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ADOPTION OF BIOFORTIFIED CASSAVA AMONG FARMERS IN SOUTH WEST NIGERIA: A BINARY LOGIT ANALYSIS OF THE DETERMINANTS

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Abstract

The adoption of agricultural technologies is a vital strategy in addressing food security and improving households' nutrition. This study examined the determinants of adoption of biofortified cassava among farmers in South West Nigeria using a binary logistic regression model. Primary data through administration of structured interview were obtained from 396 respondents which were selected using a multistage sampling technique. Descriptive analysis of the socio-economic characteristics analysis showed the mean of 46.9 years, 1.8ha, 20.0 years and ₦238,693.18 for age, farm size, years of experience and income of the respondents respectively. Most (68.9%) of the respondents were males, 77.0% were primarily farmers, 90.2% were literate, 87.1% were married, 86.1% had group membership while 89.4% had access to extension services. There were low levels of awareness of the benefits of biofortified cassava and cosmopliteness of the respondents. The Binary logistic regression model result revealed that adoption of biofortified cassava was influenced by increase in awareness, perception, income from cassava, marital status and a decrease in age. It is therefore recommended that increase in awareness, income, and positive perception and younger farmers should be targeted when channeling a course for adoption of a new technology.

Key words: *adoption, determinants, biofortified cassava, binary logistic, regression*

INTRODUCTION

The prevalence of hunger and malnutrition has continued to be a daunting and haunting challenge around the world. About 805 million people of the 7.3 billion people in the world, or one in nine, were suffering from chronic undernourishment, consuming less than the recommended 2,100 calories a day between 2012 and 2014. Also, there are 11 million people undernourished in developed countries and almost all the hungry people, 791 million, live in developing countries, representing 13.5 percent, or one in eight, of the population of developing counties [4]. Specifically, 11.5% of the Nigerian population is undernourished [6]. It is estimated that about two billion people suffer from hidden hunger in which vitamin A is an integral part [7] Available records show that in Nigeria, Vitamin A Deficiency (VAD) afflicts about 30 per cent of children under five years, almost 20 per cent of pregnant women, and 13 per cent of nursing mothers [12] This shows that, Nigeria is not yet successful in combating malnutrition because of the percentage of its populace that is still malnourished. Though, progress has been made to control micronutrient deficiencies through supplementation and food fortification, new approaches are required, especially to reach the rural poor. There is a new public health approach to control vitamin A, iron, and zinc deficiencies of staple food crops in poor countries known as biofortification [8].

Biofortification is the process of breeding food crops that are rich in micronutrients, such as vitamin A, zinc, and iron. It refers to technologies for enhancing, through biological processes such as breeding and transgenic techniques, the micronutrient content of staple foods. Cassava has been chosen for the biofortification programme in

Nigeria because of its easy accessibility to the resource-poor farmers. Nigeria currently produces about 54 million metric tonnes (MT) per annum [5] making her the highest cassava producer in the world. The nutrient content in cassava can be enhanced by developing new varieties through biofortification affirming that scientific evidence shows this is technically feasible without compromising agronomic productivity [15]. The roots of these varieties are coloured yellow due to the presence of high levels of beta-carotene, the precursor for vitamin A. Biofortification is different from ordinary fortification in that it focuses on making plants more nutritious as the plants are growing, rather than adding nutrients to the foods during processing. When eaten, biofortified crops can provide essential micronutrients to improve nutrition and public health. The crops have the capacity of boosting farmers' income and ensuring food security and agriculture transformation in the country [7]. Technological change has been the major driving force for increasing agricultural productivity and promoting agricultural development in many parts of the world. As a result of increased research and improved methods of communication, a great variety of new materials and ideas have been generated and made available to Nigerian farmers and other rural dwellers. Adoption is defined as a decision to continue full use of an innovation while adoption process is a decision making process [3]. Adoption of innovation by the target beneficiaries is very essential to arriving at a target change and ultimate economic development in any economy. In many developing nations, a huge amount have been devoted to extension services in order to educate farmers on new agricultural practices. The efficiency and overall success of whatever innovation that is being introduced depends on a number of factors that influence its adoption. The understanding of these factors is an essential pre-requisite for such an intervention on biofortification of staple food in order to address malnutrition. The adoption of agricultural technologies is a challenging and dynamic issue for farmers, extension agents, researchers, agri-business and policy makers. However, because of variability in natural resources, culture, political system, traditions, beliefs and socio-economic factors, the factors affecting technology adoption differs across locations.

This research focused on examining the factors that influence the adoption of Vitamin A biofortified cassava variety among farmers among farmers in South West, Nigeria.

Specifically, the study described the socio-economic characteristics of the respondents in the study area identified factors that influenced farmers' adoption of biofortified cassava.

MATERIALS AND METHODS

A multi-stage sampling procedure was used for respondents' selection. At first stage, three states namely; Oyo, Lagos and Ogun were purposively selected for the study because of the volume of cassava produced in the states. The states were also among the locations where the biofortified cassava was first introduced and disseminated in the country. The sampling frame used was based on the agrarian zoning system of the Agricultural Development Project (ADP) which is applicable to all the states in the country. Only registered farmers with the Agricultural Development Project (ADP) were included in the sample frame. At the second stage, proportional purposive selection was used. Half of the zones in each state were selected out of the 4, 4 and 3 zones in Oyo, Ogun and Lagos States respectively. The selected halves were the first two ADP zones where the technology were first disseminated in each state. Namely; Ibadan/Ibarapa and Oyo zones in Oyo State, Abeokuta and Ijebu-Ode zones in Ogun States; and Eastern (Imota) and Far Eastern (Epe) zones in Lagos State: The third stage entails a random selection of half of the blocks in each zones to make a total of 18 ½ blocks. This was followed by an independent simple random selection of 25% of the cells in each block to make a total of 33 cells. In the final stage, 12 cassava farmers were selected from each cell. This resulted to a total number of 396 respondents being selected.

Measurement of Variables

Socioeconomic characteristics: Relevant information were solicited on selected socio-economic characteristics of the respondents such as age, primary occupation and monthly income.

Cosmopoliteness: In order to assess the level of exposure, respondents were asked how often they travel outside of their community using a four-point Likert type scale and labelled as Very often – 3, Often – 2, Rarely – 1 and Never – 0.

Awareness level of benefits of biofortified cassava: Respondents' were asked if they were aware of benefits such as presence of vitamin A and reduction in weight. A 3 point Likert type scale was used and labelled as Much Aware- 2, Just Aware – 1 and Never Aware- 0.

Farmers' Perception of Biofortified Cassava: Five - point Likert scale of Strongly Agree, Disagree, Undecided, Agree and Strongly Disagree was used to determine the respondents' perception towards biofortified cassava on a list of 29 statements. The scores of 5, 4, 3, 2 and 1 were assigned for positive statement respectively and reversed as 1, 2, 3, 4 and 5 for negative statements. The values were added together to arrive at a minimum, maximum and pooled mean for cosmopoliteness, awareness and perception.

The dependent variable of the study is farmers' adoption of biofortified cassava. The dependent variable of adoption of vitamin A biofortified cassava (*Yi*), was used as a dummy variable where an adopter of Vitamin A biofortified cassava varieties was scored 1, and non-adopters scored 0. The data analytical tools used in the study comprises of descriptive and inferential statistical tools. The independent variables were analysed using descriptive statistics such as frequency counts, means, range, percentages, standard deviations and charts. The dependent variable was analysed using binary logistic regression model and factor analysis. Binary logistic regression as an approach is similar to multiple linear regression, but takes into account the fact that the dependent variable is categorical and dichotomous. The outcome variable is binary and leads to a model which can predict the probability of an event happening for an individual [17].

The general form of the model to be adopted is expressed as

$$\text{Logit}(P) = \text{Log}\,[P / (1-P)] \quad \ldots\ldots.. \quad (1).$$

The term within the bracket is the odds of an event occurring. In this case it is the odds of a respondent adopting the technology. Using the logit scale changes the scale to plus and minus infinity and also because logit (P) = (0), when P = 0.5. Transformation back from the logit (log odds) scale to the original probability scale, the predicted values will always be at least 0 and at most 1.

$$P_i /(1-P_i) = \exp(\beta_0 + \beta_1 X_1) \quad \ldots\ldots.. \quad (2)$$

$$1- P_i = 1/ (1 + \exp(\beta_0 + \beta_1 X_1)) \quad \ldots\ldots. \quad (3)$$

$$P_i = P_i + f_i = \exp(\beta_0 + \beta_1 X_1) / 1 + \exp(\beta_0 + \beta_1 X_1)) + f_i \ldots\ldots\ldots\ldots \quad (4)$$

The regression process finds the coefficients which minimize the squared differences between the observed and expected values of Y (the residuals). As the outcome of the logistic regression is binary, Y needs to be transformed so that the regression process can be used. The logit transformation gives the following:

$$\text{In}\left(\frac{\rho}{1-\rho}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \ldots\ldots\ldots\ldots.. \beta_n X_n \quad \ldots\ldots \quad (5)$$

where ρ = probability of event occurring, that is a person adopting, and $\frac{\rho}{1-\rho}$ = odds ratio OR

$$\text{In(odds)} = \text{In}\left(\frac{\hat{Y}}{1-\hat{Y}}\right) = a + bX \quad \ldots\ldots.. \quad (6)$$

where $\hat{Y}$ is the predicted probability of the event (adoption), 1- $\hat{Y}$ is the predicted probability of the other decision (non-adoption), and X is the predictor variable.

For the probability of adoption, the logistic regression equation is written as:

$$\rho = \frac{\exp(\beta 0+\beta 1X1+ \beta 2X2+ \beta 3X3+ \beta 4X4+ \beta 5X5+ \beta 6X6+\cdots\ldots\ldots\ldots\ \beta nXn}{1+\exp(\beta 0 + \beta 1X1+ \beta 2X2+ \beta 3X3+ \beta 4X4+ \beta 5X5+ \beta 6X6+\cdots\ldots\ldots\beta 7X7+ \beta 8X8+ \beta 9X9)}\ 0\ \rho < \rho < 1$$

The same model was used by [16] and [1] on a study of determinants of adoption of Vitamin A biofortified cassava. The assumption is that the random variables yi are independently distributed. Equation (1), states that the probability that the ith farmer will adopt a given technology, such as improved cassava varieties *Pi* (*yi* = 1), is a function of the vector of explanatory variables, Xi, and the unknown parameter vector.

The independent variables are explained for the explanatory variables as follows:

X_1 = Age (continuous), X_2 = Sex (Male = 1, female = 0), X_3 = Primary occupation (farming = 1, others = 0), X_4 = Farm size (continuous), X_5 = Level of education (Formal Education = 1, No formal education = 0), X_6 = Membership of organisation (Yes = 1, No = 0), X_7 = Awareness of Vitamin A in biofortified cassava (continuous- awareness summed score), X_8 = Perception on biofortified crops (continuous- perception summed score), X_9 = Extension services access (Yes = 1, No = 0), X_{10} = Level of cosmopoliteness (continuous - cosmopoliteness summed score), X_{11} = Religion (Christianity = 1, others = 0), X_{12} = Religion (Dummy variable: Islam = 1, others = 0), X_{13} = Marital status (Married with spouse = 1, otherwise = 0), X_{14} = Farming experience (continuous), X_{15} = Income (continuous: from cassava), ei = error term, β_0 = Constant/intercept, $\beta_1 \rightarrow \beta_q$ = Coefficient for explanatory variables $X_1 \rightarrow X_q$

RESULTS AND DISCUSSIONS

Socio-economic characteristics

The results of socio-economic characteristics of the respondents is presented in Table 1. The study showed that $\bar{x}$ = 46.9 years and a standard deviation of ±10.5 reveals that the ages of the respondents spread across 36 to 56 years. This implies that most of the respondents were still in their active and productive age. This is in line with [2] who found out that the mean age of cassava farmers was 43 years. The findings showed a minimum of 0.2 hectares of cassava farm and a maximum of 12 hectares, with $\bar{x}$ = 1.8 and a standard deviation of ±1.6.This indicates that they are mostly small scale farmers and there existed a wide gap in the farm size of the farmers. A minimum of two years was recorded for years of experience and $\bar{x}$ = 20 years. That reveals respondents were well grounded in cassava farming. The mean income was ₦238,693.18 with a standard deviation of ±₦225,723.44. This reveals a wide gap in the earnings of the farmers from cassava. This is traceable to the disparity in the farm size of the farmers. In line with [13], the mean annual income from cassava was ₦234,580.67. The cosmopoliteness which reveals the level of exposure from visit to other place outside their places of residence reveals a minimum of one and $\bar{x}$ = 9.8. The findings also reveals that there was a noticeable difference in the awareness level of the respondents about the benefits of biofortified cassava with a minimum of zero, $\bar{x}$ = 6.58 and a standard deviation of ± 4.15. That shows some of the respondents were not aware of the benefits at all.

Table 1. Socio-economic characteristics of respondents

Variable	Minimum	Maximum	Mean	Std deviation
Age (years)	24	75	46.9	±10.5
Farm size (ha)	0.2	12	1.8	±1.6
Years of experience	2	57	20.0	±10.2
Income from cassava (₦)	30,000.00	1,750,000.00	238,693.18	±225,723.44
Cosmopoliteness	1.0	18.0	9.8	±3.4
Awareness	0	12	6.58	±4.15
Perception	46	125	87.75	±18.88
Percentages				
Sex	Male (68.9)		Female (31.1)	
Religion	Christianity (54.3)		Islam (43.9) Traditional (1.8)	
Primary occupation	Farming (77.0)		Others (23.0)	
Marital status	With a spouse (87.1)		Otherwise (12.9)	
Formal Education	Yes (90.2)		No (9.8)	
Group membership	Yes (86.1)		No (13.9)	
Extension services access	Yes (89.4)		No (10.6)	

Source: Field survey, 2018.

The perception of the respondents about biofortified cassava revealed a minimum score of 46 and a maximum of 125 with $\bar{x}$ = 87.75. There were more males than females cassava farmers with a record of 768.9% males and 31.1% females.

The religions practiced were 54.3% Christianity, 43.9% Islam and 1.8% Traditional worship. Most (68.9%) of the respondents has farming as their primary occupation, about 87% were married and with spouse, while 90.2% had formal education which implies a high literacy level in the study area. About 86% of the respondents were members of one group or the other while 89.4% had access to extension services, group membership and extension access are expected to make them better receptive to adoption.

Determinants of Adoption

The null model, which is a model with no explanatory variables includes a constant so that each respondent has the same chance of adoption. The null model, that is, the intercept-only model is In(odds) = β_0 = 0.674, p = 0.00. The predicted odds (Exp(β)) = 1.962. This implies predicted odds of adoption of biofortified cassava is 1.962. The Omnibus tests of model coefficients gives the result of the Likelihood Ratio (LR) test which indicates whether the inclusion of the block of variables contributes significantly to model fit. A p-value of less than 0.005 for block means that the block 1 model is a significant improvement to the block 0 model [10]. In this case, $\chi 2$ is 408.873, df = 16 and p = 0.000, which implies a significant improvement. Percentage of correctness also increased from 62.2% to 96.4%.

The values for the model summary is: -2Log likelihood statistic (also known as deviance) = 87.341. This measures how well the model predicts adoption (how much is left unexplained by the model). The smaller the statistic the better the model. The Cox & Snell R^2 = 0.651 and Nagelkerke R^2 = 0.903. These values implies that between 65.1% and 90.3% of the variation in adoption of biofortified cassava can be explained by the model. The classification table also showed good prediction performance of 96.4% of overall prediction (96.2% of non-adopters and 96.4% of adopters).

The Wald test is similar to the LR test, it is used to test the hypothesis that each β = 0. In the Significant column, the p-values are all above 0.05 except that of age (0.043), awareness (0.000), perception (0.000), marital status (0.048), and income from cassava (0.014). This means that although the following variables were included in the equation: sex (0.724), educational qualification (0.971), farm size (0.151), cosmopoliteness (0.908), Christianity religion (0.466), Islam religion (0.578), primary occupation (0.626), group membership (0.619) and years of experience (0.477), it can be concluded that the additions of these variables to the model was not statistically significant once the other variables were controlled for. That is, the variables do not explain variations in adoption, the relationship between all of them and adoption is not strong enough to elicit influence. This implies that only, age, marital status, income generated from cassava, awareness of the benefits and perception of respondents about the technology were the determinants strong enough to influence the adoption of biofortified cassava. The differences in the influence is presented on the Exp (B) column which represents the odd ratio for the individual variable. For instance, with sex, male was denoted as 1, while female was the reference sex. This means that a male is 1.271 times likely to adopt than a female having allowed for other variables in the equation. The coefficients for the model are contained in the B column. A negative value means that the odds of adoption decreases. The age coefficient is negative but statistically significantly. Exp(B) for age is 0.946, which means for each year difference of reduction in age, the farmer is 0.945 times more likely to adopt the technology having allowed for other variables in the equation in the model. The model also predicts that the odds of adoption are 2.509 higher for those aware of the benefits of the technology than for those who are not. In addition, the odds of adoption for positive perception is 1.234 higher than for those with negative perception. The income coefficient is statistically significant, while Exp(B) for income is 1.00 which means that with each unit increase in income, the farmer is 1.00 times more likely to adopt having allowed for other variables in the model.

Similar empirical studies on adoption found out that gender, marital status and membership of farmers' organisations were the major determinants [14]. It was affirmed that access to extension agents and media were the major determinants of adoption of vitamin A biofortified cassava variety [1]. Furthermore, it was discovered that age, farm size, cosmopoliteness, participations in field day and training, distance from house, contact with extension agents, market distance and income were the major determinants of adoption [11]. While using logit and transformed logit regression, it was revealed that location, knowledge on value addition and nutritional benefits awareness, and availability of vines were the key factors for the adoption of orange flesh sweet potatoes varieties [9].

From Table 2 below, the estimated model is:

$\text{Logit(Adoption)} = -15.416 - 0.055X_{age} + 1.980_{marital\ status} + 0.920_{awareness} + 0.210_{perception} + 0.00_{cassava\ income}$

Table 2. Results of Binary Logistic Regression showing the Determinants of Adoption of Biofortified Cassava

Variables in the equation						
Variable	B	S.E	Wald	Df	Sig.	Exp(β)
Age	-0.055	0.027	4.095	1	0.043*	0.946
Sex	0.240	0.678	0.125	1	0.724	1.271
Formal Education	0.036	1.011	0.001	1	0.971	1.037
Farm size	-0.549	0.382	2.067	1	0.151	0.578
Marital status	1.980	1.000	3.921	1	0.048*	7.244
Cosmopoliteness	-0.012	0.105	0.013	1	0.908	0.988
Awareness	0.920	0.196	22.073	1	0.000*	2.509
Perception	0.210	0.040	27.268	1	0.000*	1.234
Income from cassava	0.000	0.000	5.993	1	0.014*	1.000
Religion (Christianity)	-1.873	2.568	0.532	1	0.466	0.154
Religion (Islam)	-1.440	2.586	0.310	1	0.578	0.237
Primary occupation	-0.375	0.768	0.238	1	0.626	0.688
Group membership	-4.33	0.871	0.247	1	0.619	0.648
Years of experience	0.022	0.031	0.505	1	0.477	1.022
Extension visit	1.158	0.864	1.797	1	0.180	3.184
Constant	-15.416	4.204	13.445	1	0.000	0.000

Source: Data Analysis, 2019.

Number of Observations = 396; LR, $\chi 2$ (16) = 408.873; -2Log likelihood = 87.341; Cox & Snell R^2 = 0.651 and Nagelkerke R^2 = 0.903. *Statistically significant at 5%

CONCLUSIONS

This study examined the determinants of adoption of biofortified cassava using a binary logistic regression model. The study revealed that increase in awareness of the benefits of biofortified cassava, positive perception of the respondents about biofortified cassava, increase in income generated from cassava, marital status with increase in the number of people with spouse together, and a decrease in age were the strong determinants of adoption of biofortified cassava in the study area.

It is therefore recommended that increase in awareness, income, and positive perception and younger farmers should be targeted when channeling a course for adoption of a new technology.

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