203- Farmers Preferences for Cassava Variety Traits: Empirical Evidence from Ghana

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Abstract

Cassava, has received much research on improved varietal development in Ghana. The National Agricultural Research Systems (NARS) have released about 24 improved cassava varieties since 1993, which are high yielding, disease and pest resistant and early maturing. However, adoption by smallholder farmers is very low leading to low outputs and low incomes. Adoption could be improved with greater understanding of farmers' cassava variety attributes preferences. Using stated preference technique, specifically, choice experiment applied across 450 farm households, we evaluated farmers preferences for cassava variety attributes in Ghana and identified farm household-specific and institutional factors that governed the preferences. The empirical results showed that in-soil storage (longevity) and disease resistance are important attributes for farmers' choice of cassava varieties. Farmers have lower utility towards high productivity. Farmers are willing to forgo some extra incomes and yields in order to obtain a more disease and pest resistant varieties and increased longevity of matured roots in the soil. This implies that until market chains are expanded the introduction of new and improved varieties would not contribute significantly towards utilities. Among other things, age, gender, extension and years of farming experience, are the major factors causing household heterogeneity of cassava varieties preferences. Based on our experimental results, we derived important policy implications for breeding priority setting and cassava varieties adoption.

Keywords: cassava, choice experiment, market chain, policy

1. Introduction

Cassava is widely seen as a potential remedial crop for smallholder farmers in sub-Saharan Africa due to its high productivity and low input requirements. Apart from being a food security crop, it thrives very well in resource-poor areas where land availability is declining (Scott *et al*, 2000). In Ghana, the annual per capita consumption of cassava is about 155 kg, which is one of the highest in the world (MoFA, 2009). Despite its food security role during

periods of acute food shortages, the national average yield of cassava is about 14t/ha with a potential of increasing to over 47 t/ha through increased use of improved varieties and good management practices (MoFA, 2009). From 1997 to 2002, the growth rate of cassava was 6.56 % compared to 4.48 % from 2003 to 2009. Attempts over the years have been geared towards area expansion rather than increasing the yield per hectare (Nweke, 2004; IFPRI, 2007).

Evidence suggests that one of the major causes of low productivity of cassava in Ghana is the continuous use of traditional, low yielding crop varieties (MoFA, 2007). Consequently, research and extension have focused on the development and diffusion of improved cassava varieties through multilocational, on-farm and adoption trials (Manu-Aduening *et al*., 2005). The improved cassava varieties are characterised by crop-specific traits such as high yielding, pest and diseases resistance, early maturity, high dry matter and starch contents (Crops Research Institute, Annual Report, 2010). Notably, the crop variety traits or attributes are the performance characteristics of the plant varieties that include both the production (agronomic) capacity of the plant and the consumption attributes of the product (Edmeades, 2003). Despites these efforts, limited adoption of the improved varieties still persist (IITA, 1999; Manu–Aduening *et al*., 2005; Dankyi and Agyekum, 2007; Owusu and Donkor, 2012). Although improved crop varieties may be high yielding, they may not be attractive to farmers unless they possess some crop-specific traits that farmers consider important (Asrat *et al*., 2009). Recent studies on farmers' crop variety choices consider crop as a bundle of multiple characteristics (Wale *et al*, 2005, Smale *et al*., 2001; Edmeades *et al*., 2008; Badstue *et al*., 2003). Specifically for cassava, such bundle of traits may include production characteristics such as disease and pest resistance, high yielding, early maturity and adaptability to harsh environments (Manu–Aduening *et al*., 2005); consumption characteristics such as taste and colour and subjective importance farmers place on seeds (Wale *et al*., 2005).

Smale *et al*. (2001) argue that farmers choose crop varieties based on a set of attributes that best responds to production constraints, assures consumption preferences and satisfies specific market requirements. These crop-specific attributes hypothesis have been highlighted in some adoption studies (Adesina and Zinnah, 1993; Adesina and Baidu-Forson, 1995; Adesina and Seidi, 1995). Farmers' adoption decisions are therefore not only driven by profit maximisation but rather on complex processes that are affected by several socio-economic and psychological variables (Willock *et al.* 1999; Traxler and Byerlee, 1993). Moreover,

farmers grow crops that satisfy their concerns and that once there is harmony between these concerns and variety attributes, the result is varietal preference and land allocation decision (Wale and Mburu, 2006).

Although some studies have explored the determinants of adoption of improved cassava varieties by farmers in Ghana (Dankyi and Agyekum, 2007; Owusu and Donkor, 2012) and other developing countries (Conley and Udry, 2002; Mather *et al*., 2003; Faturoti *et al*., 2006; Badal *et al*., 2007) the preferences of farmers for cassava variety traits have not received much attention . Using choice experimental technique, the present study explores farmers' preferences for cassava variety traits and the values that farmers place on different traits. It further examines the preferences in terms of the perceived benefits farmers obtain from the cassava variety traits. Most studies that have applied choice experiments have done so with much emphasis on livestock-specific traits, especially in East Africa (Scarpa *et al*., 2003; Ouma *et al*., 2007; Ruto *et al*., 2008; Zander and Drucker, 2008; Girma *et al*., 2009). Fewer studies however have been undertaken on crop variety traits (Asrat *et al*., 2009; Wale *et al*., 2005). This study therefore expands the literature on crop variety traits in Africa by employing choice experiment to elicit farmers' preferences for cassava traits. The present paper contributes to the empirical literature on choice experiments by assuming a non-random fixed-cost coefficient whilst other attributes are allowed to vary. Revelt and Train (1998) pointed out that fixing the price or the cost coefficient assures the correct apriori sign of the coefficient, ensures the same distribution for the willingness to accept of the remaining attributes and assists in the empirical identification when cross sectional data is employed (Hensher *et al*., 2005).

The paper is made up of six sections. Section 1 has introduced the paper. Section 2 provides brief literature review on choice experiments. Section 3 presents the conceptual framework and the empirical models. Section 4 explains the data collection. Section 5 discusses the results of the study. Section 6 presents the concluding remarks.

2. Literature Review on Choice Experiment

Choice experiment is a stated preference analysis developed from conjoint analysis and discrete choice theory (Louviere and Woodworth, 1983; Louviere, 1988). It is also in line with the random utility theory and Lancaster consumer demand theory (Lancaster, 1966; 1971). In choice experiment, the choice and attribute trade-offs are allowed to occur

concurrently (Zou, 2011). The choice experiment methods assess the values of attributes of a product by asking people to choose the most preferred product out of a few available products. In each scenario, the alternative options are described as combinations of different levels of the attributes, and the descriptions of the alternatives vary among scenarios.

Experimental design is concerned with how to create the choice sets in an efficient way by combining attribute levels into profiles of alternatives and profiles into choice sets. According to Huber and Zwerina (1996), four principles for an efficient choice experimental designs of nonlinear models are orthogonality (where attribute levels within each choice set are not correlated), level balance (where attribute levels occur the same number of times within a choice set), minimal overlap (where attribute levels are not repeated within a choice set) and utility balance (where each alternative within a choice set has approximately the same utility). The design is developed in two-steps by obtaining the optimal combinations of attributes and attributes levels to be included in the experiment, and by combining those profiles into choice sets. A starting point is a full factorial design, which contains all possible combinations of attribute levels that characterize the different alternatives. However, a full factorial design is very large and not easy to manage in a choice experiment. To overcome this, a subset of all possible combinations must be chosen by following some criteria for optimality and construction of the choice sets. The advantages of choice experiment over contingent valuation approach are the avoidance of "yes-saying'' and built-in tests of sensitivity (Hanley *et al*., 1998). One drawback is that it's more demanding for respondents to answer the list of questions posed to them compared to the contingent valuation technique. Also, preferences may be unstable throughout the experiment and the difficulty of designing the experiment.

3. The conceptual framework and empirical models

The choice experimental framework employed in this study originated from the Lancaster consumer theory (Lancaster, 1971). This postulates that preferences for goods are a function of the traits, or characteristics possessed by the good, rather than the good per se. The overall utility of the good is decomposed into separate utilities for its constituent characteristics or attributes. The utility function translates into attributes of the goods where the attributes can generate utility or disutility to individuals (Ouma *et al.*, 2007).

It is assumed that an individual *n* derives utility *U* from choosing an alternative *i* from a finite set *j* of alternatives in a choice set *k*, if and only if, the alternative generates at least as much utility as any other alternative where X_{ni} denotes a vector of attributes of *i*. The utility of the good, $U_{ni} = U(X_{ni})$ is composed of an observable or deterministic component (V_{ni} V_{ni}) and an unobservable or random error component (ε_{ni}) (Boxall and Macnab, 2000):

$$U_{ni} = V_{ni} + \varepsilon_{ni} \tag{1}$$

Disaggregating the systematic component of the choice further, Rolfe *et al*. (2000) note that the utility could be expressed as a function of the attributes of the relevant good (Z_{ni}) and the characteristics of the individual (S_{ni}):

$$U_{ni} = V(Z_{ni}, S_{ni}) + \varepsilon_{ni} \tag{2}$$

Since the preferences cannot be fully predicted due to the inherent stochastic or random error component of (U_{ni}), the choices between the alternatives are expressed as a probability of the *n*th individual choosing *i*th alternative:

$$P_{ni} = P\left(U_{ni} > U_{ih}, \forall_i \neq h\right) \tag{3}$$

From (2) and (3), we can derive:

$$P_{ni} = P(\varepsilon_{ij} - \varepsilon_{ih} > v_{ih} - v_{ij}, \forall i \neq j) \tag{4}$$

The cumulative distribution expressed in (4) indicates the probability that each random term is below the observed quantity (Train, 2003).

Assuming a linear utility function for the deterministic component in (1) an (2), we have

$$U_{ni} = \beta_n \chi_{ni} + \varepsilon_{ni} \tag{5}$$

where χ_{ni} is a vector of observed variables such as cassava traits and socioeconomic characteristics. For multiple choice alternatives, (5) becomes, $U_{ij} = \max\{U_{io}, ..., U_{iM}\}$ and the probability that the farmer *i* with preference C_i for a cassava variety *j* from among *M* alternatives could be stated as:

$$P(C_i = j) = P\left(U_{ij} = \max(U_{io}, ..., U_{iM})\right) \tag{6}$$

Assuming that the error terms in the utility functions are logistically distributed and that the farmer *i* may prefer alternative *j*, then the conditional logit model (McFadden, 1974) could be specified as in (7):

$$P(C_i = j) = \frac{e^{\beta_j \chi_i}}{e^{\beta_o \chi_i} + e^{\beta_1 \chi_i} + ... + e^{\beta_M \chi_i}} \quad (7)$$

For the independent variables χ_i in the conditional logit model to vary across choice alternatives, we specify an indirect utility function (Ouma *et. al*. 2004):

$$v_{nj} = \beta_0 + \beta_1 Z_1 + \beta_2 Z_2 + ... + \beta_n Z_n + \beta_a S_1 + \beta_b S_2 + ... + \beta_m S_k \quad (8)$$

where β_0 is the alternative specific constant (ASC) that captures the utility effects from attributes not included in the choice specific attributes[1]. β_1 to β_n are coefficients of the vector of attributes (Z) and β_a to β_m denotes the coefficients of the vector of interaction terms (*S*).

To account for unobserved, unconditional heterogeneity the random parameter logit or the mixed logit model (Train, 1998; Hensher, 2001; Greene and Hensher, 2003; Meijer and Rouwendal, 2006; Ouma *et al*., 2007; Asrat *et al*., 2009) is specified as in (9). As noted by Boxall and Adamowicz (2002), controlling for heterogeneity enables prescription of policies that take equity concerns into account and also throws more light on who will be affected by a policy change and the aggregate economic value which is associated with such change.

$$L_{ni}(\beta_n) = \frac{e^{\beta_n \chi_{ni}}}{e^{\beta_o \chi_{ni}} + e^{\beta_n \chi_{ni}} + ... + e^{\beta_M \chi_{ni}}} \quad (9)$$

The unconditional probability is then of the form, $P_{nj}(\theta) = \int L_{nj}(\beta_n) f(\beta_i / \theta) \partial \beta_i$ with the log-likelihood function, $LL(\theta) = \Sigma_n InP_n(\theta)$. (10)

where θ is a vector of parameters of a continuous population distribution, ε_{ni} is an unobserved random term that is assumed to be identically and independently distributed. Conditional on β_n the probability that an individual chooses an alternative *j* in a choice set k is the conditional logit specified in (7) and $f(\beta_i / \theta)$ denotes the population density. The log-likelihood function is maximized via simulation. Specifically, $P_n(\theta)$ is approximated by a summation over values of β_n generated by Halton draws (Train, 1999). To detect the sources of heterogeneity while accounting for unobserved heterogeneity would be the inclusion of respondent characteristics in the utility function as interaction terms. This enables the random parameter logit model to pick up preference variation in terms of both unconditional taste heterogeneity (random heterogeneity) and individual characteristics (conditional heterogeneity), and hence improves the model fit (Asrat *et al*., 2009).

Related to the cassava traits examined in the mixed logit model are willingness-to-accept estimates considered as point estimates if the parameters are non-random.[2] If the parameters are random, then the WTA estimates cannot be derived from the mixed logit model but rather approximated via simulations (see for instance; Krinsky and Robb (1990); Hensher *et al*., 2005, pp688; Thiene and Scarpa, 2009).

4. Data Collection

Sampling Techniques

The cross-sectional data employed in this study comes from a choice experimental survey conducted between January and March in 2011 in three administrative regions of Ghana. These regions were Ashanti, Brong Ahafo and the Eastern Regions. The regions are geographically located in the semi-deciduous rainforest and the forest-savannah transition agro-ecological zones. The agro-ecological zones have bimodal rainfall distribution. Specifically, the semi-deciduous rainforest has a mean annual rainfall of 1500 mm whilst the forest-savannah transition zone has a mean annual rainfall is 1300mm. The soils in the semi-deciduous rainforest are forest ochrosols suitable for food and tree crop production. The soils in the forest-savannah transition zone are generally less leached and acidic than that of the semi-deciduous forest.

A multi-stage sampling approach was adopted for the study. After the regions were purposively selected to reflect cassava production, distribution and agro-ecological zones, a district each was purposively selected also based on cassava production levels in the three regions (MoFA, 2009). The selected districts were Atwima Nwabiagya in the Ashanti region, Fanteakwa in the Eastern region and Techiman Municipal in the Brong Ahafo region. This was followed by a random selection of five communities from each of the selected districts. Finally, 15 farm households were randomly selected from each of the selected communities making a total sample of 450 farm households. Prior to the survey, a list of all the locations in each of the selected district was obtained from the municipal offices of the Ministry of Food and Agriculture (MoFA) in Ghana. The list of farm households in each of the selected villages was also obtained from the District Agricultural Extension Agents (AEAs) from MoFA and person-to-person contacts with the local people.

The Choice Experiment

The presentation of alternatives to the farmers in the choice experiment was carried out with the use of verbal and paragraph descriptions and pictorial representations (Cattin and Wittink, 1982).The verbal descriptions used cards in which each trait level was described in brief, while the paragraph descriptions gave a more detailed description of each level. The pictorial representations used some graphical images to present the levels of traits.[3] The cards provided pictorial representations of the differences in the levels of traits of each cassava variety profile (see Appendix A1). In all, a total of 8100 choices were elicited from 450 farmers who took part in the choice experiment.

Table 1. Attribute and attribute levels used in the choice experiment

Attribute	Description	Attribute levels
Productivity	Average production harvested per hectare from planting a particular cassava variety.	• 15 tonnes • 30 tonnes • 60 tonnes
Disease and pest resistance	Whether a particular variety withstands diseases and pest	• yes • no
In-soil storage	Whether a particular variety is able to remain in soil for up to 24 months	• able to remain in the soil for up to 24 months • able to remain in the soil for more than 24 months
Multiple Usage	Development of product from a particular cassava variety	• fufu and gari • Gari and dough • Dough, gari and fufu
Producer price	The amount of money the farmer earns by selling 99 kg bag of harvested cassava of a particular cassava variety.	• 15Gh₵ • 30 Gh₵ • 45Gh₵

Note. 1 US Dollar ($) =1.74 Ghana Cedi (GH¢) in 2012
Source: Survey data, 2011

During the choice experiment, the respondents were introduced to six choice sets and asked to choose one out of the three given cassava profiles.[4] In order to identify the relevant cassava traits, informal focus group discussions were held with cassava expects such as cassava breeders and agronomists from relevant research institutions and universities. In addition, series of qualitative interviews were conducted with farmer groups from the three selected districts to identify the most important attributes of the cassava varieties. Specifically, fifteen focus groups comprising of 8 to 10 cassava farmers (males and females)

were conducted in the study sites as part of the baseline survey. As indicated in Table 1, this baseline information was used to generate a definitive set of four attributes that were relevant from the point of view of farmers' choices. To capture the marginal willingness to pay for the traits, an additional monetary trait, specifically, the producer price was included. Each attribute had two to three levels.

The data were coded according to the levels of the attributes in the choice experiment (Table 2 not presented in the interest of brevity). The primary aim of the experiment was to select the few important main effects from the many less important ones. The choice set from the design was used to construct profiles describing the differences in traits and levels of improved cassava variety which were then presented to respondents in a hypothetical setting. The profile plans were grouped into 6 types of questionnaires with three profile plans (alternatives) forming a choice set (see an example of one such choice sets used in the choice experiment in Table 3). Given the differences in attribute level between the varieties, the choice experiment was designed in such a way that farmer preferences for a particular attribute level could be associated with a particular cassava variety even though the variety was not shown directly in the individual cassava profile

Table 3 Example of a choice set

1.6	Cassava variety 16	Cassava variety 17	Cassava variety 18
Productivity	15 tons per acre	15 tons per acre	30tons per acre
Disease and pest resistance	Yes	Yes	Yes
In-soil storage	Up to 24 months	Up to 24 months	Less than 24 months
Fresh tuber usage	Fufu ,gari	Gari , fufu, dough	Fufu ,gari
Producer price	₵30	₵45	₵15
I would prefer to plant ….(check only one option)	☐	☐	☐

Note: The question asked was; assuming that the following cassava varieties were your ONLY choices, which one would you prefer to plant?
1 US Dollar ($) =1.74 Ghana Cedi (GH₵) in 2012.

5. Results and discussion

This section discusses the empirical results on mixed-logit models estimated with and without interactions and WTP estimates for the cassava traits investigated. The descriptive statistics of the variables employed in the regression models are presented in Table 4 (not presented in the interest of brevity). Males dominated the farm household heads. Although women cultivate owned crops, they do so on pieces of land within the total land of the household

(Doss, 2001). Mean ages of the farm household heads in Atwima, Techiman and Fanteakwa are 46, 48 and 43 years respectively. On the average, the number of years of education is about 8 years in Atwima, 5 years in Techiman and 7 years in Fanteakwa District. The total farm sizes are 8 acres, 11 acres and 9 acres respectively in Atwima, Techiman and Fanteakwa with farmers mostly cultivating their owned plots. The mean area under cassava cultivation is 2 acres and the average distance from farm to market is 4 km, 8km and 9 km in Atwima, Techiman and Fanteakwa respectively.

The estimates of the conditional logit and mixed logit models without interaction terms are presented in Table 5. The conditional logit was estimated before the mixed logit as it derives initial start values for the means of the coefficients and sets the starting values for the standard deviations to 0.1(Hole, 2007). Notably, the mixed logit was estimated to test the null hypothesis that the standard deviations of the parameter estimates are all equal to zero (Hole, 2007).. The estimates were obtained after 500 Halton replications. The likelihood-ratio value for the joint significance of the standard deviations is 30.19 and highly significant implying a rejection of the null hypothesis that all the standard deviations are equal to zero. Comparing the likelihood ratios at convergence of the conditional logit (-2887.028) and the mixed logit (-2547.88), suggests an improvement in the model fit. This also implies that the mixed logit model fits the data better than the conditional logit model. The mean coefficients for all the random parameters are positive and significant indicating that all the farmers have positive preference for all the attributes[5]. With the exception of multiple tuber usage attribute, the

Table 5 Pooled simulated maximum likelihood estimates

Variable	Mean coefficient	Derived standard deviation coefficient
Producer price	0.01803*** (0.00244)	-
Productivity	0 .00764***(0.00164)	0.0118** (0.0037)
Disease resistance	0.5510*** (0.0724)	0.7894*** (0.1014)
In-soil storage	1.1773*** (0.0787)	0.4161*** (0.1553)
Multiple Tuber usage	0.2723*** (0.0319)	-0.1357 (0.1044)
Observations	8100	
Likelihood ratio	30.19***	
Log-likelihood	-2547.88	
Halton's Replications	500	
Pseudo- R^2	0.33	

Note: Standard errors are in parentheses; ** and *** denotes 5% and 1% significance levels respectively.
Source: Authors' computation, 2012

standard deviations of the random parameters are highly significant indicating preference heterogeneity in the population. The results also show that the cassava farmers have constant preference for multiple tuber usage variables.

Although the mixed logit accounts for unobserved heterogeneity, it fails to explain the sources of heterogeneity (Boxall and Adamowicz, 2002). To detect the sources of heterogeneity and at the same time account for unobserved heterogeneity, interactions of the farmer-specific social, economic and attitudinal characteristics with choice specific attributes are included in the mixed-logit model (Revelt and Train, 1998). This enables the mixed logit model to pick up preference variation in terms of both unconditional taste heterogeneity (random heterogeneity) and individual characteristics (conditional heterogeneity), which thus improves the model fit. Table 6 presents the estimates from the mixed-logit when interaction terms are included. The log-likelihood ratio test showed that including the interaction terms improves in the model fit.

When the socio-economic characteristics are included, the tuber usage (multiple uses) attribute is no longer statistically significant and producer price produces positive utility. The rest of the choice specific attributes remain statistically significant, indicating that data supports choice specific unconditional unobserved heterogeneity for these attributes. This shows that most of the positive utility derived from producer price, and tuber usage attributes of cassava varieties, as reported in previous results, is explained by the interaction terms between these attributes and the socio-economic characteristics.

The variables household size, years of education, farm size and field days or demonstrations had no influence on respondents' preferences for any cassava traits. Gender (coded as 0=male, 1= female) and household size were expected to have a positive effect on the preference for the producer price of cassava. Higher producer price was expected to influence males’ choice of cassava variety. The fact that most of the characteristics describing respondents' were insignificant signifies that all respondents were very homogenous in their socio-economic background. Significant interactions were found for the following three variables

Experience and demand for disease resistance attribute is positive and highly significant. More experienced farmers may also have larger family sizes and are more likely to adopt improve varieties that have yield increasing attributes. This is to avert the shock towards

yield decreases associated with disease and pest occurrences in order to guarantee good outputs for family consumption and for sale. This finding is similar to the work by Asrat *et al*. (2009) where he finds that farm households with larger families demand yield stability as a way of averting the shock associated with disease and pest occurrences. Farmers who are more experienced might have encountered cassava mosaic virus disease and its effect on output thus inducing more experienced farmers to look for cassava varieties that are better

Table 6 Results of mixed logit model with socio-economic interactions

Cassava traits	Coefficient	Stand error
Mean parameters		
Productivity	0.0146**	0.0078
Disease resistance	1.593***	0.3414
In soil storage	0.3894***	0.3159
Producer price	0.0179	00113
Tuber usage(multiple usage)	-0.1576	0.1506
Disease resistance*gender	-0.4009***	0.1460
Disease resistance*age	-0.0253***	0.0072
Disease resistance* experience	0.0238***	0.0067
Disease resistance*extension	0.266*	0.1561
Soils storage*gender	0.2587**	0.1386
Multiple tuber usage *gender	0.11259*	0.0665
Multiple tuber usage*age	0.0096***	0.0033
Standard deviations of parameters		
Productivity	0.0099***	0.0040
Disease resistance	0.7107***	0.1044
Soils storage	0.3720**	0.1720
Multiple usage	-0.0819	0.164
Number of respondents	450	
Number of observations (choices)	8100	
Pseudo- R^2	0.40	
Log likelihood at convergence	-2504.81	

*significance at 10%, **significance at 5%, ***significance at 1%
Source: Authors' computation, 2012

resistant to cassava mosaic virus disease. Extension contacts and demand for disease resistance was positive and significant. This suggests that those who have contacts with extension agents are more informed about technology and are able to make informed decisions. Farmers can only be informed about the characteristics of an introduced variety by reading and through extension agents.

The interaction of gender and disease resistance attribute was negative and significant. This implies that males are more concerned about disease resistance than females. Non-

susceptibility to diseases is synonymous to low yields. This result is not surprising as males rely so much on food crops production for their incomes and would want any variety that would not compromise yields. Gender also had positive and statistically significant influence on two other variables, soils storage (longevity) and tuber usage (multiple usages). Females are more likely to choose cassava varieties that can stay longer in soil after maturity whilst males are likely to choose otherwise. Females are also more likely to select cassava varieties with multiple usages. Age and disease resistance was negative and significant, meaning younger famers are more concerned about disease resistance and hence yield of the cassava variety than the older farmers. There is high demand for multiple usages by the older farm households. Older farmers are knowledgeable of different uses of cassava and hence their high affinity towards multiple usages.

To account for village-specific trait preferences, the null hypotheses that the parameter estimates from each of the locations were equal were tested. As indicated in Table 7 (not presented here in the interest brevity), the differences in the trait preferences for the three districts are visible as the Log-likelihood ratio test for pair-wise comparison of parameters are different. This shows that farmers from each district had different preferences for cassava breeding traits. Moreover, the Pseudo-R^2 for Techiman municipality compared to the rest is relatively low suggesting that the attributes do not equally well reflect each of the three locations and that other breeding attributes not included in the study (for instance, canopy formation) may be relevant breeding characteristics of cassava in the studied districts.

The mean price coefficients are positive and significant in the three surveyed locations (Table 7). This indicates farmers' strong preferences for higher producer price in all the districts. Smallholders consider higher producer prices as beneficial since it increases their incomes and thereby improving their livelihoods. This finding is similar to Timu *et al* (2012) who found that the ability of a variety to fetch higher producer price was incentive to farmers' selection of that variety. The attribute disease resistance attribute is positive and statistically significant in all the three locations. Implying that, smallholders attach importance to cassava varieties that are resistance to cassava mosaic virus disease. This ensures low input use and guaranteed yields. Ghanaian farmers mostly practice low input agriculture (MoFA, 2007) and so any cassava variety with tolerance to cassava mosaic virus disease and which would not need spraying would increase farmers' choice of that variety.

Estimates obtained for the pooled sample suggest that another important cassava breeding trait is In-soil storage (longevity).

Table 8 presents the mean WTP and confidence intervals (CI) estimates (not presented in the interest of brevity). These were calculated using the Krinsky and Robb (1990) bootstrapping procedure embedded in Stata 11.2 software. [6] Notably, 95% CI of each WTP estimate from the random parameters are reported. The negative WTP values for all of the attributes suggest that farmers are willing to pay less, in terms of income generated from cassava sale, for more productive, more disease tolerant, increase in underground storage period and the ability of cassava varieties to be used for multiple purposes. Farm households in all locations attach importance to in-soil storage and disease resistance attributes. At Atwima Nwabiagya, farmers are willing to pay averagely, ₵ 321 production per hectare of cassava produced for a unit increase in period of storage and ₵123 and for a unit increase in the crops ability to withstand cassava mosaic virus diseases. Farmers in Techiman municipality are willing to give up even more sales per hectare for improved underground storage of cassava variety and more resistance to cassava mosaic virus disease. This suggests that farmers do not look for a single attribute when making seed selection decisions but focus on non-tradable attributes like in-soil storage and disease resistance The trait tuber usage (ability for multiple usages) is also valued by smallholder farmers in all the districts. The magnitudes though differ from each of the district.

6. Conclusions

Farmers' preferences for cassava varieties traits have been examined using discrete choice models such as mixed logit models**.** The choice experiment method used in this study is a good example of a bottom-up approach to research. It can be used to either fine-tune existing technologies or to generate information about farmers' preferences for new technologies such as the new improved cassava varieties. The empirical results have provided insights to understanding farmers' choice of cassava varieties. Results revealed preference heterogeneity amongst farm households in the study areas. The mean coefficients for all the attributes parameters were positive and significant although results indicate high preference for in-soil storage (longevity) and disease resistance. Productivity and producer price attributes were only weakly preferred by farm households in the sample population. These findings may explain the low adoption rates of high yielding improved cassava varieties in Ghana over the

years. The fact that farmers attach substantial weights to both in-soil storage and disease and pest resistant traits allude to the need for breeding varieties that have the ability to stay longer in the soil to serve as storage facility. The reason is that cassava market chains are not well developed except the fresh tuber market and farmers face challenges in distributing their produce.

We also find that farm households value in-soil storage, disease resistance and multiple usages than increased productivity. Farmers are ready to give up more in sales for varieties that can store well in the soil after maturity and varieties that are disease resistant, probably reinforcing their high preference for increased storage of matured tuber in the soil and disease resistant attributes. Farmers also value varieties that have multiple uses. In a country where cassava value chains are less developed and where storage facilities for food crops are limiting, risking output is an important consideration when making production decisions. This is perhaps one major reason behind the low adoption rates of high yielding improved varieties, which are generally believed to deteriorate a few months after maturity in the soil. This result has important implication for breeding of cassava varieties and for subsequent adoption. It shows how important the in-soil storage and disease resistance attributes are in motivating farmers to participating in improved cassava varieties.

These results have important implications for breeding priority setting, and targeted diffusion of improved cassava varieties in Ghana. For breeding priority setting, given that farmer's preferences for variety traits determine to a large extent their choice of a variety breeding should satisfy the demand of farm households. The results show that farmers attach greater importance to in-soil storage and disease resistance. The national agricultural research systems (NARS) primarily dealing with crop breeding programs in Ghana, should therefore prioritize these attributes in their direct or supportive breeding programs.

According to the results, in order to increase demands of farmers, the variety attributes of in-soil storage and disease resistance should be prioritised over productivity traits, which farmers deem less important. This probably suggests the importance of development of market chains for cassava. Farmers would not see the need to adopt more productive cassava varieties when constraints to marketing are not alleviated. Government intervention should therefore emphasize improving markets and value chains.

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Endnotes:

[1] The constant term β_0 is dropped from the model estimations in this study because the choice sets do not include a status quo or an opt-out option (Bateman *et al.*, 2003: pp 75). As pointed out by Asrat *et al*.(2009), the ASCs are largely included to return the differences in utilities for each alternative relative to the base (status quo) when all attributes are equal.

[2] The willingness-to-accept estimates are the marginal rate of substitution between prices and traits.

[3] These were deemed plausible due to high illiteracy rates and language differences

[4] Unlike traditional choice experiment, no ''opt-out'' was included in the choice sets. The farmer had to choose amongst one of the alternatives. This is so because the study did not examine the willingness to pay for improved cassava variety but rather marginal willingness to pay for variety attributes. As noted by Carlson *et al*. (2007), it is not necessary to include an opt-out alternative in such a case.

[5] The mean coefficient estimates of each of the random parameters are linked with standard deviations which indicate the amount of spread that are present in the sample population.

[6] See Krinsky and Robb (1990) for full model specification