Exploring dietary diversity, nutritional status of adolescents among farm households in Nigeria: do higher commercialization levels translate to better nutrition?

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Abstract

Purpose:
This study explored dietary diversity and nutritional status of adolescents among rural farm households in Southwestern Nigeria. It analyses if higher commercialization levels of farm households translate to better nutrition.
Design/methodology/approach: The study was conducted in Ogun and Oyo States of Southwestern Nigeria, utilizing primary data from 352 farm households with a total of 160 adolescent members. The individual version of dietary diversity score (DDS) of nine (9) food groups was used to calculate adolescent DDS over a 24-h recall period, World Health Organization (WHO) AnthroPlus software was used in analyzing adolescents' anthropometric data (height-for-age z-score and BMI-for-age z-score) while household crop commercialization index (CCI) was estimated for each farm household. Separate logit models were used to examine the drivers of adolescents' dietary diversity and malnutrition.
Findings: The study findings indicated that 100% of the adolescents consumed starchy staples while 0%, 3.1% and 12.5% consumed organ meat, milk/milk poducts, and eggs respectively. Results revealed that 74.1% and 21.2% of boys were stunted and thin while the prevalence in adolescent girls was 50.7% and 9.3% respectively. Prevalence of stunting was found to be very high (60-83%) in all the four CCI levels' households indicating that belonging to highly commercialized households (CCI 3-4) may not necessarily translate to better nutrition of adolescent members. Food expenditure ($p< 0.01$) and access to piped water ($p< 0.01$) negatively influenced adolescents' stunting mainly due to lower expediture on food items and lower percent of household having access to piped water respectively while education ($p< 0.01$) had positive effect on adolescents' dietary diversity.
Originality/value: Previous studies have contributed to the body of knowledge concerning the link between agricultural commercialization and nutrition using under-five children of the households. However, this is the first study that investigated the influence of CCI on DDS and nutritional status of adolescent members of farm households in Nigeria. Our study fills this existing knowledge gap in investigating adolescents' dietary diversity and malnutrition among smallholder farm households.

Keywords: Farm households; Crop Commercialization Index (CCI); malnutrition; stunting; WHO AnthroPlus; dietary diversity score.

1. Introduction

Adolescence is a unique phase of human life with major developmental experiences ushering the much anticipated transition from childhood to adulthood. The health and wellbeing of the children and

adolescents (10-19 y old) is of utmost importance to every nation as they are regarded as one of the critical determinants of future economic and societal development (WHO, 2021). In 2020, adolescent (10-19 y old) population reached 1.25 billion, with 16% share of the world's population. Among countries with highest number of adolescents in the world, India was ranked 1st (252.2 million), followed by China (166.6 million) and Nigeria was 3rd (47.7 million) in 2020 (UNICEF, 2021). However, more than 50% of all adolescents globally reside in Asia, with South Asia having the highest number (306.04 million) among all regions while Sub-Saharan Africa (SSA) is the region with the highest population proportion (23%) of adolescents (10-19 y old) in 2020 (UNICEF, 2021).

Globally, the prevalence of overweight among children and adolescent has gone up, from 9.5% to 12.5% among boys (5-9 y old) and 10.0% to 12.6% among girls (5-9 y old) from 2010 to 2019 while among adolescents aged 10-19 y (male), it increased from 8.1% in 2010 to 12.5% in 2019 and among female adolesecents (10-19 y old), it went up from 10.3% in 2010 to 12.9% in 2019. However, children and adolescents'prevalence of thinness has witnessed a little decline since 2010 with -1.9% (boys) and -0.7% (girls) reduction among 5-9 y childen and -1.1% (male) and -0.2% (girls) decrease among adolescents (10-19 y old) from 2010-2019 (GNR, 2021). The young children and adolescents (5-19 y old) are among the most vulnerable groups of the population usually burdened by unhealthy diets and carbohydrate-dense foods in both developed and low-and middle-income countries (Global Panel, 2016; IFPRI, 2017; GNR, 2021; Otekunrin et al., 2022; Otekunrin, 2022).

Healthy and diversified dietary composition of young children and adolescents are pivotal to their growth and developent. The consumption of lose-lose diets predispose this group to different forms of malnutrition (stunting, overweight, micronutrient deficiency) while the adolescent girls of child-bearing age are exposed to burdens of malnutrition (Global Panel, 2016; Garnett, 2016; Willet et al., 2019; Otekunrin et al., 2022). However, other members of the households also need to consume healthy and diversified diets for good nutrition and healthy living. Likewise, diverse diet is viewed as a health guage that indicates the worth of the diets consumed and regarded as very crucial in estimating food and nutrition security of individuals or households (Mirmiran et al., 2006; Azadbahkt and Esmailzader, 2012; Obayelu and Osho, 2020; Otekunrin et al., 2022). However, the challenge of hunger and food insecurity was experienced by almost every country in 2020. Globally, it was estimated that 161 million more people experienced hunger in 2020 more than that of 2019 while about 2.4 billion of the population did not have access to quality and sufficient food in 2020, reflecting an unprecedented increase of 320 million in 12 months period (FAO et al., 2021).

Moreover, high-quality diets was far from the reach of about 3 billion people in 2019, owing to the soaring cost of healthy diets, ever-increasing poverty levels in developing nations, and income inequality in all regions of the world. More so, high prevalence of food insecurity was related to the rising unaffordable healthy diets.The emergence of COVID-19 has really aggravated hunger and food insecurity in all regions of the world, putting so much pressure on the food systems and health sector in every country (FAO et al., 2021). With 282 million malnourished population (1/3 of global population) found in Africa in 2020, malnutrition remained a serious challenge in the region (FAO et al., 2021). However, a study revealed that many of the malnourished population are high among smallholder farm households in poor nations who depend mostly on agriculture as means of livelihood (IFPRI 2017; Otekunrin et al., 2022). Good health of members of farm households mostly adolescent members (future head of households) are pivotal to their agricultural productivity, produce marketing and that of the nation's food security strategy.

Agricultural commercialization occurs when agricultural operations depend largely on the market for the sale of produce and for the purchase of production inputs, and labour (APRA, 2018). More so, Agricultural commercialization refers to increased market transactions in a position of enjoying gains from specialization (Carletto et al., 2017; Opondo et al., 2017; Otekunrin, 2022; Otekunrin et al., 2022). The estimaion of the extent of commercialization of smallholder agriculture from the output side of production gives us the opportunity to take advantage of marketing behaviour from (small-scale to full commercialization) of individual households (Carletto et al. 2017; Opondo et al. 2017; Otekunrin et al., 2022).

Previous studies in Africa, such as Northern Ethiopia found high level of stunting (26.5%) and thinness (58.3%) among adolescent students (Melaku et al., 2015). More so, a study in Northwest Ethiopia also reported 21.8% stunting and 16.9% thinness among school-aged adolescents (Kebede et al., 2021). However, some studies also reported nutrition outcomes and dietary diversity (DD) of both under-five children and women of rural farm households in Nigeria (Lawal and Samuel, 2010; Babatunde et al., 2011; Ukegbu and Ogu, 2017; Ogunnaike et al., 2020; Otekunrin et al., 2022). Likewise, few works have described the relationships that existed between agricultural commercialization and nutritional status of under-five children (Okezie and Nwosu, 2007; Carletto et al., 2017) while Otekunrin et al (2022) investigated DD of young children of farm households in Southwestern Nigeria. From literature, studies on agricultural commercialization, dietary diversity, and nutrition outcomes nexus among adolescent members of farm households have not yet received research priority.

However, from our knowledge, this study is the first that focuses on the effect of agricultural commercialization on dietary diversity and nutrition outcomes of adolescent members of rural farm households. This study is set to fill knowledge gap concerning the dietary pattterns and nutrition outcomes of adolescent members of smallholder farm households. The study employed primary data and used individual dietary diversity score (IDDS) module to calculate the DDS of the adolescent members of the cassava farm households while WHO AnthroPlus software was used to determine the nutrition outcomes (stunting and thinness) of the adolescents (boys and girls). The result of the study is crucial to the stakeholders in prioritizing the implementation of nutrition-sensitive policy interventions that will improve the health and standard of living of adolescents as well as other members of the households.

2. Methodology

2.1. The study area

This study was conducted in Southwestern Nigeria. The country is one of the West African countries with land mass of 923,768 square kilometer (Maps of World 2021; Otekunrin et al., 2022). The region has six (6) states namely; Lagos, Ekiti, Ogun, Ondo, Osun and Oyo. However, majority of the people in this part of the country speak Yoruba fluently but not without diverse dialects within and across the states. The study was carried out in Ogun and Oyo states, Southwestern Nigeria. Agriculture is the major occupation of the rural people in this region (Lawal and Samuel 2010; Otekunrin, 2022).

2.1. Sampling and data collection procedure

This study utilized primary data which was collected through multi-stage sampling procedure. In the first stage, two (Ogun and Oyo states) out of six (6) cassava producing states in the Southwestern Nigeria was randomly selected. The stage two included the selection of 5 Local Government areas (LGAs) from Oyo state and 3 LGAs from Ogun state giving a total of eight (8) LGAs in the two states. The third stage included the selection of 24 villages from the 8 LGAs while stage four included selection

of 16 smallholder cassava farm households resulting in 384 farm households. The data were collected with the help of structured questionnaire which include; the household socioeconomic factors, adolescents' DDS, expenditure on food and other germane household and adolescent-related issues. Thirty-two (32) of the questionnaires were unusable after data cleaning. In the 352 farm households, there were 160 adolescent members. However, anthropometric measurements such as age of adolescents, gender, height and weight were measured and recorded. The number of food groups consumed by the adolescents were recorded and used in calculating their DDS while measurement details were used in obtaining malnutrition indices such stunting-height-for-age z-score (HAZ) and thinness-body mass index z-score (BAZ).

2.2. Data Analysis

2.2.1. Evaluating the levels of agricultural commercialization

The commercialization levels of smallholder cassava farming households in the study areas were estimated, adapting the Crop Commercialization Index (CCI) by Strasberg et al., 1999, Carletto et al., 2017; Otekunrin et al., 2022 which is expressed as:

$$CCI_i = \frac{Gross\ value\ of\ crop\ sale_{hhi,\ yearj}}{Gross\ value\ of\ all\ crop\ production_{hhi,yearj}} \times 100 \quad (1)$$

We have hh_i as the i^{th} household in year j.

Using this method, agricultural commercialization is represented by a continuum from real subsistence ($CCI_i = 0$) to full commercialization ($CCI_i = 100$). Using this method, cassava farm households were categorized on their commercialization levels. Farm households that did not participate in the sale of cassava roots were grouped as (i) zero level households (CCI 1 = 0%) while participants were classified into; (ii) low level (CCI 2 =1-49%) (iii) medium-high level (CCI 3 = 50-75%) and (iv) very- high level (CCI 4 = >75%) of commercialization (Otekunrin, 2022; Otekunrin et al., 2022).

2.2.2. Measuring individual dietary diversity score (IDDS) for adolescents

The IDDS for adolescents helps in detemining the individual member of the household dietary pattern in a particular period of time such as 30-d, 7-d, and 24-h recall period. Nine (9) food groups (FG) was adapted for adolescents aged 10-19 y old. However, the minimum of 4 food groups or more out of 9 was used (Kennedy et al., 2010a, b; Steyn et al., 2014; Otekunrin et al., 2022). It is worthy of note that IDDS capured all foods consumed by specific individual irespective of how the foods were prepared whether at home or outside. The food groups are: (i) Starchy Staples, (ii) Dark green leafy vegetables, (iii) Other vitamin A rich fruits and vegetables (a combination of vitamin A rich vegetables and tubers and vitamin A rich fruit), (iv) Other fruits and vegetables (a combination of other fruit and other vegetables), (v) Organ meat (offals), (vi) Meat and fish, (vii) Eggs, (viii) Legumes, nuts and seeds, (ix) Milk and milk products used (Kennedy et al., 2010; Steyn et al., 2014; Uzosike et al., 2020; Otekunrin et al., 2022).

The DDS of adolescents was determined by summing the number of different food groups consumed over 24-h recall period while a score of 1 was assigned to each food group resulting in a total of 9 points. The percentage of adolesents meeting up the minimum of 4 food groups out of 9 was calculated. This means an adolescent having DDS less than 4 is regarded as having low DDS.

2.2.3. Anthropometric measurements of adolescents

Anthropometry is a human body measurements which is commonly used to obtain crucial nutrition details about a sample or population (Babatunde et al., 2011). Previous rural farm household studies have applied anthropometric data to under-five children (Babatunde et al., 2011; Ogunnaike et al., 2020). Empirical studies on anthropometric measurements of adolescent members of households especially rural farm households are scare. The anthropometric measurements for adolescents (10-19 y old) were measured using stunting (HAZ) and thinness (BAZ). The anthropometric indices of adolescent members of cassava farm households were obtained for this study. These are stunting and thinness. However, adolescents having HAZ < -2 Standard Deviation (SD) and < -3SD compared to the 2007 WHO reference were classified as stunting and severe stunting while BAZ < -2SD and < -3SD referred to as thinness and severe thinness respectively (de Onis et al., 2007; Bhargava et al., 2020). The anthropometric analysis for 160 sampled adolescents of cassava farm households was analyzed using the WHO AnthroPlus software (WHO, 2009; Bhargava et al. 2020).

2.2.4. Modelling the drivers of adolescents' dietary diversity and malnutrition

The determinants of dietary diversity (DD) among adolescent members of cassava farm households were analyzed using logit regression model (Otekunrin et al., 2022). The choice of this model was appropriate based on the fact that the regressand (adolescents DDS) is binary in nature and categorized as 1 if an adolescent obtains 4 or more food groups out of 9, and zero otherwise, given as a function of a vector of regressors (explanatory variables) assumed to affect DD of adolescents of cassava farm households. The explanatory variables used in the model are; adolescent age, gender, household head year of schooling, farm size, household size, farm income, non-farm income, food expenditure, household primary occupation, transport cost, access to healthcare, access to electricity, access to toilet, access to nutrition training and crop sold ratio (commercialization levels). Following Gujarati and Porter (2009), Otekunrin et al (2022) the logit regression is expressed as:

$$Logit\ (p) = ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_i X_i + U_i \quad (2)$$

where p denotes the probability of having DD of 4 or more food groups out of 9, the $\beta_i's$ are the parameter estimates of the regressors, the $X_i's$ represent the regressors and $U_i's$ are the random error terms (Gujarati and Porter, 2009; Otekunrin et al., 2022).

Furthermore, the drivers of adolescents' malnutrition (stunting and thinness) of farm households were also analyzed using logit regression model, as expressed in equation (2) above. Here, the dependent variables are the malnutrition status (stunting and thinness) of the adolescent members of the farm households were presented in separate regression models. In each case (dummy variable), one (1) is for malnourished adolescent and zero (0) otherwise (i.e. stunted =1, 0 otherwise; thinness = 1, 0 otherwise) expressed as a function of a vector of explanatory variables assumed to affect the malnutrition of adolescent members of cassava farm households. This indicated that in each case, the parameter estimate shows the likelihood that an adolescent will be malnourished. Here, the positive sign on the parameters reveals increased level of malnutrition while negative sign indicates low level of malnutrition (Babatunde et al., 2011).

The regressors included in the model are; adolescent age, household head gender, household head year of schooling, farm size, household size, farm income, non-farm income, food expenditure, distance to market, transport cost, access to healthcare, access to electricity, access to toilet, access to piped water, access to nutrition training and crop sold ratio.

$$Logit\ (p) = ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_i Zi + U_i \quad (3)$$

The $Z_i's$, as the only parameter that is different from equation (2) represents the regressors in the model (Gujarati and Porter, 2009; Otekunrin et al. 2022).

Ethical approval and consent to participate:

The Department of Agricultural Economics and Farm Management Review Board of Federal University of Agriculture, Abeokuta (FUNAAB), Nigeria approved this study. In addition, Oyo State Ethics Review Committee of the Ministry of Health also approved this study (Ref No: AD13/479/4420[A]). However, informed consent was received from the respondents before data collection while respondents' data are completely anonymized.

3. Results and Discussion

3.1. Socioeconomic description of adolescents' farm households

The results of the socioeconomic description of adolescents' farm households of this study is revealed in Table I. The results indicated that, from the 160 adolescents of farm households, 53% were male while 47% were female. The mean age of the adolescents was 13.6 y old. However, 63% of the household heads were men while the rest were women. The mean household farm size was about 7 persons while household head year of schooling was 7. More so, Table I also showed that mean household farm size was 1.46 hectare, while farrm income and non-farm income wee at ₦122, 281 (388 US $) and ₦71, 500 (221 US $) respectively. The mean household food expenditure (monthly) was ₦25, 006 (77 US $). The mean household head (HH) farm expeience was 14 years while mean household head cassava farming experience was about 11 y. The mean household transport cost, distance to market and crop share ratio was ₦3, 673 (11 US $), 9.3 hectare and 0.62 respectively. The adolescents' mean DDS was 4.7 while mean HAZ and BAZ was -2.6 and -0.88 respectively.

<Table 1>

Furthermore, the results of the food groups consumed by adolescent members of cassava farm households in the previous 24-h recall period indicated that 100% of the adolescents consumed starchy staples (i.e. rice, "eba", "amala", yam etc) in the two states while about 30% and 65% consumed green leafy vegetables in Ogun and Oyo states respectively. However, the results also indicated that 60% of the adolescents consumed legumes, nuts and seeds in the two states. More so, it is interesting to note that only 9.3% and 16.2% of the adolescents consumed eggs in previous 24-h in Ogun and Oyo states respectively. Only 3.1% adolescents in the two states (Ogun, 1.2%; Oyo, 5.4%) consumed milk and milk products while no adolescents consumed organ meat in the two states in 24-h recall period. However, 47% and 10.8% of the adolescents did not meet the minimum 4 food groups in Ogun and Oyo states respectively. The adolescents have DDS mean score of 4.5 and 4.85 in Ogun and Oyo states respectively.

3.2. The cassava commercialization levels

The commercialization levels of households in the study areas indicated the extent of their cassava commercialization. The commercialization level is calculated using the CCI of each cassava farm

household (equation 1). The results revealed that 9.2% and 16.1% of cassava farm households are non-participants in the sales of cassava roots in the market (zero level) in Ogun and Oyo states respectively. About fifty percent of the households had above 75% CCI in Ogun while 33.7% were in Oyo state. However, about 40% of the households were categorized as very-high commercialization households (CCI 4).

3.3. Exploring adolescents' DDS across farm households' CCI levels

This section explores the adolescents' DDS in all the four CCI levels (CCI 1-4) of farm households. However, results in Table 2 indicated that less than twenty-five percent (21.1%) of the adolescents of zero level (CCI 1) households in the two states (Ogun, 28.6%; Oyo, 16.7%) did not meet the minimum 4 food groups out of 9 within 24-h recall period. Also, in Ogun state, the results revealed that farm households in higher CCI levels (CCI 3-4) recorded higher percent of adolescents consuming less than minimum DDS of 4 food groups, with medium-high level farm households (CCI 3) recording more than fifty percent (53.7%) while very-high level (CCI 4) recorded 43.2% of the adolescents failing to meet up with the minimum DDS in 24-h recall period. Contrariwise, Oyo state recorded less than fifteen percent (CCI 3 = 11.5%; CCI 4 = 8.0%) of the adolescent members of farm households consuming less than 4 food groups in the previous 24-h. However, the scatter plot showing the association between adolescents DDS and CCI revealed the existence of very weak negative relationship between the two variables with Correlation Coefficient (r) = -0.03. Similarly, in Table 2, the relationships between adolescents' DDS and farm households' CCI in the two states are not statistically significant (Ogun, $p = 0.45$; Oyo, $p = 0.91$).

<Table II>

3.4. Nutritional status of adolescent members of farm households

The results of the study in Table 3 presents the nutrition outcomes of adolescent members of smallholder farm households in the study areas. The results revealed that 85 were boys while 75 were girls. Also, among the adolescent boys, fifty-four (54) were in the age-group 10-14 y old while thirty-one (31) were in the age bracket 15-19 y old. There were forty-nine (49) adolescent girls in the age-group 10-14 y old while twenty-six (26) fall within 15-19 y old age bracket. The results also showed the mean and standard deviation of adolescents' HAZ and BAZ as -2.58 ± 1.3 and -0.88 ± 1.9 respectively. The results further revealed that 74% of the boys were found to be stunted (having HAZ < -2SD) while about 44% of them were severely stunted (having HAZ < -3SD). Interestingly, stunting prevalence in adolescent girls are lower when compared to that of boys. About 57% and 39% of girls were found to be stunted in 10-14 and 15-19 y of age respectively. However, thinness (BAZ < -2SD) among adolescent boys (10-19 y old) of cassava farm households was found to be 21.1% while 9.4% of them were severely thin (BAZ < -3SD). The prevalence of thinness is lower in adolescent girls with 9.3% thinness and 1.3% severe thinness. However, Figure 1-2 (A and B) revealed the nutrition outcomes (HAZ and BAZ) curves of adolescents of all cassava farm households and gender distribution (boys and girls) in rural Ogun and Oyo states compaed to the WHO reference. The results revealed a conspicuous shift of the curves to the left (negatively skewed distribution).

<Table III>

<Figure I>

<Figure II>

3.5. The Prevalence of adolescents' undernutrition across farm households' CCI levels

This section invesigated the link between cassava commercialization and nutrition outcomes (HAZ and BAZ) of adolescent members of the farm households. It further revealed the relationship between cassava commercialization and nutrition indices of adolescent members. Anthropometric indices were used to measure adolescents' nutritional status (stunting and thinness). The results in Table 4 indicated that all (4) cassava farm households' CCI levels (CCI 1-4) recorded very high stunting prevalence of about 60% while low level households (CCI 2) recorded the highest percent (83.3%) of stunting in the study areas. Furthemore, among total sampled adolescents, 63% (101 adolescents) were found to be stunted. Futhermore, thinness is lower when compared to that of stunting among adolescents in the study areas. The prevalence of thinness was was found to be about 16% and 17% of the adolescents belonging to zero (CCI 1) and low level (CCI 2) households in the study areas. However, medium-high level (CCI 3) households recorded the highest adolescent thinness percent (20.9%) while the lowest percent thinness (9.7%) in adolescents was found in the very-high level (CCI 4) households.

However, in Table 4, the relationships between cassava commercialization and nutrition indices of adolescent members of farm households (stunting and thinness) are not statistically significant (stunting prevalence: $\chi^2 = 3.67$, p-value = 0.30; thinnnes prevalence: $\chi^2 = 3.09$, p-value = 0.38). Furthermore, the scatter plots showing the relationships between adolescents' nutrition outcomes (HAZ and BAZ) and CCI revealed the existence of weak negative relationship between HAZ and CCI (Correlation Coefficient (r) = -0.26) while there existed a very weak positive relationship between BAZ and CCI (Correlation Coefficient (r) = <0.01).

<Table IV>

3.6. Determinants of adolescents' dietary diversity and malnutrition

This section presents the results of logit regression of drivers of adolescents dietary diversity and nutritional status (stunting and thinness) of farm households (Table 5 & 6). As specified above, logit regressions were used to regress dietary , stunting, and thinness against some sets of household and adolescent-centred variables (as regressors). The regressand (dependent variable) in each case is a dummy, 1 if adolescent meet the minmum 4 food groups and 0 otherwise; 1 if adolescent is malnourished and 0 otherwise (i.e. stunted = 1, 0 otherwise; and thinness = 1, 0 otherwise). The resulting parameter estimates from the logit regressions indicate the likelihood of the adolescents meeting the recommeded DDS and the probability of the adolescents being malnourished.

The results in Table 5 revealed the factors influencing adolescents' dietary diversity of cassava farm households. The results revealed that household size ($p< 0.03$) is negatively related to the probability of meeting the recommeded DDS while household head year of schooling ($p< 0.01$) is positively related to the likelihood of meeting the recommended adolescedents DDS in the study areas. However, household toilet ($p< 0.03$) and nurition training access ($p< 0.01$ negatively influenced the dietary diversity of the adolescents. It is noteworthy that commercialization level of farm households (crop sold ratio) was not

significant (p< 0.42) in the model but was positively related to the dietary diversity of adolescent members of cassava farm households.

From Table 6, the first part of the results (stunting) showed some of the significant drivers of stunting among adolescent members of cassava farm households such as household size (p< 0.01), farm income (p< 0.01) and nonfarm income (p< 0.02) positively influenced the incidence of stunting while age of adolescent (p< 0.01), food expenditure (p< 0.01), access to electricity (p< 0.01), access to piped water (p< 0.01), and commercialisation level (p< 0.01) negatively influenced stunting of adolescents in the study areas. However, the second part of the results (thinness) in Table 6 revealed some of the significant determinants of thinness among adolescents of cassava farm households which include; adolescent gender (p< 0.02), household head year of schooling (p< 0.08), and commercialization level (p< 0.01) positively affect adolescent thinness while access to nutrition training negatively influenced adolescent thinness in the study areas.

<Table V>

<Table VI>

3.2. Discussion

The dietary diversity of adolescent members of farm households in the study areas revealed a 100% consumption of starchy staples in the two states. This indicated the 100% inclusion of carbohydrate-dense food in the diet of all the adolescents in the last 24-h recall period. This result was similar to the study among school-aged children (6-11 years old) in Port Harcourt metropolis, Nigeria (Uzosike et al., 2020). Previous studies have also revealed that starchy foods top most of the diets in Nigeria and in most low-and middle-income countries (Garnett, 2016; Ochieng et al., 2017; Willet et al., 2019; Uzosike et al., 2020; Otekunrin et al., 2021; Otekunrin, 2022). The DDS of the adolescents in the two states further showed that eggs and milk/milk products were consumed by only 12% (20/160) and 3.1% (5/160) respectively while no adolescents consumed organ meat in the last 24-h recall period. This result was contrary to the study of Uzosike et al (2020) who reported that 11.7% (99/847) of school-aged children (6-11 y old) in Port Harcourt metropolis consumed organ meat in the last 24-h recall period.

More so, the low proportion of the adolescents consuming dark green leafy vegetables (Ogun, 30.2%) and eggs (Ogun, 9.3%; Oyo, 16.2%) is a source of concern because of the importance of such food groups in the diets of children and adolescents in the households. However, this kind of dietary pattern among adolescent members of the farm households may be a reflection of the one that existed among children and their mothers. Few empirical studies reported similar dietary patterns among children, adolescents and women of child bearing age in Nigeria and other parts of the world with most of the foods consumed being carbohydrate-dense (Ochieng et al., 2017; Nithya and Bhavani, 2018; Keats et al., 2018; Rammohan et al., 2018; Otekunrin, 2022; Otekunrin et al., 2022).

Assessing the dietary diversity of the adolescents across farm households' CCI levels (Table 2) in rural Ogun and Oyo states, 53.7% of adolescents in medium-high level households (CCI 3) in Ogun did not meet the minmum DDS while about 43% (consuming < 4 food groups) were found in very-high level (CCI 4) households in Ogun state. This may be associated with the fact that rural farm households in Ogun states that are members of highly commercialized cassava households (CCI 3-4) had more of their adolescents consuming low DDS (< 4 food groups) which may be as a result of household heads' decision to plough back most of the income received from sales of their produce (cassava roots) to the cassava

farming enterprise and do not prioritize the consumption of high-quality diets in the households which may result in low-quality diets and high prevalence of malnutrition among household members especially women and children (Otekunrin, 2022; Otekunrin et al., 2022). This results was corroborated by previous studies that reported overdependence of young children and women on starchy staples and other carbohydrate-dense foods especially in low-and middle-income countries (Savy et al., 2005; Keding et al., 2012; Herrador et al,. 2015; Ochieng et al., 2017; Otekunrin et al., 2022).

Furthermore, findings from the scatter plot between adolescents DDS and CCI indicated the existence of very weak negative association (r = -0.03) between adolescents DDS and CCI and showing that as CCI increases, adolescents DDS may go down. This corroborates the results of adolescents DDS in Ogun states (Table 2) where highly commercialized households (CCI 3-4) recorded high percent of adolescents (CCI 3 = 53.7%; CCI 4 = 43.2%) consuming less than 4 food groups and affirming that belonging to highly commercialized households (CCI 3-4) does not guarantee high-quality diets among adolescent members of cassava farm households. Similarly, the relationships between adolescents' DDS and farm households' CCI in the two states (Table 2) are not statistically significant (Ogun, p = 0.45; Oyo, p = 0.91) indicating that belonging to either low or high-level CCI may not translate to adolescent members' consumption of diverse diets in the two states (Ogun and Oyo). This result was similar to that of under-five children dietary diversity score (CDDS) and CCI levels of farm households in Nigeria (Otekunrin et al., 2022).

However, this study also showed higher level of undernutrition among adolescents (10-19 y old) of farm households in the study areas. The prevalence of stunting among adolescents (boys and girls) was 63.1%. The results of the nutritional status of adolescents indicated that more adolescent boys are stunted and severely stunted than their female counterparts (Table 3). About 74% boys were stunted while adolescent girls recorded 50.7% stunting prevalence. This finding was contrary to the study conducted in Ethiopia which reported seemingly high stunting prevalence (23.8%) among girls than adolescent boys (21.9%) (Jikamo and Samuel, 2019). The adolescents' stunting prevalence in this study is higher than other studies reported in Northern and Northwest Ethiopia among adolescent students with 37.7% and 20.5% stunting prevalence among boys and 21.2% and 26.8% stunting among adolescent girls respectively (Melaku et al., 2015; Kebede et al., 2021). Other studies with lower (medium level; <20%) stunting prevalence include; Dabone et al (2013), Gebreyohannes (2014) and Woday et al (2017). This results was higher than the study in Ethiopia with stunting of 28.5% and severe stunting of 8.1% (Melaku et al., 2015).

More so, in this study, the prevalence of thinness was 15.6% while prevalence of thinness among adolescent boys (21.2%) was significantly higher than that of girls (9.3%). In contrary, Melaku et al (2015) reported that prevalence of thinness among girls was higher than that of adolescent boys. This results was lower than other studies in Ethiopia (26.1%) (Melaku et al., 2015), Seychelles (27.7%) (Bovet et al. 2011), and Bangladesh (32%) (Alam et al., 2010).

Furthermore, among all adolescents in the study areas, the results revealed that about 63% were stunted (alarming level) while about 16% experienced thinness. It is quite alarming that in all the four CCI levels of the cassava farm households, the lowest stunting percent among adolescent members was 59.7% while the highest percent (73.7%) of stunting was recorded among the zero level (CCI 1) farm households. This indicated that stunting is of grave concern among adolescent members of farm households in the study areas. With Nigeria ranked among the top 5 countries with highest population of adolescents in the world (UNICEF, 2021), high prevalence of undernutrition will portend great challenge to healthy living of adolescent population.

However, the scatter plot revealing the relationship between HAZ and CCI showed the existence of a negative association between adolescents HAZ and CCI (r = -0.26) indicating that as CCI increases, adolescents' height-for-age z-score (HAZ) may go down.

The result in Table 4 gave more insights to this finding by indicating that, being a member of higher CCI households (CCI 3-4) may not translate to better nutrition for the adolescents and other members of the farm households in the study areas. This result is different from that of the findings by Carletto et al (2017) who found no clear trends between CCI and HAZ even though with under-five children data from three African countries.

The logit regression results of the drivers of adolescents' DD (Table 5) indicated that household head year of schooling was positive and significantly affect the DD of the adolescents while household size, household primary occupation, access to toilet, and access to nutrition training was negative and significantly influence adolescents' dietary diversity. The marginal effect coefficient of household year of schooling indicated that a unit increase in year of schooling of household head is expected to lead to 0.01 rise in the likelihood of adolescent meeting up with the minimum recommended DDS. This implies that as the household head become more educated, the diets of the adolescent members and other members may become more diverse, all other factors held constant. Previous studies results from Tanzania posited that education of household heads may have positive influence on household dietary quality (Ochieng et al., 2017; Rajendran et al., 2017). More so, the household size is significant at 5% level. A unit rise in household size will reduce the probability of the adolescents meeting up with the recommended DDS by 1.5%. This result is quite in line with *a priori* expectation that farm households with larger family size may find it difficult to consume diverse diets (especially young children) because household members will have to manage the available food and this may be connected to the fact that larger percent of rural smallholder farm households are prone to increased levels of food insecurity (Ayinde et al., 2020; Otekunrin et al., 2021; Otekunrin, 2022).

However, access to improved toilet negatively influenced adolescents' dietary diversity in the study areas. A unit increase in access to improved toilet facilities reduces the likelihood of adolescent members meeting the recommended DDS by 0.08. This finding is contrary to *a priori* expectation in that more access to toilet facilities is expected to improve the nutrition and healthy living of the adolescents and other household members. This may be connected to the fact that most farm households in the study areas did not have access to improved toilet and thereby defecate in the nearby bush, revealing that most households live in an unhygienic environment. This result was corroborated by the report of Nigeria Demographic and Household Survey 2018 which stated that 59.9% rural households in Nigeria did not have access to improved toilet facilities (NPC and ICF, 2019; Otekunrin et al., 2021; Otekunrin et al., 2022; Otekunrin, 2022). Also, household access to nutrition training negatively influenced adolescents' dietary diversity. The marginal effect coefficient indicated that a unit increase in access to household nutrition training is expected to result in 16% decrease in the likelihood of adolescent member of the household meeting the recommended DDS in 24-h recall period. This may be connected to low level of nutrition knowledge occasioned by large percent of households with no formal education in the study areas. This is contrary to previous findings that access to nutrition education enhanced households' high-quality diets (Pillai et al., 2016; Ochieng et al., 2017; Rajendran et al., 2017).

More so, the results indicated crop sold ratio did not significantly influence adolescent DD in the study areas. This revealed that CCI 1-4 of farm households may not necessarily influence diet quality of the adolescents and other members of the farm households. This showed that belonging to higher CCI

households does not translate to high-quality diets for the adolescents and other members of the households. This may be connected to the fact that household heads may decide to plough back most of their income received from sales of their produce (cassava roots) to the cassava farming enterprise and did not prioritize the consumption of high-quality diets in the households (Otekunrin, 2022; Otekunrin et al., 2022).

Furthermore, the logit regression results of the drivers of adolescents' nutritional status (stunting = HAZ < -2SD; thinness = BAZ < -2SD) as shown in Table 6 revealed that adolescent age, gender, household size, household farm income, non-farm income, food expenditure, access to electricity, access to piped water, and commercialization level (crop sold ratio) significantly influenced adolescents' nutritional status of farm households in the study areas. However, a unit increase in age is expected to reduce the likelihood of the adolescent being stunted by 81%. This implies that older adolescents are less likely to be stunted. However, a unit increase in household size of farm household will make the probability of stunted adolescent go up by 9.3%. This implies that as cassava farm household member increases, stunting prevalence among adolescent members increases. Due to the prevalence of food insecurity marked with lack of access to nutritious food (food deprivation) among rural smallholder farm households, increase in household member may increase the prevalence of malnutrition (stunting) among adolescents and other young children in the households (Otekunrin et al., 2021; Otekunrin, 2022). Further, considering adolescent gender, a unit increase in adolescent boy is expected to increase the likelihood of thinness by 11.8% when other factors are held constant. This result corroborated the findings in Table 4 where thinness in adolescent boys was found to be higher (21.2%) than that of adolescent girls (9.3%) of cassava farming households. Other studies also reported higher prevalence of thinness in adolescent boys than that of girls (Gebreyohannes et al., 2014; Melaku et al., 2015; Kebede et al., 2021).

Moreover, a unit rise in cassava household's farm income and non-farm income increases the probability of stunted adolescents. This may be due to the fact that most of the income generated from the farm business was ploughed back to the farm business with little consideration for the provision and consumption of nutritious and high-quality diets for household members (especially young children and adolescents). This result is contrary to the previous study that reported that increased household income is more likely to result in higher purchasing power for high-quality food for the adolescents (Darmon and Drewnowski, 2008; Kebede et al., 2021). From the results of the analysis in Table 7, a unit increase in household food expenditure reduces the likelihood of stunted adolescents among cassava farm households by <0.01. This indicated that as household's expenditure on food go up, more food items will likely be available in the households leading to lower level of undernutrition (especially stunting) among adolescents and other members of the household. Access to rural infrastructure (piped water and electricity among others) are crucial to the well-being of rural households. However, a unit increase in access to both electricity and piped water reduces the likelihood of having stunted adolescents belonging to cassava farming households by 28.1% and 29.6% respectively. The results amplified the importance of rural electrification and access to improved drinking water facilities which have capacity of reducing the prevalence of undernutrition among young children, adolescents, and other members of the farm households (Omotayo et al., 2021; Adeyonu et al., 2022).

The marginal effects of commercialisation level (crop sold ratio) revealed that a unit increase in commercialisation level reduces the likelihood of stunted adolescents by 70.5%. This revealed that higher cassava commercialisation level households (CCI 3-4) may likely achieve a reduction in stunting prevalence among adolescent members of farm households. This result is corroborated by the assessment

of undernutrition (stunting) of adolescent members across CCI levels (Table 5). Here, stunting among adolescents was higher in both zero level (73.7%) and low level (83.3%) households when compared with that of highly commercialized households (medium-high level, 59.7%; very-high level, 59.7%). Although, all the four commercializattion levels (CCI 1-4) recorded very high percent (60-83%) of stunting among adolescent members of households in the study areas.

Conclusion and Recommendations

Previous empirical works have analyzed the prevalence and determinants of adolescents' dietary diversity and some on adolescents' malnutrition but, studies on the links between commercialization levels and adolescents' dietary diversity, and malnutrition among farming households are scarce especially in Nigeria. This study showed that the dietary pattern of the adolescent members in the study areas (especially in Ogun state) was rather monotonous with 100% consumption of starchy staples while food groups such as organ meat, milk/milk products and eggs were consumed by 0%, 5% and 20% adolescents within 24-h recall period respectively. About 47% of the adolescents in Ogun state achieved less diverse diets (< 4 food groups) by failing to meet up with the minimum dietary diversity. This study found very weak negative relationship between adolescents' DDS and CCI, indicating that belonging to higher CCI households may not guarantee access to diverse diets (especially in Ogun state).

However, more adolescent boys were found to be stunted and thin when compared to the adolescent girls while very high (≥ 60%) adolescent stunting prevalence was recorded in all the four CCI levels' households in the study areas. In addition, there existed a negative association between HAZ and CCI indicating that as CCI increases, adolescents' height-for-age (HAZ) may go down. However, belonging to a higher commercialization level households (CCI 3-4) may not necessarily translate to lower prevalence of adolescent stunting as indicated in Figure 5 where CCI 3&4 recorded about 60% stunting prevalence in the study areas. Cassava farm household heads should not be concerned about increasing the extent of cassava commercialization alone but should make concerted effort in prioritizing the provision and consumption of high-quality diets among household members which can enhance diverse dietary pattern and help in reducing undernutrition (stunting and thinness) especially among young children and adolescent members of farm households in the study areas.

This study stressed the need to support nutrition-sensitive intervention programs to provide nutrition knowledge/information on preparation and consumption of nutrient-dense diets that will improve the nutritional status of household members. Also, stakeholders should facilitate the provision of rural infrastructure development such as the provision of piped water, rural electrification and functional healthcare facilities that will enhance agricultural productivity and improve healthy living of the farm households.

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Table I Desciption of farm household and adolescent-centred factors

Variables	Description	Mean ± SD
Age	Adolescent's age (years)	13.6 ± 2.7
Household size	Persons living in the household	6.6 ± 2.5
Gender	Gender of the adolescent	0.47 ± 0.50
HH gender	Head of household gender	0.37 ± 0.48
HH education	Household head year of schooling	6.6 ± 3.5
F Size	Household cassava farmland size (ha)	1.5 ± 1.0
FarmInc	Household farm income (naira)	₦122,281 ± ₦82,102
Non-farmInc	Household non-farm income (naira)	₦71,500 ± ₦28,708
FarmExp	Household head farming experience (year)	14.4 ± 9.5
cassfarmExp	Household head cassava farming experience	10.5 ± 8.6
Food Expenditure	Household food expenditure (naira)	₦25,006 ± ₦8,820
DistMarket	Distance to market (Km)	9.3 ± 3.6
Transport cost	Monthly Transport cost (naira)	₦3,673 ± ₦1,720
CropShare	CCI level	0.62 ± 0.28
Adolescent Ht	Adolescent height (Metre)	1.4 ± 0.13
Adoelscent Wt	Adolescent weight (Kg)	33.4 ± 9.1
Adolescent DDS	DDS of adolescents (0-9)	4.7 ± 1.0
Adolescent HAZ	Height-for-age-z-score	-2.6 ± 1.3
Adolescent BAZ	Body mass index z-score	-0.88 ± 1.2

Source: underlying survey data 2020. SD means Standard Deviation

Table II. Exploring adolescents DDS across cassava farm households' CCI levels

CCI Levels	Adolescent DDS (10-19 y old)	State	
		Ogun (n=86)	Oyo (n=74)
		n (%)	n (%)
Zero Level (CCI 1)	Food groups <4	2 (28.6)	2 (16.7)
	Food groups ≥4	5 (71.4)	10 (83.3)
	Total	7 (100)	12 (100)
Low Level (CCI 2)	Food groups <4	-	1 (9.1)
	Food groups ≥4	1 (100)	10 (90.9)
	Total	1 (100)	11 (100)
Medium-high Level (CCI 3)	Food groups <4	22 (53.7)	3 (11.5)
	Food groups ≥4	19 (46.3)	23 (88.5)
	Total	41 (100)	26 (100)
Very-High Level (CCI 4)	Food groups <4	16 (43.2)	2 (8.0)
	Food groups ≥4	21 (56.8)	23 (92.0)
	Total	37 (100)	25 (100)
Total	Food groups <4	40 (46.5)	8 (10.8)
	Food groups ≥4	46 (53.5)	66 (89.2)
	Total	86 (100)	74 (100)
	Fisher's exact, p-value	-, 0.45	-, 0.91

Source: underlying survey data 2020.

This shows the number (frequency) and percent of adolescents DDS food groups in all the four CCI levels of farm households in rural Ogun and Oyo states of Nigeria. This equally explored both of the adolescents that met and those that failed to meet the recommmended food groups.

Table III. Nutrition outcomes of adolescent members of farm households

Age Group (year)		Height-for-age z-score (HAZ) (%)			BMI-for-age z-score (BAZ) (%)		
Boys (n=85)	**n**	**% <-3SD**	**% <-2SD**	**Mean ± SD**	**% <-3SD**	**% <-2SD**	**Mean ± SD**
10-14	54	42.6	70.4	-2.8 ± 1.2	9.3	18.5	-0.79 ± 1.4
15-19	31	45.2	80.6	-2.8 ± 0.88	9.7	25.8	-1.4 ± 1.1
10-19	85	43.5	74.1	-2.8 ± 1.1	9.4	21.2	-1.0 ± 1.3
Girls (n=75)							
10-14	49	34.7	57.1	-2.5 ± 1.4	0	4.1	-0.64 ± 0.91
15-19	26	30.8	38.5	-2.1 ± 1.4	3.8	19.2	-0.91 ± 1.1
10-19	75	33.3	50.7	-2.4 ± 1.4	1.3	9.3	-0.73 ± 0.98
Pooled (n=160)							
10-14	103	38.8	64.1	-2.7 ± 1.3	4.9	11.7	-0.72 ± 1.2
15-19	57	38.6	61.4	-2.5 ± 1.2	7	22.8	-1.2 ± 1.1
10-19	160	38.8	63.1	-2.6 ± 1.3	5.6	15.6	-0.88 ± 1.2

Source: underlying survey data 2020.

Note: Stunting and severe stunting is HAZ < -2SD; < -3SD respectively

Thinness and severe thinness is BAZ < -2SD; < -3SD respectively; SD means Standard Deviation. This Table revealed the nutrition outcomes (HAZ and BAZ) of the adolescents members (10-19 years old) of the cassava farm households in Ogun and Oyo states of Nigeria.

Table IV. Adolescents' nuritional status over farm households' CCI levels

	Zero Level (No Seller)	Low Level	Medium-High Level	Very High Level	Chi-square, p-value
Nutritional Status	**n (%)**	**n (%)**	**n (%)**	**n (%)**	
Stunted < - 2 SD	14 (73.7)	10 (83.3)	40 (59.7)	37 (59.7)	$\chi^2 = 3.67$,
Not stunted > -2 SD	5 (26.3)	2 (16.7)	27 (40.3)	25 (40.3)	p-value = 0.30
Total	19 (100)	12 (100)	67 (100)	62 (100)	
BAZ (Thinness) < - 2 SD	3 (15.8)	2 (16.7)	14 (20.9)	6 (9.7)	$\chi^2 = 3.09$,
BAZ (Not Thin) > -2 SD	16 (84.2)	10 (83.3)	53 (79.1)	56 (90.3)	p-value = 0.38
Total	19 (100)	12 (100)	67 (100)	62 (100)	

Source: underlying survey data 2020.

Note: Stunting is HAZ < -2SD; Thinness is BAZ < -2SD. This table indicated adolescents' nutritional status across the four commercialization levels (Zero level – very-high levels). It showed the number (frequency) of adolescents experiencing malnutrion and those not suffering from it across the CCI levels of cassava farm households in the study areas

Table V. Determinants of adolescents' dietary diversity

Variables	β ± RSE	ME (P-values)
Adolescent Age (years)	0.03 ± 0.10	<0.01 (0.79)
+Adolescent Gender	-0.50 ± 0.62	-0.02 (0.42)
Household Size (Number)	-0.51* ± 0.24	-0.02 (0.03)
Farm Size (Ha)	0.43 ± 0.94	0.01 (0.65)
HH year of schooling	0.33* ± 0.11	0.01 (<0.01)
Farm Income (Naira)	0.00 ± 0.00	<0.01 (0.89)
Nonfarm Income (Naira)	-0.00 ± 0.00	-<0.01 (0.47)
Food Expenditure (Naira)	0.00 ± 0.00	<0.01 (0.42)
+HH Primary Occupation	-3.6* ± 1.3	-0.06 (0.01)
Transport cost (Naira)	0.00 ± 0.00	<0.01 (0.30)
+Healthcare access	-1.0 ± 1.2	-0.03 (0.39)
+ Electricity access	-0.55 ± 0.93	-0.02 (0.56)
+Toilet access	-1.9* ± 0.84	-0.08 (0.03)
+Access to Nutrition Training	-2.5* ± 0.90	-0.16 (0.01)
Crop sold ratio	2.3 ± 2.8	0.07 (0.42)
Constant	6.0* ± 2.5	(0.02)

(+) represent dummy variable (0 or 1). *Significance at p<0.05 levels.
ME means Marginal Effects, RSE means Robust Standard Error
Number of observation = 160
Wald $chi^2(15)$ = 34.1
Prob > chi^2 = 0.00
Log pseudo likelihood = -33.4
Pseudo R^2 = 0.41

Note: Marginal effects measures the association between a change in the predictor and a change in the outcome. It is an effect, not a prediction. It is a change and not a level. It is the percentage change on the probability associated with a unit change in the independent variable. They tell the effect on the probability of not attainig the recommended dietary diversity score.

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Table VI. Determinants of adolescents' malnutrition

	Nutrition outcomes			
	Stunting (1)		Thinness (2)	
Variables	**β ± SE**	**ME (p-values)**	**β ± RSE**	**ME (p-values)**
Age (years)	-5.6* ± 1.4	-0.81 (<0.01)	-0.12 ± 0.11	-0.01 (0.26)
Age squared (years)	0.20* ± 0.05	0.03 (<0.01)	-	-
+Gender	-0.21± 0.60	-0.03 (0.73)	1.2* ± 0.54	0.12 (0.02)
+Household Head gender	-1.3* ± 0.73	-0.17 (0.08)	1.3* ± 0.70	0.12 (0.06)
Household Size (n)	0.64*± 0.19	-0.09 (<0.01)	-0.10 ± 0.12	-0.09 (0.42)
Farm Size (Ha)	-0.48 ± 0.60	-0.07 (0.43)	-0.35 ± 0.68	-0.03 (0.61)
HH year of schooling	0.02 ± 0.10	<0.01 (0.84)	0.12* ± 0.07	0.01 (0.08)

Farm Income (Naira)	<0.01* ± <0.01	<0.01 (0.01)	-<0.01 ± <0.01	-<0.01 (0.83)
Nonfarm Income (Naira)	<0.01* ± <0.01	0.09 (0.02)	<0.01 ± <0.01	<0.01 (0.11)
Food expenditure (Naira)	<0.01* ± <0.01	<0.01 (<0.01)	<0.01 ± <0.01	<0.01 (0.87)
Distance to market (Km)	-	-	-0.04 ± 0.08	-<0.01 (0.60)
Transport cost (Naira)	<0.01 ± <0.01	<0.01 (0.66)	-	-
+Access to Nutrition Training	0.48 ± 0.66	0.08 (0.47)	-1.2* ± 0.68	-0.14 (0.09)
+Access to Electricity	-1.9* ± 0.76	-0.28 (0.01)	-0.44 ± 0.67	-0.04 (0.51)
+Access to Piped water	-3.3* ± 1.11	-0.30 (0.00)	0.57 ± 0.83	0.05 (0.50)
+Access to Healthcare	0.55 ± 0.65	0.08 (0.39)	-0.13 ± 0.68	-0.01 (0.84)
+Access to Toilet	-	-	-1.05 ± 0.75	-0.11 (0.16)
Crop sold ratio	-4.9* ± 1.4	-0.71 (<0.01)	3.0* ± 1.2	0.29 (0.01)
Constant	38.6* ± 9.4	(<0.01)	1.2 ± 2.0	(0.56)
Number of observations	160		160	
Wald chi^2 (16)	34.9		27.1	
Prob > chi^2	0.00		0.04	
Log pseudo likelihood	-46.9		-58.1	
Pseudo R^2	0.56		0.16	

(+) represent dummy variable (0 or 1). *Significance at p<0.05 level. SE means Standard Error; RSE means Robust Standard Error. ME means Marginal Effects

The p-values are in parenthesis on Marginal Effects and p-values column.

Note: Marginal effects measures the association between a change in the predictors and a change in the outcome. It is an effect, not a prediction. It is a change and not a level. They tell the effect on the probability of being malnourished (stunting and thinnes) in a specific group for change in the regressors. It is the percentage change on the probability associated with a unit change in the independent variable.

Fig. 1A

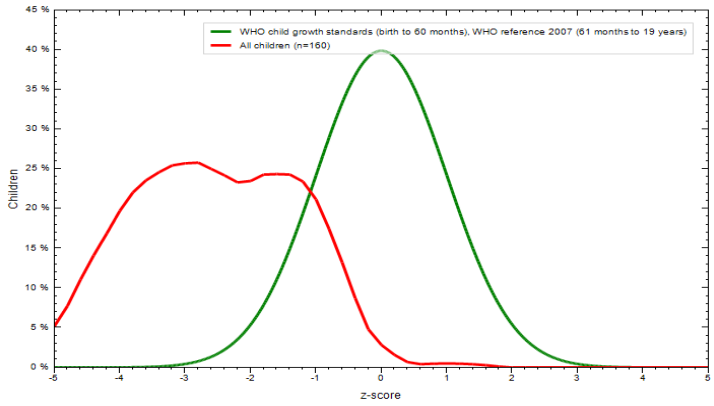

Fig. 1B

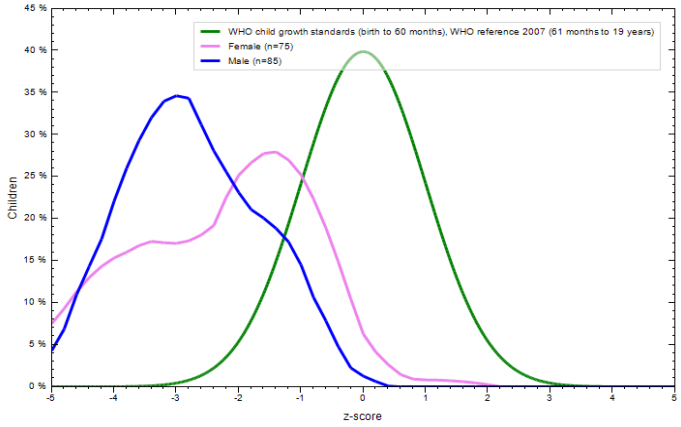

Figure I. A. Height for-age- z-score of all cassava farm households' adolescents (10-19 y) in rural Ogun and Oyo States. B. Height for-age- z-score of gender (boys and girls) of cassava farm households' adolescents (10-19 y old) in rural Ogun and Oyo States.
Note: The red line is the all children (n =160), blue line is the male (n = 85), pink line is the female (n = 75) while the red line is the WHO 2007 child growth standards.
Height for-age- z-score are compared with the WHO 2007 child growth reference population

Fig. IIA

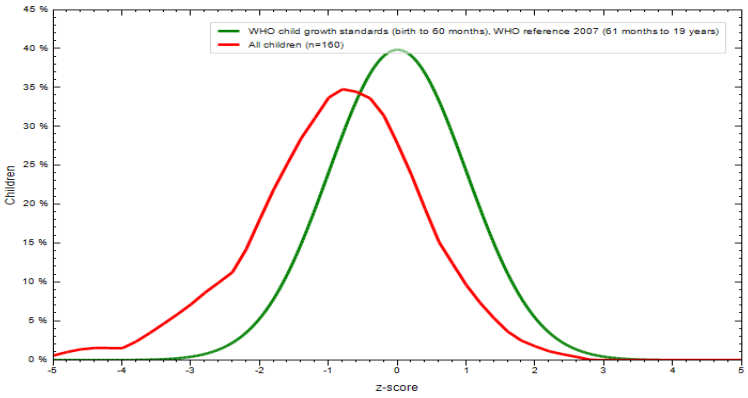

Fig. IIB

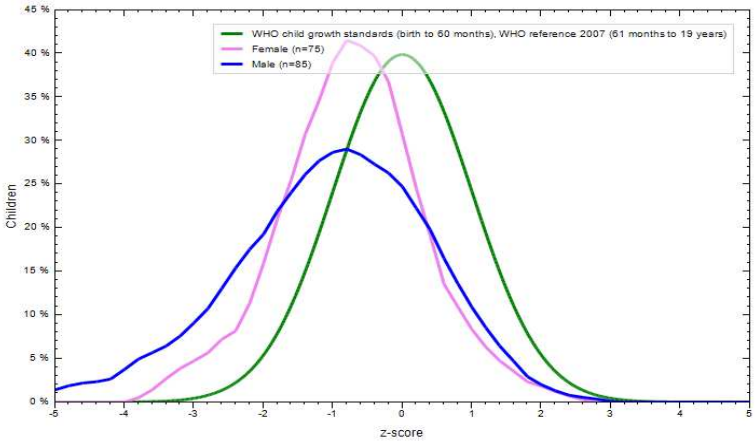

Figure II. A. BMI-for-age z-score of all cassava farm households' adolescents (10-19 y) in rural Ogun and Oyo States. B. BMI-for-age z-score of gender (boys and girls) of cassava farm households' adolescents (10-19 y old) in rural Ogun and Oyo States.
Note: The red line is the all children (n =160), blue line is the male (n = 85), pink line is the female (n = 75) while the red line is the WHO 2007 child growth standards.
BMI-for-age z-score are compared with the WHO 2007 child growth reference population.