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Preferential Adoption of Bio-fortified Pro-vitamin A Yellow cassava varieties as Smart Feeding for Rural Farmers in Southeast Nigeria

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Abstract

This study examined the preferential adoption of bio-fortified pro-vitamin A yellow cassava varieties as smart feeding for rural households. It employed cross-sectional data obtained from 318 farmers in Southeast Nigeria. Data were analysed using percentages, binary logistic regression, Mean, and standard deviation. The study found that the most highly adopted bio-fortified pro-vitamin A cassava varieties were: TMS07/0593 (92.6%), TMS 1371 (80%), and TMS 0539 (77%). The study revealed that access to farmland, farming experience, contact with extension agents, access to vitamin A yellow cassava stems, income from vitamin A yellow cassava, and low carbohydrate content were the significant predictors of adoption of bio-fortified pro-vitamin A yellow cassava varieties in the zone. The result from the study further showed farmers' order of preference for the adoption of bio-fortified pro-vitamin A yellow cassava varieties. The cost-benefit analysis revealed that the cultivation of bio-fortified pro-vitamin A yellow cassava gives a higher profit margin than the cultivation of white cassava. Farmers should be highly involved in farm enhancement collaborations to enhance their access to farm inputs that will boost their production. It is necessary to intensify the production of bio-fortified pro-vitamin A yellow cassava due to its nutritional benefits and higher profitability index.

Keywords: Preferential, Pro-vitamin A cassava; Smart feeding; Rural Farmers

Introduction

Cassava is the most important food consumed in Southeast Nigeria. It is a high-content carbohydrate crop that contributes to the staples of millions of people in Nigeria and the rest of Sub-Saharan Africa. It has been reported that Nigeria is a major contributor to cassava production and the 61st world's largest exporter of cassava (Onyediako & Adiele, 2022). Many cassava varieties are cultivated in

Southeast Nigeria which may be attributed to the presence of the National Root Crops Research Institute in Umuahia Abia State (Onyeneke et al., 2020). Cassava also thrives well in the Southeast, which is part of the rainforest agro-ecological zone of Nigeria. Furthermore, cassava thrives in less fertile soils with less water because of its climate resilience.

In the face of high cassava consumption, the population is characterised by high vitamin A deficiency, due to lack of vitamin A in cassava (Hodge & Taylor, 2023). Over 20% of pregnant women and children are reportedly vitamin A deficient (WHO, 2024). Furthermore, due to the high carbohydrate content (38.06g) and glycemic index (74-94) of cassava (Immanuel et al., 2024; Mazmanyani, 2023), a large proportion of rural households are diabetic patients (Dugani *et al.*, 2021). This higher prevalence of diabetes among people living in the rural areas can be attributed to lower access to health care information because patients travel long distances for medical care (Foss *et al.*, 2023). These disease situations have risen to pandemic level due to poor food combinations (IHME, 2023). This necessitated the need for bio-fortification which is an innovative process of enhancing the micronutrient composition of food crops (Avnee et al., 2023). It is important to adopt smart feeding to ensure continuous monitoring of the feeding process. Smart feeding is the adoption of health friendly feeding behaviour and will help to achieve the United Nations Sustainable Development Goals on nutrition, targeted at terminating all forms of malnutrition by 2025 (Amanze et al., 2023).

Vitamin A-enriched bio-fortified cassava varieties were introduced in Nigeria between 2011 and 2014 by the International Institute of Tropical Agriculture (IITA) Ibadan and the National Root Crops Research Institute (NRCRI) Umudike. Currently, the varieties of bio-fortified pro-vitamin A cassava varieties cultivated in Nigeria are UMUCASS (36, 37, 38, 42, and 43), NR 0220, TMS 0593, and TMS 0539 (Afolami, et al., 2021).

Given the prominent role of cassava in the diets of households in Southeast Nigeria, bio-fortification can reduce both the prevalence of vitamin A deficiency and carbohydrate content in cassava. According to Osunbande et al., (2023), gari from bio-fortified vitamin A yellow cassava has lower carbohydrate content than gari from white cassava (TMS 30572). In addition, Mazmanyani et al., (2023) observed that bio-fortified vitamin A yellow root cassava has higher fibre content and low fat. Most low-carbohydrate crops like beans, oats, wheat, millet and plantain are very expensive. This made bio-fortification a healthier alternative for people living with diabetes and a good supplement to control incidences of river blindness. However, there are gaps on preferential adoption of pro – vitamin A cassava varieties as a low carbohydrate staple food in relation to the usual white cassava varieties. Knowledge on its adoption pattern and feeding benefits will help agricultural innovation policy makers to make informed decisions on the varieties. It is on this premise that the study objectives were to:

- (i) identify the adoption rate of bio-fortified pro - vitamin A cassava varieties
- (ii) ascertain determinants of bio-fortified pro - vitamin A yellow cassava adoption
- (iii) ascertain farmers preferences on adoption of bio-fortified pro- vitamin A yellow cassava
- (iv) determine the profitability of adoption of bio-fortified pro- vitamin A yellow cassava varieties

Methodology

This study was conducted in the Imo and Abia States of Nigeria. Imo State lies within latitude 4°45'N and 7°15'N and longitude 6°50'E and 7°25'E (SEREDEC, 2023). Abia State lies between latitude 4° 40' and 6° 14' N and longitude 7°10' and 8°E (Latlong, 2024). Multi-stage random sampling procedure was used to select respondents. Two states, Imo and Abia States were purposively chosen for the study. The states were chosen due to their proximity to the National Root Crops Research Institute (NRCRI) Umudike and the higher level of awareness of bio-fortified vitamin A yellow root cassava in the states. Abia State has 17 Local Government Areas (LGAs) while Imo has 27 LGAs. Using a proportionate sampling procedure, four LGAs were selected from Abia State and seven LGAs were selected from Imo State. Lists of pro- vitamin A cassava farmers in the selected LGAs were obtained from the Agricultural Development Programme headquarters of each state and this formed the sample frame of 3300 farmers. From the list, 330 farmers were systematically selected based on cultivation of bio-fortified pro-vitamin A cassava varieties and cultivation of white cassava (TMS 30572). This resulted in

the sampling of 330 farmers. However, 12 farmers did not return their questionnaire and this gave rise to a sample size of 318. Data were collected on adopters of bio-fortified pro-vitamin A yellow cassava varieties and adopters of white cassava (TMS 30572) using a structured questionnaire. Data were collected on age, gender, education, household size, access to credit, access to farmland, farming experience, contact with extension agents, access to vitamin A yellow cassava stems, income from pro - vitamin A yellow cassava, and cooperative membership. Also, the questionnaire sought information on the adoption rate of varieties of bio-fortified pro - vitamin A cassava, perceived preferences for adoption of bio-fortified pro- vitamin A cassava varieties, and the profitability status of cultivation of bio-fortified pro - vitamin A yellow cassava.

The adoption rate of bio-fortified pro-vitamin A yellow cassava varieties was analysed using percentages. Binary logit regression was used to analyse determinants of the adoption of bio-fortified vitamin A yellow cassava varieties. Farmers' preferences were measured using Likert scale and analysed using frequency, mean and standard deviation. The Likert scale was a 3-point Likert scale of Yes (2), No (1) and Neutral (0). The discriminating index of 1 was achieved by the sum of 2, 1, 0 divided by 3 = 1.

The binary logit regression model is as follows:

$$Y = f (X_1, X_2, X_3, \dots, X_{12}) \dots \dots \dots (i)$$

$$Y = \text{logit} (P) = f (X_1, X_2, X_3, \dots, X_{12}) \dots \dots \dots (ii)$$

Where

P = proportion of adopters

1 – P = proportion of non-adopters

Y = Adoption

X₁ = Age (years)

X₂ = Gender (dummy 1 = male, 0 = female)

X₃ = Education (years)

X₄ = Household size (number of persons)

X₅ = Access to credit (1 = yes, 0 = No)

X₆ = Access to farmland (1 = yes, 0 = No)

X₇ = Farming experience (years)

X₈ = Contact with extension agents (1 = yes, 0 = No)

X₉ = Access to vitamin A stems (1 = yes, 0 = No)

X₁₀ = Income from vitamin A cassava (naira)

X₁₁ = low carbohydrate content (1 = yes, 0 = No)

X₁₂ = Cooperative membership (1 = yes, 0 = No)

The profitability of the adoption of vitamin A yellow cassava varieties was analyzed using Net profit margin =

$$\frac{\text{Net income}}{\text{Revenue}} \times \frac{100}{1}$$

Net income = Revenue – Expenses

Results and Discussion

The adoption rate of bio-fortified pro-vitamin A cassava varieties is shown in Table 1. The three most adopted were TMS 07/0593 (92.6% of the respondents), TMS 1371 (80%) and TMS 0539 (76.8%). The high adoption of TMS 07/0593 varieties can be attributed to the yellow branding of the cassava roots. This assertion is supported by Osunbade *et al.*, (2023), who posited that the colour of the roots and its products are liked by consumers. The last three adopted cassava varieties were: UMUCASS 42, NR 0220, and UMUCASS 37. The differential adoption rates of the varieties of bio-fortified pro-vitamin A yellow cassava may have been caused by the high cost of the cassava stems. This keeps them out of reach of low-capital farmers. This is in agreement with the report by Chidiebere-mark & Anyanwu (2020) that the high cost of cassava stem is a serious constraint affecting its adoption.

Table 1: Adoption rate of bio-fortified pro-vitamin A cassava varieties

Varieties	Adoption %
UMUCASS 36	33.3
UMUCASS 37	25.0
UMUCASS 38	35.0
UMUCASS 42	20.0
UMUCASS 43	35.6
NR 0220	22.5
TMS 1371	80.0
TMS 07/0593	92.6
TMS 0539	76.8

Source: Field survey, 2023 *Multiple responses

Results in Table 2 show the determinants of adoption of bio-fortified pro-vitamin A yellow cassava varieties. Binary logistic model was used to examine the determinants of the adoption of bio-fortified pro-vitamin A cassava varieties. The binary logistic model was estimated using the maximum likelihood method. The Chi-square (X^2) test indicated that the likelihood ratio statistics was significant ($p < 0.01, 0.05, 0.10$) indicating a strong explanatory power of the model. The marginal effects were computed to determine the unit change that might contribute to the adoption of bio-fortified pro-vitamin A cassava varieties. Examining the determinants of adoption of bio-fortified pro-vitamin A cassava varieties, access to farmland (1.689**), farming experience (2.208*), contact with extension agents (4.431***), access to vitamin A yellow cassava stems (3.801***), income from sales of vitamin A yellow roots (3.458***) and low carbohydrate content (2.201*) influenced positively the adoption of bio-fortified pro-vitamin A yellow cassava varieties. The positive and significant relationship between access to farmland and the adoption of bio-fortified pro-vitamin A cassava varieties implies that as more farmers have access to farmland, the adoption of bio-fortified pro-vitamin A cassava varieties increases.

Table 2: Determinants of adoption of bio-fortified pro-vitamin A yellow cassava varieties

Variable	Marginal effect	Standard error	Coefficient
Age	-0.121	0.001	-3.219
Gender	0.001	0.439	0.024
Education	0.002	0.738	-0.301
Household size	0.002	0.436	0.045
Access to credit	0.002	0.726	0.018
Access to farmland	0.003	0.008	1.689**
Farming experience	-0.005	0.070	2.208*
Contact with extension agents	-0.359	0.002	4.431***
Access to vitamin A yellow cassava stems	0.165	0.001	3.801***
Income from vitamin A yellow cassava	-0.121	0.001	3.458***
Low carbohydrate content	-0.006	0.080	2.201*
Cooperative membership	0.060	0.074	0.597
Constant			-29.700
Number of observations			318
Prob >chi 2			0.0001
Log-likelihood			33.21175

Computation from Field Survey, 2023

NB * Significant at 1%, ** significant at 5%, *** Significant at 10%

This result is in alliance with the research report by Adetomiwa *et al.*, (2021), and stated that access to farmland and farming experience has a positive and significant relationship with the adoption of bio-fortified pro-vitamin A cassava varieties. This implies that farmers cannot get into production without farmland. Also, as farmers' experience in farming increases, they get acquainted with the gains of the adoption of innovations and this increases the adoption of bio-fortified pro-vitamin A yellow cassava varieties. Contact with extension agents had a significant and positive relationship with the adoption of bio-fortified pro-vitamin A yellow cassava varieties, in agreement with the a priori expectation. This implies that the more farmers interact with extension agents, the more they become aware of the benefits of the adoption of agricultural innovations. The findings are similar to those of Adzenga & Dalap, (2023) and Odoemelum & Anyim (2019) that increased contacts with extension agents enhance the adoption of innovation.

Access to bio-fortified pro-vitamin A yellow cassava stems has a positive and significant relationship with the adoption of bio-fortified pro-vitamin A yellow cassava varieties. The implication is that as the cassava stems become readily available, farmers can access them for adoption. The result aligns with that of Anugwa *et al* (2024) report that the availability of inputs is a determinant of production. Income from the sale of bio-fortified pro-vitamin vitamin A yellow cassava also has a significant and positive relationship with the adoption of bio-fortified pro-vitamin A yellow cassava varieties. This implies that as income from cultivation of bio-fortified pro-vitamin A yellow cassava varieties increased, more farmers adopted bio-fortified pro-vitamin A yellow cassava varieties. The result conforms to those of Onyeneke *et al.*, (2020) and Adetomiwa *et al.*, (2021) that farmers like to adopt innovations that increase their income. Low carbohydrate content has a positive and significant relationship with the adoption of bio-fortified pro-vitamin A cassava varieties. This implies that the lower the carbohydrate content of bio-fortified pro-vitamin A yellow cassava varieties, the more the adoption. The reason could be that most households like low-carbohydrate foods. The result concurs with Oteh *et al.*, (2023) and

Beilder (2024) that farmers and consumers are aware of the nutritional value of bio-fortified pro-vitamin A cassava varieties which influenced the adoption.

Farmers preference on adoption of bio-fortified pro-vitamin A yellow cassava

The result of farmers' preferences on the adoption of bio-fortified pro-vitamin A yellow cassava varieties is presented in Table 3. The result shows that the order of preference was: yellow gari (1.90*), contains vitamin A (1.86*), early maturity (1.85*), low carbohydrate (1.76*), easy access to stem (1.49*), weed resistant (1.40*), easy to peel (1.39*), soil tolerant (1.23*), and fast dewatering (1.13*). Preferences for the adoption of bio-fortified pro-vitamin A cassava due to its yellow gari are supported by Chidiebere-mark & Anyanwu (2020) who reported that the yellow colour of the roots and its products is liked by consumers. The yellow branding improves the marketability of the final products of the roasted cassava flour (gari). The high preference for the adoption of bio-fortified pro-vitamin A yellow cassava varieties due to their vitamin A content may be a response to nutrition-sensitive agriculture. The high adoption of bio-fortified pro-vitamin A cassava varieties due to their early maturity status concurs with the findings of Zhihui *et al.*, (2024) and disagrees with the report by Nzola *et al* (2021) that vitamin A yellow root cassava is not cultivated due to its early maturity. Its adoption due to early maturity may be to tap into its early returns on investment. The preference for the adoption of bio-fortified pro-vitamin A cassava varieties due to their low carbohydrate content is supported by the findings of Amy & Eric (2022) on reasons for the adoption of bio-fortified pro-vitamin A yellow cassava varieties.

Table 3: Farmers' preferences on the adoption of bio-fortified pro-vitamin A Yellow cassava varieties

Preference	Mean	SD
Early maturity	1.85*	3.10
Yellow gari	1.90*	3.42
Easy access to stem	1.49*	1.42
Fast dewatering	1.13*	0.44
Contains vitamin A	1.86*	3.10
Low carbohydrate	1.76*	2.56
High quantity gari	0.91	0.00
Soil tolerant	1.23*	0.56
Weed resistant	1.40*	1.04
Easy to peel	1.39*	0.88

Field survey, 2023

Discriminating index = 1, SD = standard deviation, *mean above discriminating index of 1

The favourable preferences on the adoption of bio-fortified pro-vitamin A cassava based on easy access to its stems may be attributed to the proximity of the area to the National Root Crops Research Institute, Umudike. This may have enhanced the multiplication of the stem in the study area. This is not in line with the report by Onyeneke *et al.*, (2020) that hybrid cassava varieties have a low multiplication ratio in Southeast Nigeria. The adoption of bio-fortified pro-vitamin A cassava due to weed resistance stems from the weed resilience of the variety. This is in agreement with TAAT's (2024) status that cultivation of bio-fortified pro-vitamin A cassava varieties reduces weed encroachment. The adoption of bio-fortified pro-vitamin A cassava varieties due to soil tolerance is in line with the soil adaptation characteristics of the crop. High quantity of gari was not a preferred attribute for the adoption of bio-fortified pro-vitamin A yellow cassava (mean = 0.91) because high dewatering indicates high moisture content which reduces the quantity of the final product. The high moisture content may also have enhanced the ease of peeling. This concurs with the findings of Zhihui *et al.*, (2024) that farmers like cassava tubers that are easy to peel. This is supported by Onyeneke *et al.*, (2020) who reported that high moisture content accounts for its low quantity of gari and is an undesirable genetic composition. The standard deviation range of 0.00 to 3.42 implies that farmers differed in their opinion about preferences for bio-fortified vitamin A yellow cassava adoption.

Table 4: Comparative cost and returns on bio-fortified pro-vitamin A yellow cassava (TMS 07/0593) and white cassava (TMS 30572)

Item	TMS 07/0593	TMS 30572
Revenue from sales of tubers	500,000	420,000
Revenue from 100 bundles of stems	300,000	150,000
Total revenue	800,000	520,000
Expenses		
Leasing 4 plots of land	40,000	40,000
Cost of land clearing	20,000	20,000
Cost of ridging	30,000	30,000
Cost of 20 bundles of stems	60,000	30,000
Cost of planting	15,000	15,000
Cost of fertilizer application	34,000	34,000
Labour for weeding	30,000	48,000
Cost of disease control	10,000	15,000
Labour for harvesting	20,000	20,000
Total	259,000	252,000
Net income = Revenue – Expenses		
07/0593 = 800,000 – 259,000 = 541,000		
30572 = 570,000 – 252,000 = 318,000		
Net Profit Margin = $\frac{\text{Net income}}{\text{Revenue}} \times 100$	67.6%	55.8%

Computation from Field Survey, 2023

Results in Table 4 show that bio-fortified pro-vitamin A Yellow cassava has a higher profitability index (67.6%) than white cassava (55.8%). The implication is that there is high awareness of the nutritional value of yellow cassava root which enhanced the consumption among households. This is supported by the result from TAAT's (2021) that cultivating pro-vitamin A-enriched cassava offers a substantial economic advantage to the growers over non-improved types. This concurs with the submission of Adetomiwa et al., (2021) that rate of adoption of a variety is subject to its profitability capacity and nutritional value. Hence, the WHO (2024) acknowledges the nutritional value of bio-fortified pro-vitamin cassava by stating that the replacement of white cassava with bio-fortified pro-vitamin A Yellow cassava reduces the cost for treatment of diet related issues by \$1.01. This is buttressed by Ofori et al., (2022) report that in Nigeria, cultivation of bio-fortified pro-vitamin A yellow cassava reduces cost of treating sugar related diseases. This makes it to be food cost-effective with the potential to reach rural households who may not have regular access to fortified food and supplements. The cost of disease control was less with TMS 07/0593 because bio-fortified pro-vitamin A yellow cassava varieties are less prone to disease attack (Afolami et al., 2021).

Conclusion and Recommendations

The highly adopted bio-fortified pro-vitamin A cassava varieties were TMS 07/0593, TMS1371, and TMS 0539. The adoption of bio-fortified pro-vitamin A yellow cassava varieties was positively influenced by access to farmland, farming experience, contact with extension agents, access to vitamin A yellow cassava stems, income from vitamin A yellow cassava, and low carbohydrate content. Farmers' order of preference on the adoption of bio-fortified pro-vitamin A yellow cassava was yellow gari, vitamin A content, early maturity, low carbohydrate, easy access to stem, weed resistant, easy to peel, soil tolerant and fast dewatering. Bio-fortified pro-vitamin A yellow cassava had a higher net profit than white cassava. There is a need for wider awareness and multiplication of varieties of bio-fortified pro-vitamin A yellow cassava varieties to enhance the adoption rate. Farmers should be highly involved

in farm enhancement collaborations like cooperative membership and contact with Ministries & Agencies of Agriculture and Non-government Agricultural organizations. This is to enhance their access to farmland, farming skills, and access to bio-fortified pro-vitamin A cassava stems, and ready market for products. Also, breeders should enhance the quality of bio-fortified pro-vitamin A yellow cassava to reduce the moisture content. This will enhance the quantity of gari derived from the cultivation of bio-fortified pro-vitamin A yellow cassava. Furthermore, there is a need to intensify the production of bio-fortified pro-vitamin A yellow cassava due to its nutritional benefits and higher profitability index. The boost in the production of bio-fortified pro-vitamin A yellow cassava will help to reduce the prices of other low-carbohydrate food crops due to its high demand.

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