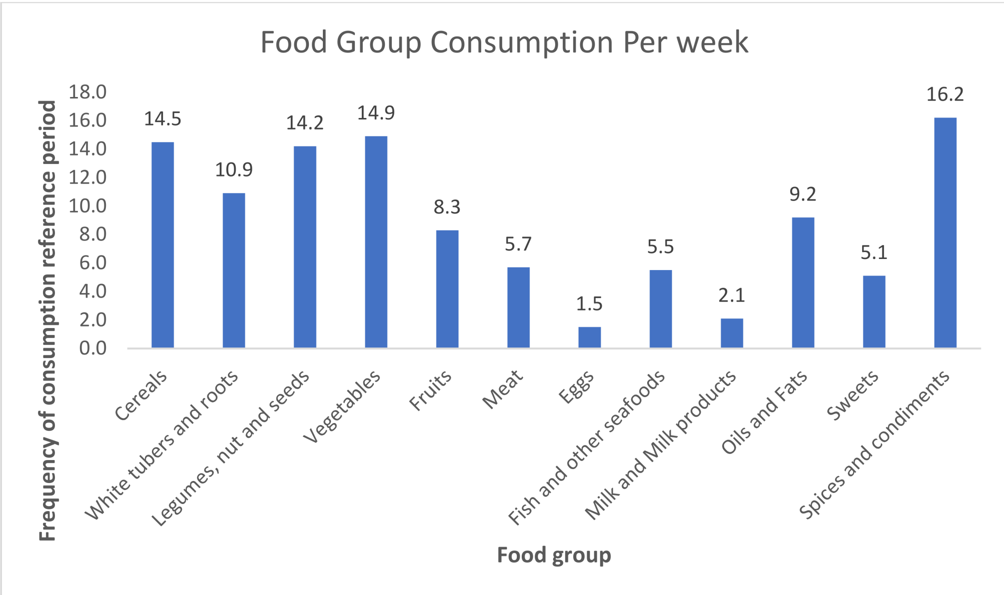

Figure 2. Food group consumption per week.

Table 3. Household dietary diversity score distribution.

Range	HDD Score
<2.00	4 (2.09)
2.00–3.99	134 (70.16)
4.00–5.99	50 (26.18)
>5.99	3 (1.57)
Mean	3.52
SD	0.91
Minimum	0.8
Maximum	6.43

Values in parentheses are percentages.

The mean HDD score was 3.52, which means that only about four groups of food contributed greatly to the HDD of the respondents.

3.4. Determinants of Dietary Diversity among UIVs Producers

The results of the econometric estimation are summarized in Table 4. The factors determining the HDDS were modelled using the negative binomial regression model. Negative binomial regression allowed for the modelling of count data, in this case, the dietary diversity score (which ranged from 0 to 12) and did not assume an equal mean and variance and was particularly correct for over-dispersion in the data when the variance was greater than the conditional mean. In addition, when modelling the count data, this model assumed that the results are Poisson-distributed.

Table 4. Effect of UIVs cultivation on household food security: negative binomial regression.

HDD	Coef.	St. Err.	*p*-Value	dy/dx	Std. Err.	*p*-Value
Varieties of UIVs cultivated	0.137	0.062	0.028 **	1.482	0.686	0.031 **
Age of household head	0.006	0.008	0.039	0.070	0.082	0.392
Gender of household head	0.002	0.134	0.990	0.017	1.449	0.990
Years of formal education of household head	−0.004	0.013	0.770	−0.042	0.143	0.770
Marital status of the household head	0.178	0.091	0.052 **	1.922	1.000	0.055 **
Number of plots of UIVs farm	0.009	0.007	0.195	−0.097	0.075	0.198
Farm distance from home	−0.037	0.021	0.083 *	−0.403	0.236	0.088 *
UIV land area	0.388	0.134	0.004 ***	4.201	1.495	0.005 ***
Access to extension agents	0.003	0.115	0.977	0.036	1.249	0.977
Off-farm income	−0.084	0.009	0.000 ***	−0.907	0.122	0.000 ***
UIVs gross margin	0.083	0.013	0.000 ***	0.895	0.160	0.0000 ***
Per capita food expenditure	0.034	0.017	0.043 **	0.372	0.187	0.000 **
Oyo	0.385	0.128	0.003 ***	4.166	1.435	0.004 ***
Ekiti	0.077	0.157	0.624	0.835	1.705	0.624
Constant	1.583	0.442	0.000 ***			
Mean dependent variable	3.531					
Pseudo r-squared	0.1006					
Chi-square	127.36					
SD dependent var	0.892					
Number of obs	190.000					
Prob > chi2	0.000					

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4 shows the coefficients of the different factors that determine the HDD at the household level, their marginal effects, and the *p*-values. The coefficients can be interpreted as elasticities or semi-elasticities, representing a percentage change in the HDD score when the explanatory variable changes by one unit. The positive or negative and significant marginal effects in column (5) suggest that the HDDS of households increases or decreases with a change in one of these explanatory variables (Table 4). The results of the marginal effects of the model show that the varieties of UIVs cultivated, marital status, farm distance from home, UIVs land area, off-farm income, UIVs gross margin, and food expenditure per capita were statistically significant variables and important factors determining the HDDS.

The varieties of UIVs cultivated had a positive and significant effect with respect to the HDDS ($p < 0.5$). The marital status of the household head variable also had a *p*-value below 0.05 and was therefore significantly associated with HDDS. The marital status variable had a positive coefficient, meaning that when the household is married, the household size would invariably be high; the diverse food consumed would increase and thereby increase the HDDS. The coefficient of the farm distance from the home variable was negative and significantly influenced HDDS ($p < 0.1$). Consequently, the further away the UIVs farm is to the homestead the lower is the HDDS. The coefficient of the cultivated land area variable was positive and was statistically associated with the HDDS ($p < 0.01$). In other words, having access to more land area increased the dietary diversity score and probably the ability to produce more varieties of crops.

Further, the off-farm income variable was negative and significantly ($p < 0.01$) reduced the HDDS; that is, when off-farm income increases, HDDS reduces significantly. Increased off-farm income is probably a result of reduction in farming activities, which can reduce the ability of farmers to produce more varieties of crops. The UIVs' gross margin was also positive and significantly ($p < 0.1$) increased the HDDS. Increased UIV gross margin, which could habitually lead to increased household farm income, will no doubt increase their purchasing power. Similarly, the monthly food expenditure per capita variable impacted HDDS positively and significantly. Whenever food expenditure per capita increases, the HDDS increases as well. The Oyo state location was positive and had a significant effect on HDDS. An increase in the production of UIVs in the state of Oyo increased HDDS in the location.

4. Discussion

The purpose of this research was to establish the link between the household dietary diversity (HDD), UIVs diversity, and other socioeconomic characteristics of UIVs producers in the rural area of Southwest Nigeria. Based on the literature reviewed globally and specifically in Africa [27,33–35,37], positive relationships were established between crop diversification and HDDS. Although, there is a dearth of literature in Nigeria in this regard. This study therefore bridges this gap in knowledge.

The results of the study show that the diet of the sample UIVs producers in the study area is based on starch. This result is consonant with [38,43], who also reported a cereal-based diet for the sample respondent. It is noteworthy that the diets of the UIVs producers lacked protein-source products (such as eggs (1.5), milk and dairy products (2.1), fish and other seafoods (5.5), and meats (5.7)), which was an indicator that the households' diets lacked the important nutrients requirement by the body. The low consumption of animal products could be due to higher prices attached to such commodities compared to vegetables and other food items. This result was similar to [38,43] who also found that consumption of food rich in micronutrients such as milk/dairy products and fish and seafoods is low in the study area. Meanwhile, the frequency of vegetables' consumption in the study area is high. This is probably because the producers have better access to the vegetables they produce. This indeed has a way to complement their starch-based diet and supply the necessary micronutrients that the body requires. This was similar to the results of [43], where the result showed that the highest food group consumed was vegetables. It is therefore important to encourage farmers to cultivate UIVs alongside other crops to boost their dietary diversity and, hence, the quality of their diet. It was noteworthy the variables such as the number of UIVs cultivated and land area cultivated to UIVs were statistically significant and had a positive relationship with HDD. The implication of this is that there is strong relationship between the cultivation and consumption of agricultural produce, and to improve the nutrition security of the rural households, diversity in crop production should be encouraged. The cultivation of crops rich in micronutrients (like vegetables and protein), which will boost the nutrition quality, is advocated for, since food security is not only in the quantity of food consumed but the quality. This result was similar to Keding [25], who established a link between the production of vegetables and dietary diversity score. This result was also in line with Pellegrini [33], who also established a positive link between the number of crops produced and HDD. Chegere and Stage [2] also established a significant relationship between household agricultural production and HDD. Cordero-Ahiman et al. [38] specifically identified the area of land cultivated as an important factor that determines HDD because households with larger agricultural land enjoyed higher dietary diversity.

Further, farm distance from home had a significant and negative influence on the HDD. Food crops that involve walking a long distance to access, especially by women who prepare food in the house, will be less consumed but would instead be harvested in large quantities and sold. The promotion of homestead vegetable gardens may be a good method to improve HDD. Easy and close access to UIVs will increase consumption and also complement the starch-based diet of many households in developing countries [25].

Dietary diversity studies generally provide information on the household access to diverse food in order to measure the HDDS, which reflects a household's economic ability to access a variety of foods. In order to assess the economic ability of the UIVs respondents, three welfare indicators (off-farm income, UIVs gross margin, and monthly food expenditure per capita) were included in the model, and all the three significantly influence the HDDS. The off-farm income reduced HDD significantly when rural households shifted their attention from farming and became involve in non-farming activities, and their access to varieties of food may be reduced and affect HDD negatively. Conversely, income generated from UIVs influences the HDDS positively, which is probably because the proceeds from the UIVs could be used to purchase other food items that are not produced by the households. This result is in agreement with [2]. The study also reported that there was a greater chance that increased revenue from agricultural produce will translate into a higher diverse diet. Moreover, the monthly food expenditure per capita influences HDDS positively. The result of monthly per capita food expenditure contributed to improving the HDDS in the study area. The purchasing of food is important to achieve a greater HDDS in order to meet the basic food needs of households.

The variable Oyo location increases the HDDS significantly, and further research is recommended to probe the significance of location on UIVs and HDDS. Although, [15] identified agroecological zone as one of the significant factors that influence the production of UIVs in Southwest Nigeria.

It is worth mentioning a couple of limitations despite the findings of this research. Agricultural production in many developing countries is mainly rain-fed, and the seasonal effect of UIVs production for some households on HDD was not put into consideration. The study suggests the use of panel datasets instead of cross-sectional data used in this study. The panel data account for farmers' experiences with both planting and harvesting periods as these periods determine what the households consume in term of quality and quantity. Additionally, the role that location plays on the HDDS of UIV-producing households needs to be investigated. These limitations should be seen as a research gap for further study.

5. Conclusions

The study findings conclude that although the HDD of the UIV-producing household was low, the frequency of UIVs consumption was high and thereby complemented their starch-based diets. Based on the empirical findings, the study concludes that the key determinants of UIVs producing HDD are UIVs diversity, marital status, farm distance from the home, UIVs farm area, off-farm income, UIVs gross margin, monthly per capita food expenditure, and Oyo location.

Overall, the outcome of this study highlighted critical roles of the incorporation of UIVs into the cropping systems of farmers in rural areas and also home gardening practices in both the rural and urban areas to increase HDD and ensure nutrition security. The strategic policy, targeting research and investment in the above area, can play a significant role towards improving both rural and urban HDD and household food and nutrition security.

Author Contributions: Conceptualization, V.A.T., D.N., S.N.A.C. and A.B.A.; Methodology, V.A.T.; Software, V.A.T.; Validation, D.N., S.N.A.C. and A.B.A.; Formal analysis, V.A.T.; Investigation, V.A.T.; Data curation, V.A.T.; Writing—original draft preparation, V.A.T.; Writing—review and editing, V.A.T. and D.N.; Visualization, D.N.; Supervision, D.N., S.N.A.C. and A.B.A.; Project administration, V.A.T.; Funding acquisition, V.A.T. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Department for International Development (DfID).

Informed Consent Statement: Ethical review and approval were waived for this study, due to studies not involving humans or animals.

Data Availability Statement: Data are available on request.

Acknowledgments: The authors are grateful to all the enumerators involved in the data collection and also appreciate the cooperation of the sampled respondents. The effort of NICANVEG desk officer is also appreciated.

Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

UIVs: underutilised indigenous vegetables; HDD: household dietary diversity; NICANVEG: Nigeria–Canada Vegetable project; HDDS: household dietary diversity score; IDRC: International Development Research Centre; DFATD: Department of Foreign Affairs, Trade, and Development Canada; ODK: open data kit; DfID: Department for International Development; CIRCLE: Climate Impact Research Capacity and Leadership Enhancement.

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