

# Effect of varietal attributes on the adoption of an orange-fleshed sweetpotato variety in Upper East and Northern Ghana

Outlook on Agriculture  
2020, Vol. 49(4) 311–320  
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DOI: 10.1177/0030727020950324  
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## Abstract

Despite sustained economic growth and reduction in some of forms of malnutrition, Ghana still faces a national prevalence rate of 20.8% vitamin A deficiency (VAD) among for children 6–59 months old. Orange-fleshed sweetpotato (*Ipomoea batatas* L.) (OFSP) can significantly improve vitamin A intake and contribute toward reducing VAD, especially in Northern Ghana where VAD is 31% among young children. Several poverty and nutrition projects in Ghana have promoted the use of OFSP for its health benefits. This study assesses the effect of three varietal attributes on adoption of the first released OFSP variety in Northern Ghana namely, Apomuden. The study concluded that sweetness, taste and dry matter have joint significant effects on adoption of an OFSP variety. The positive and negative traits highlighted will inform the on-going breeding effort.

## Keywords

Orange-fleshed, sweetpotato, biofortification, varietal attributes, adoption, Ghana

## Introduction

Adequate micronutrient intakes are critical for human health, and vitamin A in particular is essential for a strong immune system and excellent eyesight (Micronutrient Initiative, 2009). Vitamin A deficiency (VAD) has been officially classified as a public health problem over the past four decades in many developing countries (Ritchie and Roser, 2017). Globally, an estimated 2 billion people are affected by micronutrient deficiencies, including VAD (FAO, 2018). Among children 6–59 months of age, the highest VAD rates (48 percent) are found in sub-Saharan Africa, followed by South Asia (44 percent) (Stevens et al., 2015). For children, lack of vitamin A can cause visual impairment and blindness, significantly increases the risk of illness, and even death, from such common childhood infections as diarrheal disease and measles (Stevens et al., 2015). Among pregnant women, VAD causes night blindness and can increase the risk of maternal mortality (WHO, 2017). Ghana Micronutrient Survey (GMS, 2017) indicates that despite two decades of sustained economic growth and reductions in some forms of malnutrition, progress on minimizing malnutrition, including micronutrient deficiencies, has been slow in Ghana. Further the report indicates that in 2017 approximately 20.8% of pre-school children were suffering from VAD and 21.5% from iron deficiency. However, in Northern belt of Ghana, with drier agro-climatic

conditions and higher poverty rates than the rest of the country, VAD prevalence reaches 31% in pre-school children and iron deficiency 39.6%. Currently, Ghana fortifies both wheat flour and vegetable oil with vitamin A. However, a study in 2011 noted that wheat flour was often inadequately fortified and stability issues of the retinyl palmitate added to oils are of concern (GMS, 2017). Greater dietary diversity and intake of vitamin A rich foods is a critical part of the solution. Orange-fleshed sweetpotato (OFSP) provides an effective way for combating VAD (Low et al., 2017) and the crop grows well in Northern Ghana in particular. Consuming just 100 grams of boiled OFSP roots regularly can meet vitamin A requirement of a young child and when introduced alongside a community level nutrition education campaign, significant impact is made on vitamin intakes and status (Hotz et al., 2012; Low

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et al., 2007). In the past decade, there has been increasing investment of developing processed products using OFSP as a key ingredient to diversify market opportunities for farmers and better reach urban consumers (Adekambi et al., 2020; Low et al., 2017).

In order to improve nutritional indicators and livelihood of smallholders, the Crops Research Institute (CSIR-CRI), in Ghana, released, in 2005, an OFSP variety known as Apomuden. From 2014 to 2017, International Potato Center (CIP), with other developmental partners intensively promoted this variety under a project called “Jumpstarting Orange-fleshed Sweetpotato in West Africa through Diversified Markets” (Jumpstarting project for short). The project conducted market sensitization and demand creation campaigns, nutrition education, and training on good agricultural practices in Upper East and Northern Ghana. Further, in order to improve access to planting materials, decentralized vine multipliers were created in the communities where sweetpotato is predominantly grown, and linkages established between breeding stations and “seed” multipliers.

Despite these efforts, adoption of Apomuden was considered to be lower than anticipated (Abidin and Amoafu, 2015), particularly in areas where the project activities were less intensive and in non-target areas, even though the project used radio broadcasting as a tool for scaling with the aim of creating awareness of the new variety in such areas. Low adoption rates are often attributed, among other factors, to the attributes of the technology, in this case the variety. Past studies have indicated that varietal attributes play a major role in the adoption of improved varieties (e.g., Timu et al., 2014). Within the biofortification literature, however, limited attention has been given to the role specific varietal attributes play on the adoption of nutritionally enhanced crops. Notable exceptions are De Groote et al. (2014), Birol et al. (2015) and Larochelle et al. (2016) who do not focus on the sweetpotato. De Brauw et al. (2018) explored the high rates of adoption (61–68%) among smallholders in Uganda and Mozambique, and concluded that knowledge of key nutrition messages did not drive uptake, implying that agronomic features (disease and drought tolerance, etc.) are likely to be key. Other explanations of the adoption behavior related to OFSP have mostly focused on farmers’ socioeconomic characteristics, farm, physical environment factors, and perceived health and economic benefits (e.g., Mudege et al., 2018).

Our study differs from previous studies, by focusing on sweetpotato in Upper East and Northern Ghana, West Africa, where studies indicate that certain varietal attributes, in particular sweetness (that is, high sugar content), can hinder adoption and consumption of improved varieties (Baafi et al., 2016). Indeed, since 2010, a major initiative to breed for low/non-sweet sweetpotato has been a major focus of sweetpotato breeding by CIP and the national programs in Ghana and Nigeria (Low et al., 2017). This effort has been informed by the argument that West African consumers prefer “non-sweet” roots, akin to yam and cassava (Baafi et al., 2016; Kayodé

et al., 2005). Other studies have further documented the role of taste and dry matter content in adoption of improved crop varieties. Veeck and Burns (2005) found a strong effect of taste of new variety and food on uptake in rural China.

The objective of this study was to measure the effect of varietal attributes namely sweetness (or lack of it), taste, and dry matter on adoption of the OFSP variety in Upper East and Northern Ghana. This study specifically sought to investigate i) the relative importance of different varietal traits on adoption of the OFSP variety Apomuden and ii) the individual and joint effect of sweetness, taste and dry matter content on adoption of Apomuden. It specifically investigated the role of these attributes on demand for OFSP vines (seed).

## Methodology

### Study area

The study was conducted in the Upper East and Northern Regions of the Northern Belt of Ghana, that included areas covered by the Jumpstarting project (Figure 1). The regions are characterized by a unimodal rainy season that begins in May and ends in October, with mean annual rainfall varying between 950 and 1,200 millimetres (GSS, 2010). Farmers in these regions traditionally engage in rainfed agriculture, and grow maize, groundnuts, rice, cassava, and sweetpotato as the major crops. However, the total area under sweetpotato (including OFSP) was still relatively low compared to other major crops (Ministry of Food and Agriculture, 2014), with the exception of the Upper East Region, i.e. Bawku area where sweetpotato is the dominant cash crop.

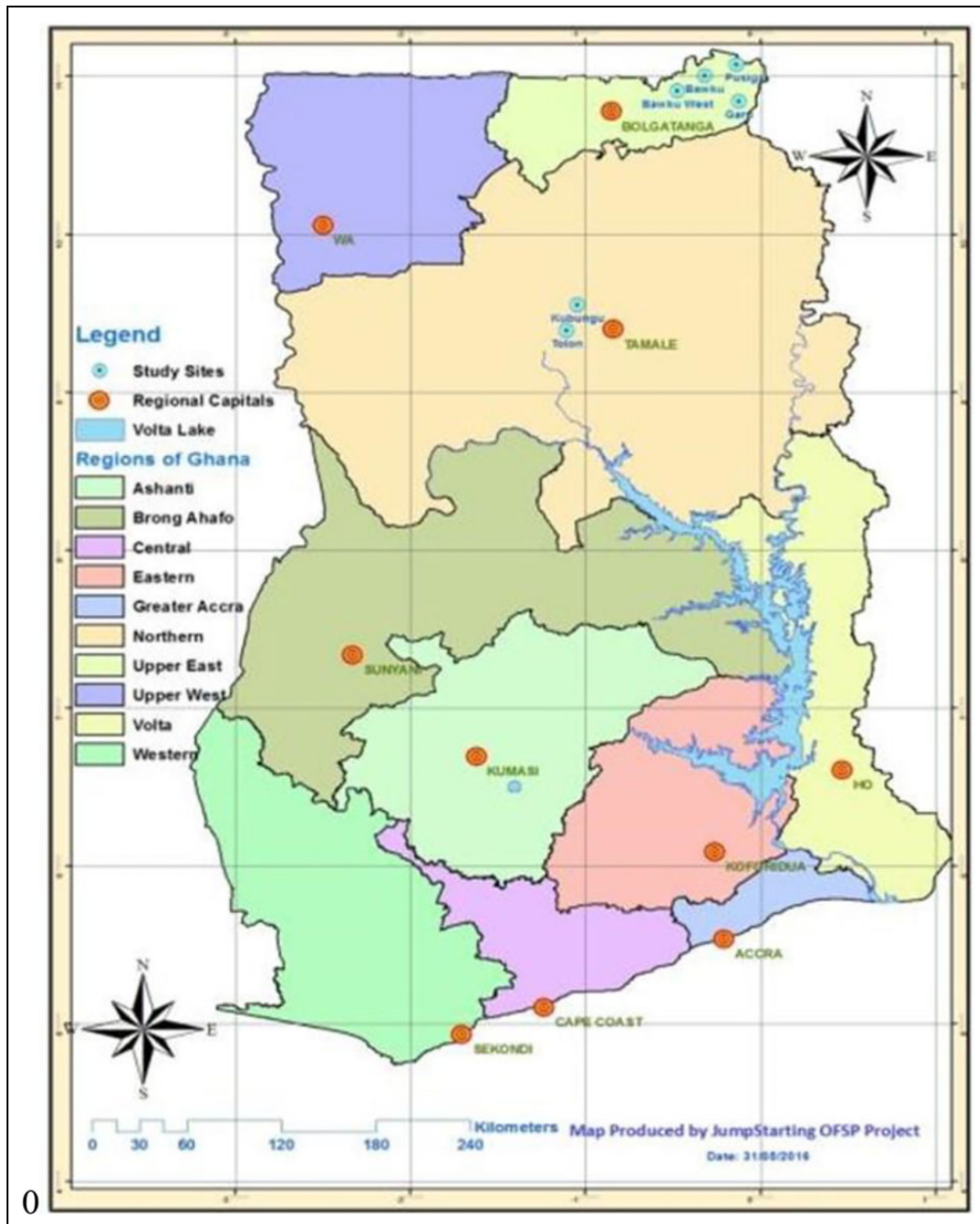
### Theoretical and empirical approaches

Assume that a farmer seeks to maximize the expected utility of producing a given sweetpotato variety ( $\pi$ ). The farmer will thus grow OFSP if its expected utility, represented by  $U_1^*(\pi)$ , outweighs the expected utility of growing local (i.e., non-OFSP) sweetpotato varieties, represented by  $U_0^*(\pi)$ , that is,  $U_1^*(\pi) > U_0^*(\pi)$ . The utility maximization ( $U_i^*(\pi)$ ) underlying farmers’ decision to adopt a variety is usually not observable but depends on a set of socioeconomic, institutional and varietal attributes ( $X_i$ ) and can be stated as:

$$U_i^* = X_i\beta + \varepsilon_i, i = 1, 2, \dots, N \quad (1)$$

where  $\beta$  is a vector of adoption parameters to be estimated, and  $\varepsilon_i$  is a random error term.

The study focuses on two sweetpotato varieties: an improved OFSP variety (i.e., Apomuden) and a popular local-check variety (i.e., Obare) which is white-fleshed, and assumes that farmers are more likely to cultivate more than one variety at a time. Then, the decision to adopt Apomuden will likely be correlated with that of Obare. The adoption patterns for the two varieties can thus be represented by the system of binary response variable



**Figure 1.** Map of study regions.

$y_i$  ( $y_1$  for Apomuden and  $y_2$  for Obare). The response variable  $y_i$  takes the value 1 if the expected utility of adopting Apomuden (or Obare) is greater than that of not adopting it, and 0 otherwise; that is:

$$\begin{cases} Y_1 = 1 \text{ if } U_1^*(\pi) > U_0^*(\pi), Y_1 = 0 \text{ otherwise} \\ Y_2 = 1 \text{ if } U_2^*(\pi) > U_0^*(\pi), Y_2 = 0 \text{ otherwise} \end{cases} \quad (2)$$

Since Equation (2) represents a system of two binary choice models, the errors terms of the two equations are likely to be correlated and failure to account for this could lead to biased and inefficient estimates (Lin et al., 2005). To account for this potential correlation between the error terms, this paper uses the multivariate probit (MVP) approach (Greene, 1995). The MVP allows for joint estimation of regression models to assess the factors

influencing the decision to adopt Apomuden and Obare and controls for correlation in the decision to adopt one variety over the other.

**Data and sampling**

This study focused on smallholder farm households in the Northern and Upper East Regions of Ghana, where the sweetpotato is an important crop both for home consumption and cash generation. The selection of the study areas was guided by OFSP dissemination activities undertaken by the Jumpstarting OFSP project and its partners. The study focused on 38 communities (13 in the Northern and 25 in the Upper East) included in the project. A stratified multistage random and probability proportionate to size

**Table 1.** Description of variables used in the multivariate probit.

	Definition	Expected sign
Adoption of OFSP	Grew OFSP varieties in 2015	Dependent variable
<b>Farmer characteristics</b>		
Age of farmer (years)	Age of the farmer (years)	Positive
Gender of the farmer	1 if farmer is male; 0 = otherwise	Positive
Education level of the farmer	Education level of the farmer (1 = Primary; 2 = Junior high; 3 = Senior high; 4 = Tertiary)	Positive
Presence of pregnant/lactating woman in the household	1 if pregnant and/or lactating woman is present in the household; 0 otherwise	Positive
<b>Farm assets/resources</b>		
Farm size owned (hectares)	Total area planted in crops in 2015 in hectares	Positive
<b>Institutional factors</b>		
Farmer belongs to a group/association	1 If farmer belongs to group/association; 0 otherwise	Positive
Distance to the nearest main road (minutes)	Distance to the nearest main road (minutes)	Negative
Distance to the nearest agricultural field office (minutes)	Distance to the nearest agricultural field office (minutes)	Negative
Participation in the trainings on Apomuden production management	1 If farmer participated in the trainings on Apomuden production management; 0 otherwise	Positive
Participation in the project activities	1 If farmer participated in the project activities; 0 otherwise	Positive
Participation in cooking demonstrations	1 If farmer participated in cooking demonstrations; 0 otherwise	Positive
<b>Sensory attributes variables</b>		
Very Sugary/Sweet	1 if variety (very) sweet; 0 otherwise	Negative
Roots/leaves have desirable taste	1 if variety's roots and or leaves have desirable taste; 0 otherwise	Positive
Not Watery (soft)	1 if variety is not watery; 0 otherwise	Positive
<b>Other variety attribute variables</b>		
Early maturity	1 if variety is early maturity; 0 otherwise	Positive
Resists diseases	1 if variety is disease resistant; 0 otherwise	Positive
Variety high yielding	1 if variety is high yielding; 0 otherwise	Positive
Easy to establish with scarce rain	1 if variety is easy to establish with scarce rain; 0 otherwise	Positive
Variety drought tolerant	1 if variety is drought tolerant; 0 otherwise	Positive
Easy to conserve vines during the long dry period	1 if vines are easy to conserve during the long dry period; 0 otherwise	Positive
Easy to store in the ground	1 if variety is easy to store in the ground; 0 otherwise	Positive
Cooks quickly/ease of cooking	1 if variety is easy to cook; 0 otherwise	Positive

sampling technique was used to select the study respondents. First, lists were drawn of all the communities where OFSP dissemination had occurred stratified by the project implementation region. Next, using probability proportionate to size sampling technique, 7 communities were randomly selected in the Upper East and 11 in the Northern Region, resulting in a total of 18 communities being randomly selected to participate in the study. Finally, all the farmers who grow any type of sweetpotato varieties in the selected communities were identified and listed and 262 farmers randomly selected for the study, again, using probability proportionate to size sampling technique. Data were collected between April and May 2016 from the person most responsible for sweetpotato production in the household and included farmer and farm characteristics, capital/asset endowments, varietal attributes and institutional characteristics faced by the household. A total of 16 varietal attributes including production, sensory, cooking and market-oriented were identified and data on farmer ranking of each attribute relevant to the adoption of OFSP collected. Data were collected via face-to-face interview using a pre-tested questionnaire, and analyzed using Stata version 15.

Explanatory variables used to fit the regression models include farmer characteristics, farm characteristics, institutional factors, and varietal attribute variables. The definitions and expected signs on their coefficients are presented in Table 1. These explanatory variables were identified from the relevant literature (Adekambi et al., 2020; Mudege et al., 2018; Timu et al., 2014). Collinearity tests found no evidence of multicollinearity among the independent variables.

The present study hypothesized that sensory varietal attributes (specifically sugar content, taste and dry matter content) influence the adoption of Apomuden. To test this hypothesis, we control for other factors likely to affect decision to grow Apomuden. Studies have shown that the larger the size of land-owned, the more likely farmers are to adopt agricultural innovations (Feder et al., 1985). Human capital, proxied by education and training, has been found to positively influence farmers' search for information about innovation. Such knowledge then enhanced their decision making toward adoption (Okello et al., 2017; Singh et al., 2008). For example, Singh et al. (2008) found a positive and significant relationship between the adoption of integrated pest management (IPM) practices and formal

**Table 2.** Summary statistics for adopters and non-adopters of OFSP varieties.

Variable	OFSP adopters		OFSP non-adopters		p Value of test of difference in means
	Mean	Std. dev.	Mean	Std. dev.	
Number of farmers	N = 181		N = 81		
Farmer characteristics					
Age of farmer (years)	39.53	13.29	35.81	11.85	0.015
Gender of the farmer (1 = male; 0 = otherwise)	0.73	0.44	0.84	0.37	0.026
Education level of the farmer	5.18	1.68	4.89	1.94	0.107
Presence of pregnant/lactating woman in the household	0.73	0.44	0.67	0.47	0.131
Farm assets/resources					
Farm size owned (hectares)	5.27	6.25	7.33	11.95	0.034
Institutional factors					
Farmer belongs to a group/association (1 = yes; 0 = no)	0.80	0.40	0.09	0.30	0.000
Distance to the nearest main road (minutes)	33.04	35.78	35.85	36.16	0.279
Distance to the nearest agricultural field office (minutes)	152.45	119.27	181.54	115.21	0.033
Participation in the trainings on Apomuden production management	0.44	0.49	.03	0.19	0.000
Participation in the project activities	0.77	0.03	0.06	0.02	0.000
Participation in cooking demonstrations	0.35	0.04	0.01	0.0	0.000
Sensory attributes variables					
Very Sugary/Sweet	0.26	0.44	0.21	0.41	0.170
Roots/leaves have desirable taste	0.63	0.48	0.75	0.43	0.025
Not Watery (soft)	0.16	0.37	0.21	0.41	0.196
Other variety attribute variables					
Early maturity	0.9	0.30	0.73	0.45	0.000
Resists diseases	0.36	0.48	0.43	0.49	0.131
Variety high yielding	0.98	0.15	0.85	0.36	0.000
Easy to establish with scarce rain	0.49	0.50	0.42	0.49	0.123
Variety drought tolerant	0.02	.14	0.04	0.19	0.245
Easy to conserve vines during the long dry period	0.03	0.18	0.02	0.16	0.357
Easy to store in the ground	0.03	0.17	0.02	0.15	0.357
Cooks quickly/faster or ease of cooking	0.16	0.36	0.16	0.37	0.497

crop-specific IPM training in the production of cotton and paddy rice in India. Okello et al. (2017) also found a positive influence of nutrition education and training on adoption of OFSP varieties. Farmers who benefit from institutional support such as frequent advice from extension personnel have a higher probability of adopting agricultural innovations (Elizabeth, 2015).

Additionally, the more farming experience farmers have (here proxied by age), the more capable they are to evaluate the suitability of new improved technologies to their circumstances, which affects the decision to adopt such technologies. It is also expected that male farmers are likely to adopt Apomuden more readily, especially as it becomes commercialized. Dolan (2001), for instance, argues that men gain interest in crops hitherto considered women's as they become commercialized. Pregnant and/or lactating women and young children are the most vulnerable to vitamin A deficiency and are typically the targets of interventions based on promotion of OFSP, since it has the potential to provide the nutrients needed by the household. Hence, households with young children, pregnant and lactating women are likely to adopt OFSP (Chowdhury et al., 2013).

Previous studies further indicate that there is a positive relationship between technology adoption and membership of farmers' organizations and access to input and output

markets. Other studies have found that poor access to markets has negative effects on adoption of agricultural technologies (Tenywa and Fungo, 2011; Yengoh et al., 2010). We hypothesize that farmer membership to any organization or association, proximity to source of agricultural information and good access to markets (proxied by distance to main road and market) will have positive effect on OFSP adoption.

## Results

### *Socioeconomic characteristics of the interviewed households*

Table 2 contains descriptive statistics of the variables for adopters and non-adopters of Apomuden. Farmer characteristics such as level of education, distance to the nearest main road and the presence of pregnant and/or lactating woman in the household did not significantly differ between adopters and non-adopters of Apomuden, while their age and the gender breakdown of adopters differ significantly by adoption state. On average, the interviewed sweetpotato producers were 38 years old and were a 34 minute walk away from the nearest main road. Males outnumbered females, and three quarter of the interviewees had pregnant and/or lactating women present in their households. Adopters owned less land (5.27 hectares) than

**Table 3.** Relative importance rankings by farmers for sweetpotato attributes.

	Planting/postharvest characteristics		Cooking characteristics		Overall	
	Mean Rank	Rank	Mean Rank	Rank	Mean Rank	Rank
High Yielding	2.96	1	—	—	4.47	1
<b>Roots taste good</b>	—	—	2.22	1	4.99	2
Early Maturity (has roots in 4 months)	3.88	2	—	—	6.13	3
<b>Leaves taste good</b>	—	—	2.86	2	6.14	4
Resists diseases	3.91	3	—	—	6.31	5
Easy to establish with scarce rain	3.95	4	—	—	6.41	6
Does not die even when the rains stops early	4.04	5	—	—	6.57	7
<b>Very Sugary/Sweet</b>	—	—	3.14	3	6.92	8
Easy to conserve vines during the long dry period	4.18	6	—	—	6.94	9
Cooks quickly/Faster	—	—	3.19	4	6.96	10
Not Watery (soft)	—	—	3.59	5	7.73	11
Easy to store in the ground	5.09	7	—	—	8.43	12
N	262		262		262	
Kendall's W	0.098		0.025		0.98	
Chi-Square ( $\chi^2$ )	154.407		33.205		310.511	
Degree of Freedom	6		5		11	
p Value	0.000		0.000		0.000	

non-adopters (7.33 hectares). More producers in the adopter group are members of farmer organizations (80%) as compared to farmers in the non-adopter group (9.8%). Farmers who adopted Apomuden have somewhat good access to extension office (152 minute walk away from the nearest office as compared to 182 minute walk for non-adopters). Importance of early maturity, high yield, and good taste are higher among adopters of Apomuden. However, we found no significant difference between adopters and non-adopters with respect to the importance of the following attributes: disease resistance, ease of establishment when rain is scarce, drought tolerance, ease of conserving vines during the long dry period, ease of storing roots in the ground for long, ease of cooking, having high sugary content (i.e., very sweet), and wateriness (i.e., soft when cooked).

#### Farmer perceptions of improved sweetpotato variety attributes

Table 3 shows interviewees' ordinal ranking of the importance of the varietal attributes including sweetness (sugar content in terms of perception of sugariness), taste and dry matter content (perception of starchiness or dryness) in decision to plant/grow Apomuden. The ranks were based on a Likert scale ranging from 1 = completely unimportant to 5 = very important. The degree of agreement between the interviewees' rankings of OFSP attributes is measured using the Kendall's coefficient of Concordance (W).

The results show that among the sensory attributes, taste and sweetness were ranked highly in importance. Among planting/postharvest attributes, the most important attributes are yield, early maturity, resistance to pests and diseases. These production attributes have already been the

major focus of sweetpotato breeding programs in sub-Saharan Africa seeking to increase food security.

#### Drivers of OFSP adoption and effects of sensory attributes

The results of the estimation of the multivariate probit are presented in Table 4. The model was estimated jointly for two dependent variables: Apomuden and Obare. The likelihood ratio test of rho is highly significant ( $p$  value = 0.000), suggesting that a multivariate probit specification fits the data well. Importantly, the correlation coefficient between the two error terms is positive and significant (Chi-square = 92.442,  $p$  value = 0.000), indicating that the decision to adopt Apomuden is indeed correlated with the decision to adopt other varieties; the Obare variety in this study. This finding suggests that the adoption of the two studied varieties are interdependent. Consequently, estimates of the effect of low-sugar, taste and dry matter content based on an ordinary probit or logit regression would have been statistically inefficient.

#### Apomuden adoption and the role of sweetness, taste and dry matter content

As hypothesized, the results presented in Table 4 show that the attribute taste has a very strong effect on Apomuden adoption ( $\beta = -0.88$ ,  $p$  value = 0.014). The coefficient of dry matter content was negative and statistically significant at 10% ( $\beta = -0.54$ ,  $p$  value = 0.058), indicating that the attribute dry matter content influences adoption of Apomuden. The attribute sweetness was not statistically significant but had the right hypothesized signs. The results of Wald joint exclusion restriction test of the three sensory attributes (taste, sweetness and dry matter) was statistically significant at the 10% level ( $p$  value = 0.057).

**Table 4.** Factors affecting adoption of OSFP varieties: Results of multivariate probit regression.

	Apomuden			Obare		
	Coefficient	Std. Err.	p Value	Coefficient	Std. Err.	p Value
Sensory attributes variables						
Very Sugary/Sweet	-0.05	0.34	0.892	0.36	0.34	0.285
Roots/leaves have desirable taste	-0.88	0.36	0.014	0.94	0.38	0.014
Not Watery (soft)	-0.54	0.29	0.058	0.28	0.28	0.316
Other variety attribute variables						
Early maturity	0.62	0.28	0.025	-0.71	0.25	0.005
Resists diseases	0.42	0.23	0.067	-0.56	0.22	0.012
Variety high yielding	0.86	0.41	0.037	-0.89	0.29	0.003
Easy to establish with scarce rain	0.47	0.27	0.079	-0.45	0.25	0.073
Variety drought tolerant	0.37	0.62	0.546	-0.47	0.56	0.407
Easy to conserve vines during the long dry period	1.09	0.80	0.172	-0.76	0.79	0.339
Easy to store in the ground	-1.26	0.55	0.021	0.17	0.53	0.752
Cooks quickly/faster or ease of cooking	-0.82	0.44	0.061	0.81	0.52	0.115
Farm assets/resources						
Log of farm size owned (hectares)	0.08	0.13	0.535	0.07	0.12	0.550
Farmer characteristics						
Presence of pregnant/lactating woman in the household	-0.06	0.14	0.641			
Log of age of farmer (years)	-0.55	0.40	0.167	0.6	0.34	0.011
Education	0.18	0.26	0.489	-0.22	0.25	0.382
Institutional factors						
Participation in the trainings on Apomuden production management	0.41	0.22	0.070			
Farmer belongs to a group/association (1 = yes; 0 = no)	2.43	0.39	0.000	-2.53	0.36	0.000
Log of distance to the nearest main road (minutes)	0.07	0.13	0.583	-0.06	0.12	0.628
Log of distance to the nearest agricultural field office (minutes)	-0.34	0.14	0.015	0.21	0.14	0.140
Participation in the project activities	0.18	0.31	0.569			
Participation in cooking demonstrations	0.52	0.17	0.002			
Constant	1.71	1.66	0.303	-2.61	1.48	0.079
Wald chi2(38) = 220.04***						
Likelihood ratio test of rho21 = 0 chi2(1), chi2(1) = 92.4425***						

Note: \*\*\*, \*\* and \* denote 1 per cent, 5 per cent and 10 per cent levels of significance, respectively.

Results also show that early maturity had a positive and significant influence on adoption of Apomuden ( $\beta = 0.62$ ,  $p$  value = 0.025). Yield potential also has a significant effect on adoption of Apomuden ( $\beta = 0.86$ ,  $p$  value = 0.037). Similarly, disease resistance as did ease of establishment with scarce rains had positive and statistically significant coefficients ( $\beta = 0.42$ ,  $p$  value = 0.067 and  $\beta = 0.47$ ,  $p$  value = 0.079, respectively). The coefficients for easy to store in the ground and ease of cooking were both negative and statistically significant at 5% ( $\beta = -1.26$ ,  $p$  value = 0.021) and 10% ( $\beta = -0.82$ ,  $p$  value = 0.061), respectively.

As expected, a number of institutional factors influence the adoption of OFSP. For instance, results show that participation in farmer organizations has a strong positive effect on the adoption of Apomuden ( $\beta = 2.43$ ,  $p$  value = 0.000). Moreover, the coefficient of the distance to the nearest agricultural field office, a proxy for access to extension advise, is negative and significant at the 5% level ( $\beta = -0.34$ ,  $p$  value = 0.015). Further, the coefficients for participation in the trainings on Apomuden production management and in cooking demonstrations are both positive and statistically

significant at 10% ( $\beta = 0.41$ ,  $p$  value = 0.070) and 1% ( $\beta = 0.52$ ,  $p$  value = 0.002), respectively.

#### *Obare adoption and the role of sweetness, taste and dry matter content*

The results of multivariate probit model further showed that maturity cycle, disease resistance, yields, and tolerance to scarce rains negatively affect the adoption of Obare. The results also showed that the attribute taste of the roots and leaves has a positive and statistically significant influence at 5% ( $\beta = 0.94$ ,  $p$  value = 0.014), so a very strong effect on Obare adoption. The coefficients for easy to store in the ground, ease of cooking, and dry matter content were all positive but not statistically significant.

Among the socioeconomic variables included in the model, age had statistically significant coefficient ( $\beta = 0.60$ ,  $p$  value = 0.011). The positive and significant coefficient of age implies that the probability of adopting Obare variety increases with an increase in the age of the farmer.

Results further showed that the decision to cultivate Obare is also affected by institutional variables. In particular, group membership was found to affect the adoption of

Obare variety. Its coefficient was negative and statistically significant at the 1% level ( $\beta = -2.53$ ,  $p$  value = 0.000), implying that membership into farmer organization decreased the likelihood of cultivation of Obare.

## Discussion

### *The role of sweetness, taste and dry matter content in determining OFSP adoption*

The attribute sweetness was not statistically significant but had the right hypothesized signs. This finding did not corroborate previous studies that reported significant influence of sweetness on the likelihood of growing improved varieties (e.g., Okello et al. 2017). Although the individual effect of the attribute sweetness was not statistically significant, the set of the three sensory attributes (taste, sweetness and dry matter) had joint significant effect on the decision to adopt Apomuden. It is especially notable that even though sweetness has no effect individually, when combined with the other two sensory attributes (i.e., taste and dry matter), we get a relatively strong significant effect on adoption of Apomuden. This finding suggests that farmers' decision to adopt an improved variety is based on assessment of the variety using a combination of attributes rather than on individual/isolated attributes. This finding is consistent with that of Wilson-Jeanselme and Reynolds (2006) on online grocery retailing.

Notably, the attribute taste had negative and statistically significant coefficient in the Apomuden model but positive and statistically significant coefficient in the Obare model. Thus, in comparison to Obare variety, the farmers found taste of Apomuden inferior, hence the negative and significant effect. The findings regarding the attribute taste is consistent with those of Shikuku et al. (2019) and Kikulwe et al. (2011) who found that taste was an important consumption attribute with a strong influence on adoption of improved varieties.

The negative and significant coefficient of the attribute dry matter in the Apomuden model but with no significant influence in the Obare model suggests that adoption of Apomuden is impeded by the perception that it has low dry matter content.

### *The role of other varietal attributes in the adoption of OFSP*

One notable finding is the positive and significant influence of early maturity attribute on adoption of Apomuden. Early maturity is an important attribute for sweetpotato cultivated in the study areas which frequently experience erratic rains. Early maturity enables the crop to escape drought and complete its growing cycle. These results corroborate those of Joshi and Bauer (2006) and Napisintuwong and Pray (2014) who also found that early maturity significantly affects adoption of improved varieties. The significant effect of yield potential on adoption of Apomuden is also in line with prior findings (Carena, 2011), especially given that Northern Ghana has a unimodal rainy season distribution pattern.

The significant and negative coefficients of early maturity, disease resistance, yield potential, and ease of establishing with scarce rains in the Obare model imply that the farmers found these attributes of Obare inferior as compared to those of Apomuden. The findings therefore support the point of view that the improved sweetpotato Apomuden had better early maturity, disease resistance, yield potential and drought tolerance than the local variety, Obare.

Among the control variables, we find that institutional factors greatly influence adoption of the two varieties. The significant and positive influence of farmer's participation in farmer associations on the adoption of Apomuden and its negative and significant influence on the adoption of Obare variety suggest that being a member of such associations significantly contribute to increase the probability of OFSP adoption as access to improved seeds is facilitated by farmers' networks such as farmers' associations (e.g., Lipper et al., 2009; Nagarajan and Smale, 2006). This is probably because farmer associations facilitate the sharing of information, knowledge learning, and access to improved seeds, and as such the adoption of new technologies.

We also found that the higher the distance of the farmer's house to the nearest agricultural field office, the lower the probability that farmers will adopt Apomuden, all else equal. Extension agents inform and educate farmers about new technologies and practices. Thus, farmers who live closer to the extension office are likely to get information about the benefits of growing and consuming Apomuden. In other words, these results indicate that farmers farther away from source of extension services are less likely to receive information about new technologies. Our findings are in line with those of Adesina and Zinnah (1993) and Shiferaw and Holden (1998) who argued that access to extension agents increases the likelihood of adoption of improved technologies.

Our results also showed that participation in training on agronomic practices relating to Apomuden production, and in cooking demonstrations, increased the likelihood of adoption of Apomuden. These findings indicate that there was strong evidence from the data to suggest that participation in the Jumpstarting project (hence knowing how to manage Apomuden production and being aware of benefits of eating OFSP) affected the decision to adopt OFSP. Adekambi et al. (2020) document the intensive efforts by the project to sensitize farmers about the health benefits of eating OFSP in Ghana and Nigeria including effect of using strategies such as market awareness, radio programs, production of cookbooks and cooking demonstration, and training of trainers to encourage adoption of OFSP.

## Summary, conclusion and recommendations

The objective of this paper was to test the effect of sensory attributes on farmers' decision to adopt the released OFSP variety, Apomuden. The study showed that the most desirable attributes preferred by the respondents were related first to high yield, then to the taste of the roots, followed by early maturity, the taste of the leaves, resistance to pests



and diseases, and ease of establishment with scarce rain. The results of the multivariate probit analysis showed that the attributes taste and dry matter content individually affect the decision to adopt Apomuden. However, the directions of the effects of taste and dry matter differ: taste increases likelihood of adoption while dry matter content (known to be lower compared to Obare) reduces it. We find no evidence that sweetness by itself affected adoption of Apomuden. Results of the Wald joint exclusion test however show strong evidence that the three sensory attributes (taste, sweetness and dry matter content) have a joint influence on the decision to adopt Apomuden.

Other variety-specific attributes (early maturity, disease resistance, high yield, ease of establishing with scarce rains, ease of storing in the ground, and ease of cooking) played a stronger role in farmers' decision about which variety to cultivate than the organoleptic attributes. On the one hand, the local variety, Obare, had desirable taste compared to Apomuden. On the other hand, Apomuden was perceived better with respect to early maturity, disease resistance, superior yield potential, and drought tolerance. In addition, variety-specific attribute factors, institutional factors (being trained on Apomuden production management, participation in cooking demonstrations, access to extension services and group membership) also appeared to drive adoption of Apomuden in the study areas. Although this variety had low dry matter content, it was accepted due to good sensitization on its biofortified nature. This study therefore concludes that sensory attributes have joint significant effect on adoption of Apomuden, an OFSP variety. It also concludes that taste and dry matter individually affect adoption of Apomuden, but in different directions.

The policy implication from this study is that breeders need to pay attention to a comprehensive list of agronomic and sensory attributes. Clearly, farmers' preferences should be taken into account when developing new OFSP varieties. This often occurs at harvesting times for agronomic performance assessment, but often there is inadequate involvement of farmers in assessing taste and other sensory traits. Breeders were aware prior to the Jumpstarting project that low dry matter would likely be an issue, and how to shorten cooking times for Apomuden was included in the cooking trainings. Nonetheless these findings provide important feedback to the breeding program regarding the issue of low dry matter in Apomuden. The finding about institutional factors suggests the need for policies that will facilitate farmer access to agricultural advisory services if OFSP adoption is to be improved.

#### Declaration of conflicting interests


The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

#### Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The authors acknowledge funding from Bill & Melinda Gates

Foundation through the project OPP1081538 "Jumpstarting Orange-fleshed Sweetpotato in West Africa through Diversified Markets". This research was undertaken as part of the CGIAR Research Program on Roots, Tubers and Bananas (RTB).

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