

**Adoption of Bio-fortified Pro-Vitamin-A Cassava and Health Outcome of Farming
Households in Abia and Anambra States Nigeria**

<https://dx.doi.org/10.4314/jae.v24i2.9>

Onyeneke, Robert Ugochukwu

Department of Agriculture
Faculty of Agriculture
Alex Ekwueme Federal University Ndufu-Alike, Ebonyi State, Nigeria
E-mail: robertonyeneke@yahoo.com, Phone: +2348037902744

Emenekwe, Chukwuemeka Chinonso

Department of Economics and Development Studies
Faculty of Management and Social Sciences
Alex Ekwueme Federal University Ndufu-Alike, Ebonyi State, Nigeria
E-mail: emenekwe.c@gmail.com, Phone: +2348143003703

Munonye, Jane Onuabuchi

Department of Agriculture
Faculty of Agriculture
Alex Ekwueme Federal University Ndufu-Alike, Ebonyi State, Nigeria
E-mail: munojane@gmail.com, Phone: +2349090979007

Olaolu, Michael Olatunji

Department of Agriculture
Faculty of Agriculture
Alex Ekwueme Federal University Ndufu-Alike, Ebonyi State, Nigeria
E-mail: michealolaolu@yahoo.com, Phone: +2348065489702

Izuogu, Chibuzo Uzoma

Department of Agriculture
Faculty of Agriculture
Alex Ekwueme Federal University Ndufu-Alike, Ebonyi State, Nigeria
E-mail: chibuzoizuogu@gmail.com, Phone: +2348066903334

Ibrahim-Olesin, Sikiru

Department of Agriculture
Faculty of Agriculture
Alex Ekwueme Federal University Ndufu-Alike, Ebonyi State, Nigeria
E-mail: sikiruib@gmail.com, Phone: +2348135788167

Amadi, Mark Umunna

Department of Agriculture
Faculty of Agriculture
Alex Ekwueme Federal University Ndufu-Alike, Ebonyi State, Nigeria

E-mail: mikkmore@yahoo.com, Phone: +2348069021950

Njoku, Chukwudi Loveday

Department of Agriculture

Faculty of Agriculture

Alex Ekwueme Federal University Ndufu-Alike, Ebonyi State, Nigeria

E-mail: chukzy4now1980@gmail.com, Phone: +2347064749413

Obi, Joy Nneamaka

Department of Agriculture

Faculty of Agriculture

Alex Ekwueme Federal University Ndufu-Alike, Ebonyi State, Nigeria

E-mail: inamaka1@yahoo.com, Phone: +2348038970898

Abstract

This study examined the relationship between the adoption of bio-fortified pro-vitamin-A cassava varieties and farming households' health outcomes using cross sectional data obtained from 318 cassava farmers in southeast Nigeria. The data was analysed using binary logistic regression, propensity score matching of treatment effects and percentages. The study found that number of children under five, household size, education of head of household, extension service, ownership of television, radio, mobile phone and tricycle, membership of cooperative societies, and access to credit were the significant predictors of adoption of pro-vitamin-A bio-fortified cassava varieties in the States. The study also found that the main constraints militating against adoption of pro-vitamin-A bio-fortified cassava include decaying of roots immediately after maturation, high cost of cassava stem, and high moisture content. The estimate of the effect of the adoption of bio-fortified pro-vitamin-A cassava varieties on incidence of vitamin-A deficiency related diseases was significant with an average treatment effect on the adopters of -0.463. The adoption of bio-fortified pro-vitamin-A cassava varieties has substantial effect on the reduction of vitamin-A deficiency related health outcomes. There is need for wider awareness and dissemination of the varieties among cassava farmers, while interventions should target the promotion of both production and consumption of such cassava varieties.

Key words: adoption of bio-fortified cassava varieties; vitamin A deficiency related diseases

Introduction

Bio-fortification is an innovative process of enhancing the micronutrient composition of food crops (Olatade et al., 2016; Saltzman et al., 2016). Since local staple foods dominate the food consumption of the rural poor, bio-fortification of such local staples serves as an effective micronutrient deficiencies reduction strategy (Glopan, 2015; Rao & Annadana, 2017). Nigeria currently has a high Vitamin-A deficiency (VAD) problem; over 20% of pregnant women and children under five years are reportedly vitamin-A deficient (Aghaji et al., 2019; Ayinde & Adewumi, 2016). Furthermore, Nigeria has a high incidence of impaired vision such as night blindness and

xerophthalmia linked to vitamin-A deficiency (Ayinde & Adewumi, 2016; Aghaji et al., 2019). Poor diet is an important cause of vitamin-A deficiency in Nigeria, where rural dwellers consume mostly local staple food crops with relatively low micronutrients. Cassava is a major staple in Africa and specifically in Nigeria. Cassava production in Africa is the largest in the world, representing about 54% of global cassava production, while based on country production; Nigeria is the largest cassava producer (Wossen et al., 2017).

Cassava thrives in all agro-ecological zones in Nigeria; however, it thrives best in the rainforest agro-ecological zone, where the southeast Nigeria is located. Significant proportion of vulnerable groups such as rural women of child-bearing age and children whose diets consist mostly of cassava (and cassava by-products) are potentially at risk of vitamin-A deficiency, leading to efforts being intensified to develop and distribute vitamin-A-enriched cassava varieties across Nigeria through a process known as bio-fortification (De Moura et al., 2015). Vitamin-A enriched bio-fortified cassava varieties were introduced in Nigeria in two waves. The first wave in 2011 had 50% pro-vitamin-A target level, while the second wave in 2014 increased to 70% pro-vitamin-A target level (Oparinde et al., 2016). Currently, several varieties of bio-fortified pro-vitamin-A cassava varieties exist in Nigeria. These include UMUCASS (36, 37, 38, 42, and 43 varieties), NR 0220, TMS 1371, TMS 0593, and TMS 0539 (Ayinde, 2016; Eyinla et al., 2019). Bio-fortification can reduce the prevalence of Vitamin-A deficiency, given prominent role of cassava in the diets of rural households in Nigeria (Oparinde et al., 2016; Garg et al., 2018).

Despite this, adoption and consumption of bio-fortified pro-vitamin-A cassava varieties remains low in Nigeria (Ayinde, 2017). More so, factors driving the adoption of this improved variety of cassava remain under-researched in southeast Nigeria, which is a major cassava producing region in the country. Furthermore, previous studies on cassava bio-fortification in Nigeria have focused on various aspects such as the physicochemical properties and sensory attributes of bio-fortified cassava varieties (Alake et al., 2016; Edoh et al., 2016), consumer acceptance and demand for bio-fortified cassava varieties (Oparinde et al., 2016; Birol et al., 2015), adoption pattern and risks associated with bio-fortified pro-vitamin-A cassava adoption (Olatade et al., 2016; Ayinde, 2016), expected economic benefits and probable impact of bio-fortified cassava on household expenditure and income (Ayinde & Adewumi, 2016). Incidentally, there is a dearth of research on the impact bio-fortified pro-vitamin-A cassava varieties on health outcomes in southeast Nigeria.

The purpose of this study was to analyse the impacts of bio-fortified pro-vitamin-A cassava adoption on the welfare, health and nutrition outcomes of farming households in southeast Nigeria. Specifically, this study:

- i. examine the determinants of adoption of bio-fortified pro-vitamin-A cassava varieties;
- ii. determined the effect of adoption of bio-fortified pro-vitamin-A cassava varieties on the health outcome of households;

- iii. ascertained factors that limit to the adoption of bio-fortified pro-vitamin-A cassava varieties.

Methodology

The study was conducted in Abia and Anambra States. These States are in the southeast geopolitical zone of Nigeria. Anambra State lies between latitudes 5° 40' 00" N and 6° 50' 00" N and longitudes 6° 40' 00" E and 7° 20' 00" E (Ndukwe et al., 2019) while Abia State lies between latitudes 4° 40' and 6° 14' N, and longitudes 7° 10' and 8° E (Apeh et al., 2017). This paper used a multistage sampling procedure to select respondents. Two states (Anambra and Abia) were purposively selected for this study. The choice of these states was informed by the presence of the National Root Crops Research Institute (NRCRI) in the areas. The headquarters is located in Abia State while its sub-station is in Anambra State. The dissemination of bio-fortified pro-vitamin-A cassava varieties is higher in these states than any other states in the area. Local government areas (LGAs) with more concentration of cassava farmers were obtained from officials of the Agricultural Development Programmes in each state. Abia State has 17 LGAs while Anambra has 21 LGAs. Proportionate sampling procedure was adopted in selecting LGAs. Four LGAs were selected from Abia while five LGAs were selected from Anambra; then four town communities were randomly selected from each LGA. In each town community, ten cassava farming households were selected. The final sample consisted of 360 cassava farming households. However, 318 households completed and returned their questionnaire.

Data were obtained, using a structured questionnaire from the cassava farming households (including adopters and non-adopters of biofortified pro-vitamin-A cassava varieties), which included socio-economic characteristics such as age, sex, ownership of phone, radio, television, educational level, household size, membership to cooperative society, farm size, access to credit, contact with extension, occupation, farming experience, marital status, etc. Also, the questionnaire sought data on the welfare status of the farmers (value of cassava output, and income), quantity and cost of pesticides used in cassava cultivation, costs and revenue of cassava production, Incidence of vitamin-A deficiency associated disease was used as the health outcome.

Binary logit regression was used to analyse the determinants of adoption of pro-vitamin-A bio-fortified cassava, the effect of adoption of pro-vitamin-A bio-fortified cassava on incidence of vitamin A deficiency related diseases was analysed using the Propensity Score Matching of the treatment effects while constraints to adoption of bio-fortified pro-vitamin-A cassava were analysed using percentages. The binary logit regression model is as follows:

$$Y = f(X_1, X_2, X_3, \dots, X_{21})$$

(1)

$$Y = \text{logit}(p) = \ln\left(\frac{p}{1-p}\right) = f(X_1, X_2, X_3, \dots, X_{21})$$

(2)

Where:

p = proportion of adopters

1 – p = proportion of non-adopters

Y = Adoption (1 = adopter; 0 = non-adopter)

- X_1 = Sex (dummy variable, 1 = male; 0 = female)
 X_2 = Number of children under five (count)
 X_3 = Household size (number of persons)
 X_4 = Educational level of head of household (years)
 X_5 = Educational level of spouse (years)
 X_6 = Cassava farming experience (years)
 X_7 = Age of household head (years)
 X_8 = Age of spouse (years)
 X_9 = Contact with extension agent (1 = yes; 0 = no)
 X_{10} = Actual number of extension visits (number/year)
 X_{11} = Ownership of television (1 = yes; 0 = no)
 X_{12} = Ownership of radio (1 = yes; 0 = no)
 X_{13} = Ownership of mobile phone (1 = yes; 0 = no)
 X_{14} = Ownership of car (1 = yes; 0 = no)
 X_{15} = Ownership of motorcycle (1 = yes; 0 = no)
 X_{16} = Ownership of tricycle (1 = yes; 0 = no)
 X_{17} = Ownership of bicycle (1 = yes; 0 = no)
 X_{18} = Household head is a member of cooperative society (1 = yes; 0 = no)
 X_{19} = Spouse is a member of cooperative society (1 = yes; 0 = no)
 X_{20} = Farm size (Ha)
 X_{21} = Access to credit (1 = yes; 0 = no).

The treatment effect model used in this study was the propensity score matching. The matching method employed was the Nearest Neighbor Matching (NNM). The model specification is as follows:

$$ATE = \frac{1}{n} \sum_{i=1}^n (Y_i^1 - Y_i^0) \quad (3)$$

$$ATT = \frac{1}{n_1} \sum_{i \in Z_1} (Y_i^1 - Y_i^0) \quad (4)$$

Where:

ATE = Average treatment effect

ATT = Average treatment effect on the treated

Y_i^1 = Outcome (in this case number of self-reported vitamin-A deficiency associated diseases) of the treated group (adopters)

Y_i^0 = Outcome (in this case number of self-reported vitamin-A deficiency associated diseases) of the untreated group (non-adopters)

n_1 = number of adopters

n = sample size (adopters plus non-adopters)

$i \in Z_1$ = exposed to treatment condition

Results and Discussion

Determinants of Adoption of Bio-fortified Pro-Vitamin-A cassava

The binary logistic model was estimated using the maximum likelihood method. The Chi-Square (χ^2) test indicated that the likelihood ratio statistics was significant ($P \leq 0.05$), indicating a strong explanatory power for the model. The results are shown in

Table 1. Household head's membership of cooperative society, access to credit, contacts with extension service agents, ownership of radio, ownership of television, ownership phone and education of household heads were significant and positive determinants of adoption of bio-fortified pro-vitamin-A cassava varieties. Also, the results showed the significantly negative determinants for bio-fortified pro-vitamin-A cassava adoption to be the number of under-five, household size and ownership of bicycle.

Table 1 also shows the marginal effects of the determinants of adoption of bio-fortified pro-vitamin-A cassava varieties analysed using binary logit regression. The coefficient of children under-five, ownership of tricycle, and household size are significant and negatively related to adoption of bio-fortified pro-vitamin-A cassava varieties.

Head of household membership of cooperative increased the likelihood of adoption of the pro-vitamin-A cassava varieties. This could be linked to the cost of the new technology and the advantage of pooling resources for the smallholder farmers through cooperatives actions. This implies that involvement in cooperative organization may expose them to some information and financial assistance that can aid their farm activities and help in adoption of new practices. This finding is similar to the works of Olatade et al. (2016) and Odoemelam and Anyim (2019), that being members of cooperative society is a determinant of adoption of bio-fortified pro-vitamin-A cassava varieties.

Similarly, the coefficients of ownership of television and radio, household head's member of cooperative society, and access to credit are positive and significant, indicating that households that own communication equipment such television and radio are 46% and 36% more likely to adopt the bio-fortified pro-vitamin-A cassava, respectively. With membership of cooperative societies and access to credit, households are 99% and 47% more likely to adopt bio-fortified pro-vitamin-A cassava, respectively. Ownership of tricycle is negatively related to adoption, which means that increase in farmers' ownership of tricycle decreased the likelihood to adopting bio-fortified pro-vitamin-A cassava varieties. This is because many owners of tricycle use it for commercial purposes in towns and cities, and they have little or no use to cassava farming activities except in cases where they need to transport their farm produce.

The marginal effects analysis shows that household size and the number of children under five decreased the likelihood to adopt biofortified pro-vitamin-A cassava varieties. Large households are characteristic of families of married people with children and individuals who may be of help in terms of providing more labour hands. Also Olaosebikan et al. (2019) argue that hired labour is the major sourced labour for bio-fortified cassava varieties production. Furthermore, household members under the age of five are prone to early mortality consequent to vitamin-A deficiency, but there are other effects of the deficiency of vitamin-A, which are not limited to the members of households under the age of five. This suggests that an increase in household size will not increase in adoption of bio-fortified pro-vitamin-A cassava varieties because;

adoption of these varieties of cassava goes beyond poverty reduction, but for health and other extraneous reasons.

Ownership of television and ownership of radio are positive determinants of adoption of bio-fortified pro-vitamin-A cassava varieties. This is *a priori* expected given the importance of multimedia broadcasting channels in creating awareness and quickly getting information to large number of people. This means that as farmers are exposed to these media devices, they obtain more information about bio-fortified pro-vitamin-A cassava varieties, which in turn increases adoption of the cassava varieties. This is similar to Ayinde (2017), who asserts that exposure to media by farmers increases their tendency to adopt improved varieties of cassava. Awareness creation is very crucial and is the first of the stages of adoption of an innovation. These multimedia means are commonly used in recent times for this purpose.

Access to credit is a significant and positive determinant of adoption of bio-fortified pro-vitamin-A cassava varieties. This is expected, given the high cost of the new technology and the enormous role credit/finance plays in the provision of input resources for the production process. This positive determinant implies that increased access to credit facility will increase the adoption of bio-fortified pro-vitamin-A cassava varieties. The credit may otherwise be specific for the new innovation planting materials, and the positive sign on credit access is supported by literature (Mondo et al., 2019).

The education of head of household is a significant factor affecting adoption of bio-fortified pro-vitamin-A cassava varieties. Higher educational attainment of the household head increases the tendency to adopt these cassava varieties. This is in conformity with Mittal and Mehar (2016), who asserted that education influences the behaviour of farmers to adopt innovation. Education is a key to the reception of new ideas. This increase adoption could be as a result of the better understanding and appreciation of benefits of innovations and increased accessibility to information that will enable adoption. Education is a mind-opening and information driven activity which exposes recipients to lots of new ideas. This is otherwise an avenue for awareness creation and information sharing which also stimulates interest in new knowledge. These are major aspects in diffusion and adoption processes. Moreover, the head of household is the main decision-maker for the household.

Contact with extension service agents was a significant and positive determinant of adoption of bio-fortified pro-vitamin-A cassava varieties. The more visits farmers have with extension service agents, the more they get to know of new innovation and help on their farm activities. This sounds reasonable, and it corresponds to the findings of many works (Olatade et al., 2016; Ayinde, 2017; Ojeleye, 2018; Odoemelam & Anyim, 2019). This is true because the research institutes where these varieties of bio-fortified pro-vitamin-A cassava are developed make use of agricultural extension agents to disseminate the innovation to farmers as well as carry out enlightenment exercises that will enhance adoption and maximum benefiting of the cassava.

Table 1: Determinants of adoption of bio-fortified pro-vitamin-A cassava

Variable	Marginal effect	Standard error	z-value
Sex of household head	-0.369	0.207	-1.77
Number of children under five	-0.162	0.071	-2.28*
Household size	-0.192	0.065	-2.98*
Education of head of household	0.069	0.030	2.31*
Education of spouse	-0.021	0.014	-1.58
Cassava farming experience	-0.011	0.010	-1.11
Age of household head	-0.026	0.015	-1.76
Age of spouse	0.015	0.010	1.44
Contact with extension agent	0.843	0.013	6.46*
Number of extension visits per annum	0.035	0.020	1.75
Ownership of television	0.460	0.169	2.72*
Ownership of radio	0.357	0.125	2.86*
Ownership of mobile phone	0.146	0.066	2.22*
Ownership of car	-0.132	0.159	-0.83
Ownership of motorcycle	0.357	0.269	1.33
Ownership of tricycle	-0.345	0.126	-2.74*
Ownership of bicycle	-0.236	0.210	-1.13
Household head is a member of cooperative society	0.993	0.010	97.65*
Spouse is a member of cooperative society	0.224	0.125	1.79
Farm size	0.227	0.136	1.67
Access to credit	0.473	0.127	3.73*
Likelihood Ratio chi ²	326.86***		

Note. * significant at 5% level

Effect of Adoption of Bio-fortified Pro-Vitamin-A Cassava Varieties on Vitamin-A Deficiency Related Diseases

The effect of bio-fortified cassava adoption on incidence of vitamin-A deficiency related diseases (VAD) is estimated using propensity score and the results are shown in Table 2. The average treatment effect is significantly negative (-0.466, at the 5% level), while the average treatment effect on the treated (adoption) is also significantly negative (-0.463, at the 5% level). These results indicate that adoption of bio-fortified pro-vitamin-A cassava is associated with a reduction in the reported cases of vitamin A deficiency associated diseases. The average treatment effects show that bio-fortified pro-vitamin-A cassava adoption positively affects the health of the adopters in terms of prevalence of vitamin-A deficiency related diseases. Thus, pro-vitamin-A cassava adoption boosts health outcomes. Similarly, Saltzman et al. (2016) note that positive health and nutrition impacts are major gains and objectives from bio-fortification research and dissemination in nations.

Table 2: Estimates of the effect of adoption of bio-fortified cassava varieties on incidence of vitamin-A deficiency related diseases

Outcome	Unit	Average Treatment Effect	Average Treatment Effect on the Treated
Self-reported cases of VAD	Count	-0.466 (-6.12)*	-0.463 (-3.72)*

*P ≤ 0.05

Factors Limiting Adoption of Bio-fortified Pro-Vitamin-A Cassava Varieties

The constraints to bio-fortified pro-vitamin-A cassava adoption are shown in Table 3. The three most reported constraining factors are as follows: 60.23% of the households report that the quick onset of root decay upon maturation of the fortified cassava variety is responsible for their non-adoption of bio-fortified pro-vitamin-A cassava varieties, 59.75% report that the high cost of cassava stems is responsible for their non-adoption of bio-fortified pro-vitamin-A cassava varieties, and 58.18% report that the high moisture content is responsible for their non-adoption of the improved cassava varieties. The three least reported factors constraining household adoption of bio-fortified pro-vitamin-A cassava varieties are poor extension supervision (reported by 25.76%), scarcity (reported by 16.04%), and difficulty in crop sprouting (8.49%).

Table 3: Constraints to adoption of bio-fortified pro-vitamin-A cassava

Constraint	Percentage
Root start decaying immediately after maturation	60.38
High cost of cassava stem	59.75
High moisture content	57.55
Requires more input for cultivation than other cassava varieties	44.03
Poor soil fertility	44.03
Poor yield	30.82
Poor extension supervision	25.79
Varieties not readily available	16.04
Difficulty in sprouting	8.49

This is however due to the perishable nature of the bio-fortified pro-vitamin-A cassava varieties.

This is similar to the finding of Olatade et al. (2016), that such unforeseen circumstance is the severest of the constraints facing the adoption of these bio-fortified cassava varieties in Oyo state. This is followed by high cost of cassava stems and this confirms the finding of Uwandu et al. (2019) who found that high cost of pro-vitamin-A cassava stem is the second most serious constraint, and in addition, Olaosebikan et al. (2019), also considered high cost of inputs as a production constraint. Furthermore, high moisture content was the third among the constraints, and this accounts for its perishable nature. It is however a technical problem that has to do with the genetic composition and it is an undesirable trait among other

undesirable traits known with the bio-fortified pro-vitamin-A cassava varieties as asserted by Onyeneke et al. (2019). The cassava varieties require more inputs for cultivation than other cassava varieties, this according to Onyeneke et al. (2019) implies that these hybrid cassava varieties have low multiplication ratio and requires improved farming practices which might not be known or practiced by many small holder cassava farmers. Poor soil fertility result is similar to Olaosebikan et al. (2019). This means that the condition of the soil is not fertile enough for the optimal growth of bio-fortified pro-vitamin-A cassava varieties among the constraints. Other constraints which are considered less severe are poor yield, which implies that that it does not produce more tubers; poor extension supervision, which shows lack of expected extension support and visits; varieties not readily available, and this makes the stems needed for planting very hard to get by the farmers. This finding is however supported by that of Olatade et al. (2016). The least severe of the constraints is difficulty in sprouting.

Conclusion and Recommendations

The adoption of bio-fortified pro-vitamin-A cassava varieties was a function of number of children under five, household size, education of head of household, extension service, ownership of television, radio, mobile phone and tricycle, membership of cooperative societies, and access to credit. The adoption, in turn, reduces the rate of incidence of vitamin-A deficiency related diseases. The adoption of the bio-fortified pro-vitamin-A cassava varieties has led to reduction of vitamin-A deficiency related diseases. The main constraints hindering adoption of pro-vitamin-A bio-fortified cassava include decaying of roots immediately after maturation and this is followed by high cost of cassava stem, and high moisture content. There is need for wider awareness and dissemination of the varieties among cassava farmers, while interventions should target the promotion of both production and consumption of such cassava varieties. Also, the breeders should further improve the cassava varieties by enhancing its ability to store the roots in the soil even after maturation to reduce farmers' losses. Furthermore, the farmers should be involved in collaborative efforts like cooperative societies; have access to information and communication devices and credit facilities to accommodate the extra input requirements for new innovations. Furthermore, there is need to hire more extension agents to reduce the extension-farmer ratio, and this will improve farmers' contact with extension agents to properly manage the technicalities of new technology.

References

- Aghaji, A. E., Duke, R. & Aghaji, U. C. W. (2019). Inequitable coverage of vitamin A supplementation in Nigeria and implications for childhood blindness. *BMC Public Health*, 19, 282
- Alake, O. O., Babajide, J. M., Adebowale, A. A., & Adebisi, M. A. (2016). Evaluation of physico-chemical properties and sensory attributes of cassava enriched custard powder. *Cogent Food & Agriculture*, 2(1), 1246116.
- Apeh, M., Chigbu, N. & Chigbu, A. (2017). *Vectorisation and database creation of Abia State*

Polytechnic Aba, Nigeria with geographic information system (GIS). Sofia, Bulgaria: FIG Working Week Proceedings

- Ayinde, O. E. (2016). *Risk analysis in innovation system: a case study of production of Vitamin A cassava variety among farmers in Nigeria*. Addis Ababa, Ethiopia: 5th International Conference of the African Association of Agricultural Economists.
- Ayinde, O. E. (2017). Determinants of adoption of vitamin A bio-fortified cassava variety among farmers in Oyo State, Nigeria. *Croatian Journal of Food Science and Technology*, 9(1), 74–79.
- Ayinde, O. E., & Adewumi, M. (2016). *Risk and adoption analysis of innovation in cassava production in Oyo State, Nigeria; A case study of vitamin A variety*. Guangxi, China: World Congress on Root and Tuber Crops.
- Birol, E., Meenakshi, J. V., Oparinde, A., Perez, S., & Tomlins, K. (2015). Developing country consumers' acceptance of biofortified foods: a synthesis. *Food Security*, 7(3), 555–568.
- De Moura, F. F., Moursi, M., Lubowa, A., Ha, B., Boy, E., Oguntona, B., ... Maziya-Dixon, B. (2015). Cassava intake and vitamin a status among women and preschool children in Akwa-Ibom, Nigeria. *PloS One*, 10(6), e0129436–e0129436.
- Edoh, N. L., Adiele, J., Ndukwe, I., Ogbokiri, H., Njoku, D. N., & Egesi, C. N. (2016). Evaluation of high beta carotene cassava genotypes at advanced trial in Nigeria. *The Open Conference Proceedings Journal*, 7, 144–148.
- Eyinla, T. E., Maziya-Dixon, B., Alamu, O. E., & Sanusi, R. A. (2019). Retention of pro-vitamin-A content in products from new biofortified cassava varieties. *Foods*, 8(5).
- Garg, M., Sharma, N., Sharma, S., Kapoor, P., Kumar, A., Chunduri, V. & Arora, P. (2018). Biofortified crops generated by breeding, agronomy, and transgenic approaches are improving lives of millions of people around the World. *Frontiers in Nutrition*, 5,12.
- Glopan. (2015). *Biofortification: An agricultural investment for nutrition*. Global Panel on Agriculture and Food Systems for Nutrition Policy Brief No. 1. London, UK:
- Mittal, S., & Mehar, M. (2016). Socio-economic factors affecting adoption of modern information and communication technology by farmers in India: Analysis using multivariate probit model. *The Journal of Agricultural Education and Extension*, 22(2), 199–212.
- Mondo, J. M., Irengbe, A. B., Ayagirwe, R. B. B., Dontsop-Nguezet, P. M., Karume, K., Njukwe, E., ... Mushagalusa, G. N. (2019). Determinants of adoption and farmers' preferences for cassava varieties in Kabare Territory, Eastern Democratic Republic of Congo. *American Journal of Rural Development*, 7(2), 44–52.
- Ndukwe, Y. E., Obiezue, R. N. N., Aguzie, I. O. N., Anunobi, J. T. & Okafor, F. C. (2019). Mapping of urinary schistosomiasis in Anambra State, Nigeria. *Annals of Global Health*, 85(1), 52.
- Odoemelam, L. E., & Anyim, C. O. (2019). *Determinants of adoption of pro-vitamin a cassava*

- (*Manihot esculenta crantz.*) varieties among farmers in Abia State, Nigeria. Abuja, Nigeria: Proceedings of the Annual Conference of the Agricultural Extension Society of Nigeria.
- Ojeleye, O. A. (2018). Socio-Economic determinants of the adoption of TME 419 and UMUCASS 38 improved cassava varieties in Ajaokuta Local Government Area of Kogi State, Nigeria. *Applied Tropical Agriculture*, 23(1), 91–96.
- Olaosebikan, O., Abdulrazaq, B., Owoade, D., Ogunade, A., Aina, O., Ilona, P., ... Parkes, E. (2019). Gender-based constraints affecting biofortified cassava production, processing and marketing among men and women adopters in Oyo and Benue States, Nigeria. *Physiological and Molecular Plant Pathology*, 105, 17–27.
- Olatade, K. O., Olugbire, O. O., Adepoju, A. A., Aremu, F. J., & Oyedele, P. B. (2016). How does farmers' characteristics affect their willingness to adopt agricultural innovation? The case of biofortified cassava in Oyo State, Nigeria. *International Journal of Science and Technology*, 5(2), 59–75.
- Onyeneke, R. U., Amadi, M. U., & Anosike, F. C. (2019). Biofortification in Nigeria: A systematic review. *AIMS Agriculture and Food*, 4(4), 892–906.
- Oparinde, A., Banerji, A., Birol, E., & Ilona, P. (2016). Information and consumer willingness to pay for biofortified yellow cassava: evidence from experimental auctions in Nigeria. *Agricultural Economics*, 47(2), 215–233.
- Rao, C. K. & Annadana, S. (2017). Nutrient Biofortification of Staple Food Crops: Technologies, Products and Prospects. In: Benkeblia, N. (Ed) *Phytonutritional Improvement of Crops*, First Edition. John Wiley & Sons Ltd, New Jersey, United States.
- Saltzman, A., Andersson, M. S., Asare-Marfo, Dorene Lividini, K., De Moura, Fabiana F Moursi, M., Oparinde, A., & Taleon, V. (2016). Biofortification techniques to improve food security. In *Reference Module in Food Science* (pp. 1–9).
- Uwandu, Q. C., Amadi, P. E., & Igwe, C. O. K. (2019). Determinants of degree of adoption of pro-vitamin A cassava varieties among farmers in Delta State, Nigeria. *Discovery*, 55(287), 578–582.
- Wossen, T., Girma, G., Abdoulaye, T., Rabbi, I., Olanrewaju, A., Alene, A., ... Manyong, V. (2017). *The Cassava Monitoring Survey in Nigeria*. Ibadan, Nigeria: International Institute of Tropical Agriculture (IITA).