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Assesing farmer perceptions, attitudes and preferences for tissue culture banana technology in Kenya

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Abstract Producers' and consumers' preference for production and sell of different TCB fruits is a critical aspect in marketing and is determined mainly by its technological attributes and farmers, farm and institutional factors. The introduction of a Tissue Culture (TC) banana (Musa spp.) in Kenya is subject to farmer and consumer tastes and preferences and the evaluation is critical in enhanced adoption. The purpose of this study was to show farmers' preferences to TCB and the potential challenges for production and consumption of the product. The paper examines the factors that lead farmers' preferences of TCB technology in the four counties of west Kenya. The primary data was collected through a survey using a semi-structured questionnaire. A total of 330 randomly selected farmers using a stratified multistage sampling method were interviewed. Both descriptive and inferential statistics were used to analyze the data. A three tire multinomial nested logit analysis was carried out to identify the factors that lead farmers' preferences to TCB cultivar preferences. Based on the analysis, six factors were identified as the reasons for preference of TCB technology. The findings indicated that the farm size, sex of household head, educational level, and family size played a significant role in TCB cultivar preferences. These factors need to be utilized in targeting TCB technology dissemination. However, consumers' preference for banana fruits is a critical aspect of marketing and is determined mainly by its sensorial aspects, among other aspects this need to be done. In addition there is need to have more cooking cultivars in tissue culture technology.

Key word: Culivars, nested mlogit analysis, preferences, TC banana

Introduction

Bananas (*Musa* spp.) are one of the world's most important food crops. Banana constitutes the fourth most important global food commodity after rice (*Oryza sativa*), wheat (*Triticum aestivum*) and maize (*Zea mays*) in terms of the gross value of production (Frison *et al*., 2007). Banana is fast becoming more and more important as cash crop. In East and Central Africa, about 70 million people depend on banana for a large proportion of their daily carbohydrate needs. In Kenya, bananas are both an important staple crop as well as a source of income for subsistence farmers. There has been an increase towards large-scale production of bananas in the traditional high potential region of Kenya. This could be attributed to the relative better income compared to other traditional crops like maize, wheat and dairy.

It is recognized that increasing population, changing eating habits and urbanization have led to enhanced bananas production and making the enterprise important as food and cash crop, providing, in some cases, the sole resource of income to the rural population, thereby playing an important role in poverty alleviation and food security (FAO, 2004). About 49% of the farming households in Kenya produce banana as their main crop. In Western and Northwestern Kenya, banana serves as source of income for some of the population.

Previous research on bananas has concentrated largely on agronomy methods with little attention given to its marketing aspects in terms of preferences (Mbogoh, 2003; Wambugu, 2004; Nguthi, 2007). As a result, little is known about banana's marketability, consumption patterns and consumer preferences. Marketability is influenced by factors such as consumers' eating habits, access to the product, knowledge and consumers preferences. Preferences are symbolised by the perceptions, taste and attitudes that consumers hold toward food types. As markets emerge, producers and consumers are faced with more choices of what to produce and consume. For successful adoption, a new crop or cultivar should offer a combination of good fruits and market demand by meeting the needs of consumers. Farmers who are producers should know that consumer preference will drive the evolution of the farm industry (Ballenger & Blaylock, 2003). The consumer preferences could orientate the production, distribution and commercialization of banana fruits.

The biotechnology products that now hold promise for poor people in Sub-Saharan Africa are those that tackle economically important, biotic or abiotic problems not easily addressed through conventional plant breeding or pest control, in crops that serve for food as well as cash, while posing little risk of endangering trade (Melinda & De Groote, 2003). Tissue Culture technology is one of them. TCB was introduces in Kenya in late 1990s. However, limited information exists on farmer preferences of some TCB cultivars. This research was designed to bridge this gap. In Kenya, it was reported that consumer preference is one of the factors that affects banana consumption pattern. In order to know and meet the consumers' need, evaluation of the consumer preference is necessary and important. The objective of this study was to evaluate the consumer preference of TCB banana cultivars in North-rift, Nyanza and Western parts of Kenya. This is expected to contribute to the development and up-scaling desirable banana cultivars including TCB in Kenya.

Methodology

Study area. East Africa (most notably the Great Lakes region covering portions of Rwanda, Burundi, Tanzania, Kenya and Congo) is the largest banana producing and consuming region in Africa. In Kenya the major banana producing regions are central Eastern Nyanya and western Kenya. This study was undertaken in selected counties of Nyanza (Kisii); Western (Bungoma), Rift valley (Trans Nzoia and West Pokot). The TCB technology was introduced and up-scaled in these counties. The counties lie in Upper midland, Lower midland, Upper Highlands, and Inner Lowlands where banana production is under furrow irrigation (Jaetzold, 1983).

Survey plan. Survey data was collected in July and August of 2012 in four counties in North West, Southwest and Western Kenya using semi-structured questionnaire through face-to-face interviews. The counties were selected based on the level of banana production. Kisii and Bungoma are net exporters of banana while Trans Nzoia and West Pokot are net importers of banana fruits. A total of 331 farmers were randomly selected using simple random sampling technique. Prior to the interviews, respondents were informed about the various aspects of survey plan and when they will be visited. This was done with assistance from county administrative staff including village elders. The questionnaire includes six sections: (1) a general characterisation of the farmers and their family members, the farmer's profile, and the farms' organization, (2) farm structure, (3) the crop systems including type of banana cultivars grown, (4) the management of the farm, (5) the farmers' attitudes and the sources of used information, and (6) their intentions towards the TCB cultivars including as well as the level of consumer preferences of banana consumed and sold.

Theoretical framework nested multinomial Discrete Choice Model. A number of researchers have explored various fac-tors affecting v consumers' acceptance and attitudes of various types of foods and services (Onyango, 2004; Brower & Bateman, 2005; Wanyonyi, 2008; Dos Santos, 2010; Kikulwe, 2010; Kim, 2010). Diverse approaches can be used to analyse consumer preference including discrete models (Louviere, 2000; Merino-Castelló, 2003). For instance, Onyango *et al*. (2004) measure consumer preferences for genetically modified foods, not yet available in the marketplace, using stated preferences techniques and both Brower & Bateman (2005) and Merino (2003) rationalise the growing popularity of stated preferences discrete choice models in the health sector, an area where one is keen on eliciting consumer preferences regarding products and services not available in the marketplace, such as new drugs and health plans. Discrete choice models are distinct from continuous choice models in that the dependent variable can take only discrete values. In the models estimated in this study, all of the dependent variables are categorical. Similar to other types of economic models, discrete choice models assume that individuals will choose the alternative that yields the highest benefit. The difference in the case of discrete choice is that the alternatives are not available in every possible combination of continuously variable attributes. This means that it is unlikely that the absolute highest benefit can be reached, and the individual must settle for the alternative that has the highest benefit of those available. In the case of the models estimated here, this benefit is in the form of utility. If the utility function can be specified and estimated for each alternative, then choosing the alternative yielding the highest utility is a simple task. In This study first the farmers choose which type on banana to grow whether TCB and NTCB after which they decide whether to plant cooking or ripening and lastly they pick on which type of varieties to choose from (Figs. 1 and 2).

To achieve objective three, nested multinomial logit model was be fitted onto the data. The nested models are commonly derived from utility models (Abdel-Aty and Abdelwahab 2001). In this study, the utility model has the form:

$$U_{ntcb} = V_{ntcb} + \varepsilon_{ntcb} \quad \text{Equation 1}$$

$$U_{tcb} = V_{cok} + Vncki + \varepsilon_{tcb} + \varepsilon_{ni} \quad \text{Equation 2}$$

$$U_{var} = Vl_1 + Vl_2 + V_{cok} + V_{cnco} + \varepsilon_{ar} \quad \text{Equation 3}$$

In this study we estimate nested logit models with three levels. A three-level nested multinomial logit was obtained by partitioning the choice set into nests and then the nests into sub-nests as shown in Figure 2. The top level describes the choice of nest (TCB or Non-TCB); the second level describes the choice of sub-nest (cooking of ripening); and the bottom level describes the choice of alternative (banana cultivars) within each sub-nest. As you would expect, the top level includes an inclusive value for each nest and this captures the expected utility that the decision maker gets from the sub-nests within the nest; it is calculated as the log of the denominator of the second level model. Similarly, the second level models include an inclusive value for each sub-nest, which represents the expected utility of the alternatives in each sub-nest; it is calculated as the log of the denominator of the third level model. Each layer of nesting introduces parameters that capture the degree of correlation among alternatives within the nests. With the full choice set partitioned into nests, the parameter *k* is introduced for nest *k*.

Figure 2 shows that total 330 individuals were in Level-1. They are nested within two clusters (Level-2 the TCB growers and non-TCB growers). These clusters are again nested into 2 groups of cooking and ripening bananas - defined as Level-3 - and finally, cooking and ripening are aggregated into 13 banana cultivars, which constitute Level-4. Thus the information in the lower levels is aggregated in the immediate upper level and hence follows the hierarchical structure.

The most widely used technique among the general extreme value (GEV) models is the NMN model which takes care of the independence of irrelevant alternative (IIA) assumption (Train 2002; (Grigolon, 2011). Suppose that there are *k* alternatives from which to choose and can be divided into M sub-groups such that the choice set can be written as: $n_1, \ldots, n_m; m_{1..} \ldots m_i$; m = 1,…....., *M* and $\sum_m n_m = N$

This choice-set partitioning produces a nested structure and logically, one may think of the choice process as that of choosing among M choice sets and then making the specific choice with the chosen set. The determinants of TCB cultivar preferences are the primary goal in this study. The mathematical form for this three-nested level logit model is as specified in equations 4 to 10 (Greene, 2003). The model assumes that if farmer 'i' decides to choose alternatives from TCB cultivar n_i from TCB types m_i then the utility of this farmer is given as given in equations 4 to 10.

$$U_i\,(\text{TCB type } m) = \beta z_i + \varepsilon_{im} \quad \forall\, m = 1\ldots.., m. \qquad \text{Equation 4}$$

$$U_i\,(\text{TCB cook\_ripe } n) = \gamma x_i + \varepsilon_{in} \quad n = 1\ldots.., n. \qquad \text{Equation 5}$$

$$U_i\,(\text{TCB cultivar } n) = \gamma x_i + \varepsilon_{in} \quad n = 1\ldots.., n. \qquad \text{Equation 6}$$

$$P_{nkm} = P_{nm} P_m \qquad \text{Equation 7}$$

$$P_{n|m} = \frac{\exp(\beta x_j \mid m)}{\sum_{n_m} \exp(\beta x_j \mid m)} \qquad \text{Equation 8}$$

$$P_m = \frac{\exp(\gamma z_m + \tau_m I)}{\sum_m \exp(\gamma z_m + \tau_m I_m)} \qquad \text{Equation 9}$$

$$I_n = I_n \sum_{n_m} \exp(\beta x_j \mid m) \qquad \text{Equation 10}$$

Where U_i is utility derived by farmer 'i', P_n is the unconditional (marginal choice) probability of choice *n*, $P_{n|m}$ is the conditional probability of choosing alterative *n* given that person has selected the choice-set *m*, P_m is the probability of selecting the choice-set *m*, $x_{n|m}$ are attributes of the TCB cultivar choices and other personal, economic and institutional factors, z_m are attributes of the TCB type choice sets, I_m is an inclusive value (log sum=) of utility derived from utility of having all the choice-sets *m*, *â* and *ã* are vectors of coefficients to be estimated, and $\hat{o}_m$ is the coefficient of the inclusive value of choice-set *m*. If we restrict all inclusive value parameters to be 1, then the nested logit model will be similar to multinomial logit model. The nested logit model is consistent with random utility maximization if the conditions' inclusive value parameter is bounded between zero and one. The model has been found to be extremely flexible and is widely used for modeling individual choice.

Explanatory factors are expected to determine the alternatives chosen by farmers/consumers at various nests. The explanatory variables that were entered into the model included; farmer characteristics (age, sex, education, family size, employment, occupation, agricultural training), farm characteristics (farm size, fertility levels, land tenure system), institutional of input and output markets (input/output market access, price of plantlets, prices of banana fruits, credit, extension access), and technological characteristics (taste, storability, yield, cost).

The dependent variable were be cooking TCB (Gold finger, Uganda green, *Nusu Ng'ombe*, and Ng'ombe), ripening TCB (Grand naine, Williams hybrid, Giant Cavendish, Dwarf Cavendish, Chinese Cavendish, Lacatan, Vallery, Gold finger), ripening purpose TCB (uganda green and solio) and dual purpose (Gold finger).

Results and discussions

General socio-economic characteristics of respondents. The general socio-economic characteristics are given in Table 1. The average household size was for TCB practicing farmers was 6.9 members while those non-practicing one was 7.2 members with an over all mean of 7.0 members. The age of those farmers who were not practicing TCB was 51.2 years while those were not was 51.6 years with an overall mean age of 51.4 years. The distance to the banana selling markets was 38km for those who planted TCB while for those who did not was 14.3 km. The pooled mean for market distance was 37.1 kilometers. The period of planting bananas in years for TCB adopters was 32.6 while those for non-adopters was 12.9 years with an average pooled mean of 23 years. The average number of years in planting TCB bananas was about seven years. The number of years in farming was 22 years for non-TCB adopters while those who had adopted TCB was 20 years. The overall mean period in years in years for respondents was 20 years. The average number of livestock for TCB adopters was 7.5 livestock units (LU) while those for non-adopters was 4.4 LU. The average farm size was about 10.6 acres for TCB adopters while those for non adopters was 6.7 acres with an overall mean of about 8.8 acres. On the other hand the average arable land for adopters was 8.7 acres while that of non-adopters was 5.2 acres with an overall mean of 7.1 acres. The main occupation for adopters was 73.1% (farming), and 17.2% (off-farm) while for non-adopters was 72.2% (farming) and 12.7% (off-farm). The proportion of male headed respondents for adopters was 45% while for non adopters was 37%. Across all the groups majority of farmers had attained at least primary level of education. Most of the respondents 52% for adopters and 61% for non adopters) had land title deeds. Most of the farmers perceived fertility level of farms to be at least from medium to high (89% for adopters and 98% for non adopters).

Table 1. Descriptive statistics sampled farmers and farm characteristics by participating and non-participating groups in TCB growing in Kenya.

		Participating n-65		Non-participating n=149		Full sample n=330	
		Mean	SD	Mean	SD	Mean	SD
Family size		6.9	2.4	7.2	2.8	7	2.6
Age of HoH-years		51.2	13.3	51.6	13.4	51.4	13.3
Distance source -km		38.3	93.8	14.3	20	37.1	9.17
Period planted bananas-years		17.48	14.26	13.8	13.44	23	13.85
Period planted TCB-years		6.5	5.2				
Period in farming-years		20.3	14	21.6	12.3	20.9	13.3
Livestock ownership (TLU)		7.5	16	4.4	3.9	6.1	12.2
Farm size in ha		10.7	65.5	6.7	40.8	8.8	55.3
Arable area in ha.		8.7	59	5.3	33.6	7.1	48.6
Number of banana stools		126.7	458.5	35.5	52	84.1	34.1
Number of TCB banana stools		131.3	586.9	-	-	54	37.8
TCB performance index		26.9	18.2	20.8	13.3	24.1	16.4
Main occupation HoH %	Farming		73.6		72.7		73.1
	Petty trade		5.2		12.7		8.6
	Off- farm		17.2		12.7		1.5
Gender of HoH %	male		45.2		37.2		8.5
	female		16		19.3		7.5
Education HoH %	None		3.4		6.7		4.9
	Primary		44.6		50.7		47.4
	Secondary		26.9		30.7		28.6
	Post secondary		25.1		12		19.1
Land tenure %	1=with title		52.1		61.3		56.1
	0=without		47.9		38.7		37.1
Soil fertility %	low dummy		10.4		7.3		9
	medium dummy		67.6		70		68.7
	High dummy		22		27.7		22.3
Labour source %	family		83.9		83.5		83.7
	hired		78.6		65.5		73.8
TCB plantlet availability %			44.9		12.5		43.2
Proportion Banana revenue-farm		54.2	41.7	42.9	43.59		

Farmer TCB variety awareness. From the total number of farmers sampled, most of the them preferred local cultivars (57%) while about 43% preferred TCB bananas. As shown in Figure 5.3, among the TCB cultivars, *grand naine* was widely preferred by farmers followed by TCB *ng'ombe*, TCB Chinese Cavendish, and TCB giant Cavendish. The least preferred cultivar was Gold finger which is a dual cultivar. The later low preference may be attributed to the fact that it does not compete favorably with the other local cooking cultivars in the region. The major attributes in terms of yield, taste and cookability do not outperform purely ripening and purely cooking cultivars.

Farmer TCB variety preferences. Farmer, farm and institutional characteristics play a significant role in technology preferences like TCB (Melinda and De Groote 2003; Kikulwe 2010). Farmers were asked to score the cultivars and their attributes of banana they grew on a likert scale of 1-4 (1=very poor, 2=poor, 3=good and 4=excellent). The proportion of farmers who preferred various attributes between TCB and NTCB were significantly different (pd”0.05) across all the attributes (Table 2). The least (considering good and excellent) rated factors as revealed by proportion of farmers among TCB cultivars were; cookability, drought tolerance and ripening while those rated as good and excellent among the non-TCB were suckering ability, finger size, finger length, and bunch size. Most farmers (>80% of sample size) preferred TCB cultivars were good and excellent in most of factors (pest tolerance, disease tolerance, yield potential, sweetness, suckering ability, finger size, finger length, bunch size, feed potential, drought tolerance, maturity period, ripening quality, and storability) than the non-TCB. Some of the preference factors are related for example finger size, finger length, bunch size and yield and they were equally scored by majority of farmers.

Farmers were asked to score on a likert scale of 1 to 4 for each of the variables. On the basis of likert scale rating there were significant differences in disease tolerance, pest tolerance, yields, sweetness, cookability, lodging, finger length, bunch size, drought tolerant, maturity period,

Table 2. Farmer preferences of TC and non-TC banana (*Musa* spp.) quality parameters in Kenya.

Quality parameter	TCB				NTCB				chi-square
	Very poor	Poor	Good	Excellent	Very poor	Poor	Good	Excellent	
Pest tolerance	0	6.3	56.9	36.8	1.5	5.3	75	18.2	26.459***
Disease tolerance	0	7.1	57.7	35.2	5.9	20.6	55.9	17.4	68.46****
Yield potential	0	2.2	47.4	49.6	0	21.2	49.3	29.5	85.484***
Sweetness	1.8	5.1	47.7	45.4	0	8.4	61.5	30.1	15.554***
Cook-ability	20.8	10.8	43.8	24.6	7	5.8	61.6	25.6	13.847***
Lodging	3.6	22.4	50.3	23.7	7.5	27.1	54.9	10.5	14.187***
Suckering ability	2.8	11.3	55.7	30.2	0.7	9.3	61.7	28.4	3.371ns
Finger size	0	3.2	54.5	42.2	0	28	46.9	23.1	1.150^2***
Finger length	0	3.9	58.2	37.9	0	30.7	44.5	24.8	1.002^2***
Bunch size	0	4	56.2	39.5	0	31.5	43.4	25.2	1.074^2***
Feed potential	0	15.7	46.4	37.2	0	11.54	63.4	25.2	12.797**
Drought tolerance	1.8	27.5	42.6	28.0	0	12.1	65.2	22.7	25.770***
Maturity period	0.2	10.7	66.7	26.1	0	7.2	37	37	8.069**
Ripening quality	0.2	11.9	49.5	38.5	0	8.1	71.1	20.7	20.791***
Storability	0.4	15.5	71.3	24	0	4.7	39.9	44.2	42.466***

Key: Significant at 1%***, 5%*** and 10%* and ns=not significant.

ripening, and storability ($p<0.05$) Table 3. The pooled summative scale showed significant differences between the TCB and non-TCB cultivars. Based on these results banana cultivars that pest/disease tolerance, gives the appropriate sweetness, cookability, finger length, bunch size, drought tolerant, maturity period, ripening, and storability can be considered tissue culture and up-scaling for enhanced impact as indicated by Kikulwe *et al*. (2010).

Determinants of TCB variety preferences. To identify determinants of TCB varieties a nested multinomial logit model was employed (Greene, 2000). Before fitting this model, the problem of multicollinearity among explanatory variables was checked using variance inflation factor (VIF) for continuous variable), condition index (CI) and contingency coefficient for dummy variables). The results showed that multi-collinearity was not a serious problem between discrete variables. Similarly, the problem of multi-collinearity was not serious among continuous variables because VIF value was less than 10 and CI value was less than 30. The parameters of an NMLM estimated in the three-stage method described above are presented in Table 4, Table 5 and Table 6 for the three decision levels. In all the decision levels the log-likelihood ratio test of goodness-of-fit of the estimated model was statistically significant ($p<0.01$).

TCB and NTCB Level analysis (level 3). In level one the factors that significantly influence the choice of TCB and NTCB were sex, experience and experience squared ($p<0.01$). The estimated values for each decision level were significantly less than one and significantly greater than zero at the 1% level. This confirms that the NMLM is consistent with the utility maximization hypothesis and the multinomial logit model may not be suitable in this case (a null hypothesis regarding independence of irrelevant alternatives is rejected). As expected, the results of the Hausman and McFadden tests suggest that the parameters of a full multinomial logit model and those of the restricted choice sets were statistically different. We also tried other nested logit models with different trees. In all cases our original nested model had a larger log-likelihood than any other and, therefore, the former was preferred.

Cooking and ripening Level analysis (Level 2). Level two was on cooking and ripening banana in TCB and NTCB nests. The results showed that the factors that significantly influenced the choice between cooking and non-cooking in the TCN and NTCB nests were primary level of education and experience. The variable primary level was positive and significant while that of experience was negative and significant.

TCB cultivar Level analysis (level 3). Crop variety choice is an important component in technology dissemination for enhanced adoption (Migbokwe, 2000; Agwu & Anyaeche, 2007). Level three was on choosing

Table 3. Likert scale rating of farmer TCB verses NTCB quality parameters in Kenya.

Preference indicator	TCB		NTCB		t-value
	Mean	SD	Mean	SD	
Disease tolerance	3.281	0.587	2.853	0.775	7.234***
Pest tolerance	3.305	0.582	3.099	0.537	3.746***
Yields	3.561	1.080	3.082	0.710	5.107***
Sweetness	3.366	0.666	3.217	0.583	2.470**
Cookability	2.723	1.054	3.058	0.772	-2.787**
Lodging	2.941	0.776	2.684	0.762	3.463***
Suckering	3.134	0.713	3.177	0.613	-.665NS
Finger size	3.390	0.551	3.350	2.832	.325NS
Finger length	3.340	0.550	2.942	0.745	7.152***
Bunch size	3.486	2.358	2.937	2.358	2.749**
Feed	3.349	1.720	3.137	0.592	1.390NS
Drought tolerant	2.968	0.793	3.106	0.592	-1.886NS
Maturity period	3.259	3.189	0.6471	0.548	1.065NS
Ripening	3.262	0.666	3.126	0.524	2.209**
Storability	3.279	0.732	3.194	0.501	1.253NS
Pooled (summative scale)	43.301	9.397	41.685	7.552	1.943*

Key: Significant at 1%***; 5%*** and 10%* and ns = not significant.

Table 4. Nested multinomial logit parameter estimates of level 1: TCB and NTCB in Western Kenya.

Variable	Coef.	Std. Err.	z	P>z	Marginal
Price	0.0032	0.007611	0.42	0.675	0.0000
Age	-0.0740	0.144707	-0.51	0.609	0.0000
Age2	0.0001	0.001223	0.06	0.950	0.0000
Sex	1.1259	0.478881	2.35	0.019	0.0002
Edu_pr	-13.1814	886.7551	-0.01	0.988	-0.0625
Edusec	-13.8017	886.7551	-0.02	0.988	-0.7223
Fam	0.0235	0.092763	0.25	0.800	0.0000
Exp	-3.3044	0.818912	-4.04	0.000	-0.0003
Exp2	0.3042	0.073414	4.14	0.000	0.0000
Farmz	0.1473	0.138112	1.07	0.286	0.0000
Title	0.8235	0.604752	1.36	0.173	0.0001
Cons	27.0857	886.7659	0.03	0.976	
Number of obs	1779				
LR chi2(12)	69.12				
Prob > chi2	0.0000				
Pseudo R2	0.2399				
Log likelihood	-109.465***				

a Coefficients are restricted to be equal among alternatives. These values are omitted in the following tables

among the TCB cultivars ripening banana in TCB and NTCB nests. The results revealed that benefits were significant ($p<0.05$) across all the TCB cultivars. This implies that the benefits accruing to all the TCB cultivars were relatively high compared to NTCB cultivars. The revenue variable was significant on two cultivars (TCB Chinese Cavendish and TCB giant Cavendish). The variable age, age squared, education and family size were and significantly different from zero ($p<0.05$) on only one cultivar (TCB dwarf Cavendish). The variable experience and experience squared in growing bananas was positive and significant on TCB giant Cavendish. The variable farm size was negative and significant ($p<0.05$). Implying that the larger the farm size the less the probability of adopting the TCB cultivars. Subsequently age is an important factor to consider in targeting TCB cultivar technologies.

Conclusions and recommendations

From the analysis the factors which were significantly different between the TCB and NTCB farmers were disease tolerance, pest tolerance, yields, sweetness, cookability, lodging, finger length, bunch size, and ripening and may be considered in meeting the farmers needs in the western and other parts of Kenya. Hence, banana breeding and promotion programs should aim at generating and

Table 5. Nested multinomial logit parameter estimates of level 2: cooking and ripening in western Kenya.

Technology specific characters	Coef.	Std. Err.	z	P>z
Index	-0.0047488	0.0198128	-0.24	0.811
Attribute	-0.0025879	0.0053979	-0.48	0.632
Rating of TCB	-0.2240209	0.4369589	-0.51	0.608
Cooking and ripening level equations				
Ck_rip1				
Benefit	-0.0111907	0.0213097	-0.53	0.599
Revenue	-0.0000185	0.000016	-1.16	0.246
Price	0.0034103	0.0034744	0.98	0.326
Age	0.0443274	0.0657632	0.67	0.5
Age2	-0.0005372	0.0005989	-0.9	0.37
Sex	-0.0433612	0.3488634	-0.12	0.901
Edu_pr	1.346148	0.8012882	1.68	0.093
Edusec	1.188823	0.8406315	1.41	0.157
Edupost	1.209694	0.8349185	1.45	0.147
Occ_off	-0.4361299	0.4046483	-1.08	0.281
Fam	0.0583728	0.0590804	0.99	0.323
Exp	-0.1654756	0.0781266	-2.12	0.034
Exp2	0.006043	0.0039286	1.54	0.124
Farmz	-0.0016141	0.0032425	-0.5	0.619
Ftype	-0.3043572	0.4361313	-0.7	0.485
Title	0.0010957	0.262283	0	0.997
Wald chi2(19)	17.48			
Prob > chi2	0.005576			
Log likelihood	-506.88085***			

Table 6. Nested multinomial logit parameter estimates of level 3: banana variety alternatives (base variety is TCB grand naine).

chosen Banana cultivars	TCB-Chinese cavendish	TCB dwarf cavendish	TCB giant cavendish.	TCB nusu ng'ombe	TCB ng'ombe
index	0.000 (0.023)				
attribute	0.006(0.005)				
rating of TCB	-0.095(0.760)				
Banana variety level equations					
	TCB-Chinese cavendish	TCB dwarf cavendish	TCB giant cavendish.	TCB nusu ng'ombe	TCB ng'ombe
Benefit	0.104(0.046)**	.127468(0.065)**	0.126(0.056)**	0.099(0.046)**	0.126(0.056)**
Revenue	0.000(0.000)*	0.000097(0.000)	0.000(0.000)*	0.000(0.000)	0.000(0.000)
Price	-0.007(0.008)	0.002(0.011)	-0.004(0.010)	-0.006(0.008)	-0.004(0.010)
Age	0.142(0.132)	0.268(0.102)***	0.085(0.160)	0.112(0.110)	0.085(0.160)
Age2	-0.002(0.001)	-0.003(0.001)**	-0.001(0.001)	-0.001(0.001)	-0.001(0.001)
Sex	-0.790(1.038)	0.550(1.258)	-1.326(1.115)	-0.662(1.040)	-1.326(1.115)
Educ	0.169(0.407)	-1.550(0.713)**	0.094(0.476)	0.163(0.406)	0.094(0.476)
Occ_off	-0.642(0.875)	1.054(1.278)	-0.209(1.050)	0.005(0.860)	-0.209(1.050)
Fam	-0.005(0.143)	-0.544(0.233)**	-0.191(0.176)	-0.097(0.145)	-0.191(0.176)
Exp	0.210(0.160)	0.010(0.378)	0.397(0.281)**	0.264(0.160)	0.397(0.281)
Exp2	-0.010(0.006)	-0.014(0.030)	-0.022(0.018)**	-0.012(0.006)	-0.022(0.018)
Farmz	-.6363009	-1.1601(0.367)***	-0.634(0.005)***	-0.634(0.005)***	-0.634(0.005)***
Wald chi2(19)	17.48				
Log likelihood	-506.88085***				
Prob > chi2	-.000097				

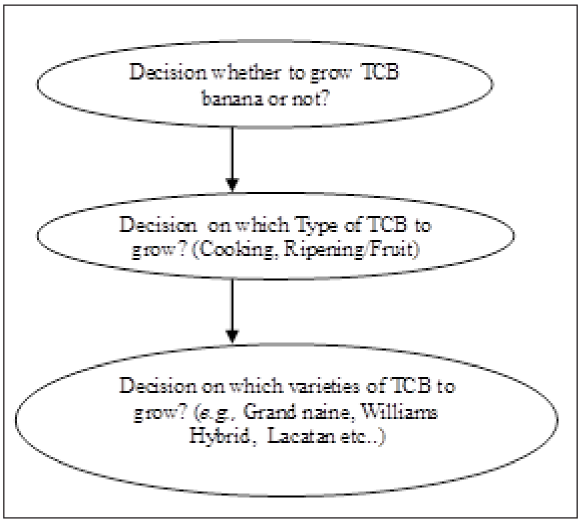

Figure 1. Decision Tree for Analysing TCB and NTCB variety preferences.

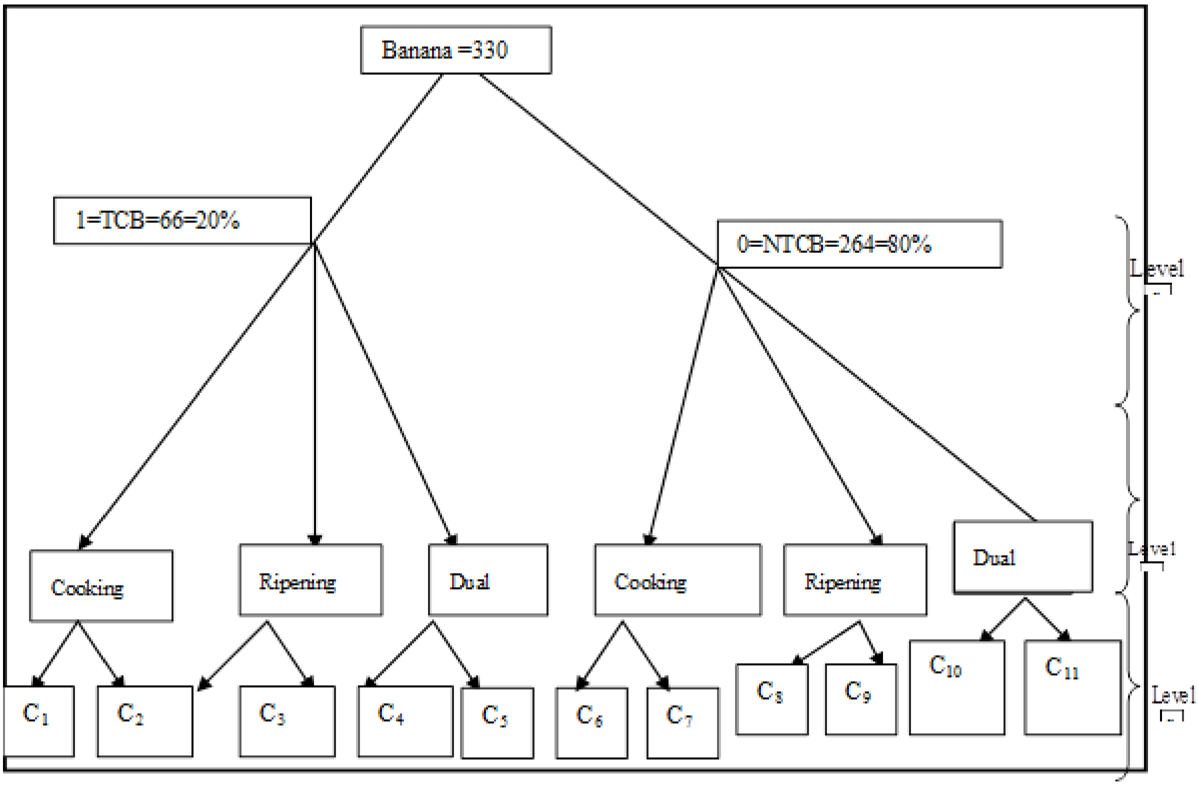

Figure 2. Three Tiered Choice (tree) structure of TC decision making process for NML model.

disseminating cultivars that address these. Thus technologies that address these attributes of banana fruits should be developed and promoted.

In addition, in this study we derived a micro-economic model of discrete choice random utility to investigate individual choice among a discrete number of banana cultivars alternatives, taking into consideration the farmer, farm, institutional, socio-economic and technological characteristics of type and cultivar of banana, by means of a nested multinomial model. The study examined the elements that make individuals choose different cultivars types and kinds of banana. The focus was on the factors that may explain the continuously increasing use of TCB cultivars as opposed to NTCB alternatives. The results of a nested multinomial logit model of the farmers as producers and also consumer choice were presented. Individual choice between alternatives is considered, in a repeated nested structure: TCB-Chinese Cavendish TCB dwarf Cavendish, TCB giant Cavendish, TCB *nusu ng'ombe*, TCB *ng'ombe* and *grand naine*. These varieties are grouped cooking and ripening. The principal findings of this study may be summarized in four main conclusions. First, our findings indicate that as the farm size plays an important role in adoption of TCB. It was revealed that as

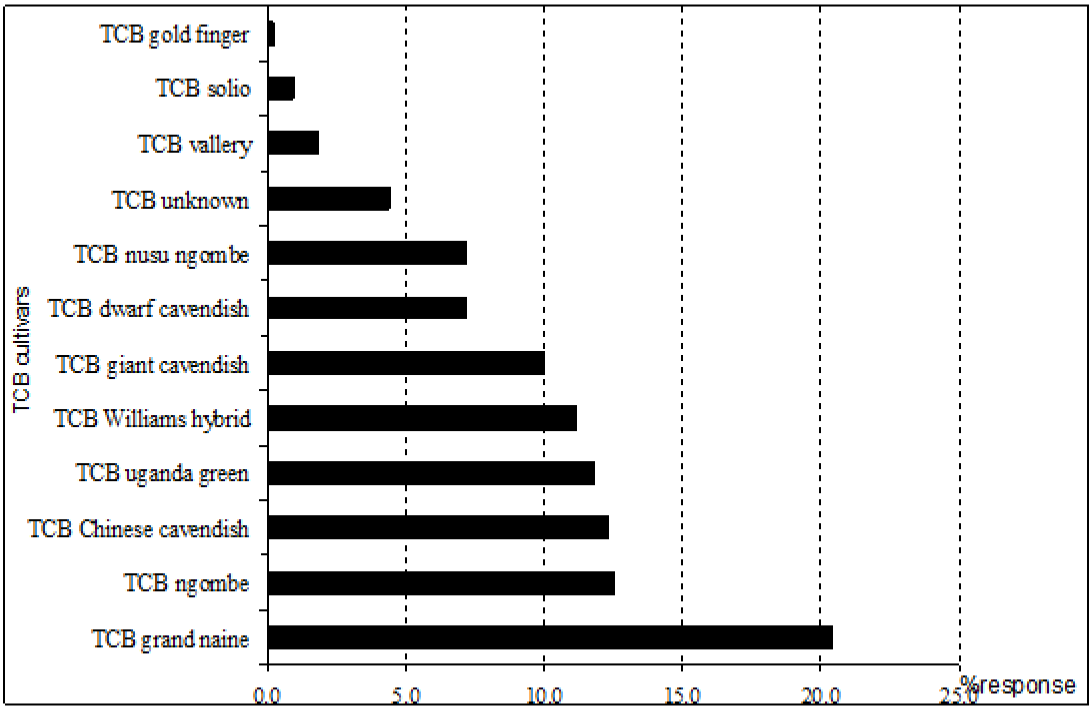

Figure 3. Percentage response TCB variety preferences by farmers in western Kenya-2012.

the farm holding increase among the TCB adopters the utility decreases.

In this study derived a micro-economic model of discrete choice random utility was derived to investigate individual choice among a discrete number of banana cultivars alternatives, taking into consideration the farmer, farm, institutional, socio-economic and technological characteristics of type and cultivar of banana, by means of a nested multinomial model. The study examined the elements that make individuals choose different cultivars types and kinds of banana. The focus was on the factors that may explain the continuously increasing use of TCB cultivars as opposed to NTCB alternatives. The results of a nested multinomial logit model of the farmers as producers and also consumer choice were presented. Individual choice between alternatives is considered, in a repeated nested structure: TCB-Chinese Cavendish TCB dwarf Cavendish, TCB giant Cavendish, TCB *nusu ng'ombe*, TCB *ng'ombe* and grand naine. These varieties are grouped cooking and ripening. The principal findings of this study may be summarized in four main conclusions. First, our findings indicate that as the farm size play an important role in adoption of TCB. It was revealed that as the farm holding increase among the TCB adopters the utility decreases. Therefore, not only are small-scale farmers benefiting but also large-scale farmers because of the income generation and commercialization aspects in the banana industry.

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