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FARMERS' PERCEPTION ON NEW CASSAVA VARIETIES GROWN IN COASTAL KENYA

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ABSTRACT

Cassava (*Manihot esculenta* Crantz) is a dicotyledonous plant, belonging to the family Euphorbiaceae. The status of cassava as a food security crop to most subsistence farmers is, however, threatened by the low quality and the potential toxicity in the crop. Cassava tissues contain cyanogenic glycosides, mainly linamarin, that are enzymatically hydrolyzed to glucose, acetone and hydrogen cyanide during cell rupture. It is believed that cyanogens present in the cassava plant confer protection against attack by some herbivores. The crop grows well over a range of climatic conditions, altitudes and on a wide variety of edaphic conditions. Cassava is mostly used as a subsistence crop in tropical countries, taking over 93% of the production for human consumption. Despite being a food security crop it is also a source of income for urban and rural populations. The roots of cassava can be consumed fresh and as processed products. Cassava roots are rich in carbohydrates. Utilization of cassava in Kenya as food varies from one region to the other. The crop agronomic advantages, such as high productivity, ease and flexibility of cultivation, tolerance to drought, and its ability to grow well on relatively poor soils has made it rapidly and extensively adaptable to different agroecological environmental conditions. Among the local varieties used by farmers in Kenya is *Kibandameno,* a very popular cassava variety because it has a sweet taste with good cooking quality starch. This variety is, however, low yielding, susceptible to diseases and therefore is not suitable for improving cassava production in coastal Kenya. Alternatively, the high yielding cassava varieties that were released in 2008 have potential of high production and adaptability to diseases and hush environments conditions. Unfortunately, farmers' adoption to the new high yielding varieties is poor. This is mainly because the new improved varieties have a bitter taste and show variability in their cooking qualities. In addition, the new cassava varieties take longer to mature hence they are not suitable emergence food security varieties at times of hunger. Farmers associate cracks that develop on the ground around the base of cassava plant to maturity. However new varieties develop such cracks earlier enough around the base of the plant because they grow fast. For this reason such signs should not be relied upon to diagnose stages of maturity. Hence the need to assess age relation to bitterness in cassava root tubers. Farmers experience loss of starch in cassava harvested immediately after weeding. The present work intends to investigate farmers' perception on new cassava varieties grown in Coastal Kenya. A survey was conducted to establish farmers' perception on new cassava varieties. The survey was conducted in Matuga and Msambweni subcounties of Kwale County, Kenya. A purposive sampling procedure was adopted to map out cassava farmers in the two subcounties. Cassava farmers were selected at random and interviewed. During the survey, a questionnaire was administered to the farmers as a tool for collection of raw data during interviews. The questionnaire used was both closed and open ended. In total three hundred farmers were interviewed during the survey, one hundred and fifty from each of the two subcounties, Matuga and Msambweni. The results of the survey revealed that majority of farmers still have high preference to the local cassava varieties despite their low performance and susceptibility to diseases. Farmers have negative attitudes towards improved cassava varieties. According to the farmers, the new improved varieties are bitter with poor cooking quality despite the fact that they are high yielding. According to the farmers, the local varieties were sweater with good cooking quality as opposed to the new improved varieties. Farmers need be trained on good agronomic practices in order to have good quality cassava and cassava processing techniques to improve cassava quality prior to consumption. Data analysis involved Statistical Package for the Social Sciences (SPSS) software and Genstat software to generate analysis of variance (ANOVA).

Key wards: Cassava; Cyanogens; Linamarin; Linamarase; Bitterness; Perception;

INTRODUCTION

The word cassava is derived from “casabi”, the local name given by the Arawaks Amerindians to the starchy roots. It is also known as “yuca” in Spanish, “manioc” in French, “mandioc” in Portuguese;” cassave” in Dutch and “maniok” in German(Alves, 2002). It is an outbreeding species possessing 2n = 36 chromosomes, and is considered to be an amphi- diploid or sequential allopolyploids.

Cassava (*Manihot esculenta* Crantz) is a dicotyledonous plant, belonging to the family Euphorbiaceae (Alves, 2002). It has genetic, geographical and agricultural origin in Latin America. The crop is native to tropical America and originated from Brazil. It was introduced to Africa by Portuguese traders in the 16th century (Olsen and Schaal, 2001). Cassava was brought to East Africa in the 18th century by the Portuguese from Cape Verde and into Mozambique from Zanzibar Island (Allen, 2002). Its domestication began 5000 – 7000 years BC in the Amazon, Brazil, and later distributed by Europeans to the rest of the world (Henry and Hershey, 2002).

The plant parts used are the storage root (tuber) and leaves. The *Manihot* genus is reported to have about 100 species, among which the only commercially cultivated one is *Manihot esculenta* Crantz.

The plant is mainly propagated from stem cuttings. However, propagation by seed results in genetically diverse plants which are used for generation of new varieties (Alves, 2002). Cassava is grown over a range of climates and altitudes and on a wide variety of soils. The plant is tolerant to drought and performs well in poor soil where other staple crops cannot grow (New World Encyclopedia, 2008). The crop is an important source of carbohydrate for humans and animals, having higher energy than other root crops, 610 kJ/100 g fresh weight, with perhaps the exception of sugarcane (New World Encyclopedia, 2008).

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The plant is characterized by palmate lobed leaves, inconspicuous flowers and a large, starchy, tuberous root with a tough papery brown bark and white to yellow flesh (New World Encyclopedia, 2008). It is one of the most perishable tuber crops with a high postharvest loss. The mature cassava storage root has three distinct tissues: bark (periderm), peel (cortex) and parenchyma. The parenchyma, which is the edible portion of the fresh root, comprises approximately 85% of the total weight, consisting of the xylem vessels radially distributed in a matrix of starch containing cells (Diasolua *et al*., 2003). The cyanide concentration in cassava varies in different parts of the plant, according to variety, location, age, and environmental conditions. Consequently, cassava is of lower nutritional value than cereals, legumes, and even some other root and tuber crops such as yams (Charles *et al*., 2005). Dried cassava root has energy similar to the cereals. In Africa, the continent with the largest cassava production, about 93% of the produce is used as food (Nweke *et al*., 2002).

Cassava plays five important roles in African development: famine-reserve crop, rural staple food, cash crop for both rural and urban households and, to a minor extent, raw material for feed and chemical industries (Nweke, 2000). Although cassava roots and leaves are used for human consumption and animal feed, the major constraint on cassava roots as human food is the presence of toxic cyanogenic glucoside compounds in the tissues. Cassava and sorghum are especially important staple foods containing cyanogenic glucosides.

Cassava contains, in all the tissues, with the exception of the seeds, 4 to 5 cyanogenic glucosides. The main ones are linamarin and lotaustralin in the ratio 97:7 (Bellotti and Riis, 2003). The concentrations of cyanogens differ in different varieties, between tissues in the same plant and even between compartments of the same tissue (Nwakaeze, M.N, 2005). Cassava leaves have the highest concentration of cyanogens. In the leaves, the concentration decreases with age (Bellotti and Riis, 2003). In new leaves, the cyanogen levels are higher in the lamina than in the petiole, but in old leaves the petiole has a higher cyanogen level than the lamina. In cassava roots, in the longitudinal direction, cyanogen concentration increases from insertion point on the plant to the root terminal and in the transverse direction, cyanogen levels decrease from the external area to centre of the root (Bellotti and Riis, 2003).

Cassava tissues also contain the enzyme linamarase, which can hydrolyse cyanogens but the enzyme is not in the same compartments as the cyanogens (Nweke, 2001). Cyanogenic glucosides are located inside vacuoles and the enzyme linamarase in the apoplastic region. Bitter cassava varieties are associated with high concentrations of cyanogenic glucosides , linamarin and lotaustralin (Chiwona-Karltun *et al.,* 2004) and bitter-tasting tubers in most varieties are known to have a high cyanogenic potential (Ceballos *et al*., 2004). The mechanisms and processes of cyanogenic glucosides synthesis which confer bitter taste in cassava tubers are well documented (Bokanga, 2004 and Chiwona-Karltum *et al.*, 2004). On the other hand, sweet varieties have a high concentration of free sugars. This does not always follow that the sweet varieties have low concentrations of cyanogens (Bellotti and Riis, 2003).

However, bitter taste and high level of cyanogens can also be related to environmental stress conditions, such as drought, low soil fertility and pest attack. Bitter cassava varieties, have cyanide levels higher than the FAO/ WHO (2000) recommendations, which is < 10 mg cyanide equivalents/kg DM (Bellotti and Riis, 2003). The presence of hydrocyanic acid is the major reason for rejection of cassava cultivars in Eastern Kenya and other societies in the Coastal region (Nweke *et al*., 2002).

Leaves are much richer in proteins than the roots (Chijindu and Boateng, 2008). Supplementation of Cassava products such as leaf-meal with methionine or any other of the nutrients it lacks serves to improve its biological value significantly. Cassava is grown widely in areas below 1500m above sea levels. The use of cassava as a food source is increasing because it yields well even in poor soil without fertilizer, and is drought resistant (El-Sharkawy, 2003). The root can be left in the ground for up to 3 years as a reserve source of food.

There are sweet cassava and bitter cassava. The term "bitter" cassava, as opposed to sweet cassava, refers to the taste of the root parenchyma. Bitterness is associated with higher levels of cyanogenic glucosides (Cock, 2000). Certain ecological stress factors, such as pest attacks, prolonged drought and low phosphorus and potassium levels in the soil may cause roots to acquire bitterness, and this coincides with an increase in the levels of cyanogenic glycosides. Bitter cassava varieties are more drought resistant and thus more readily available and cheaper (Chijindu and Boateng, 2008).

In Africa, cassava was the crop with the highest total production with 118 million metric tonnes of productions across the continent in 2010, contributing significant energy input to the population, with an average of 196 kcal/capita/day in 2008 (FAO, 2000) . Cassava is staple food of more than 500 million people in the tropics many of whom are very poor. In Africa, it is recognized as a famine reserve crop due to its tolerance to drought or infertile soils, and its ability to recover from disease and pest attacks. The area of cassava under unfavorable environments has been continuously increasing. World production of cassava root was estimated to be 184 million tonnes in 2002, rising to 230 million tonnes in 2008 (Frederick *et al.*, 2008). The majority of production in 2002 was in Africa where 99.1 million tonnes were grown, 51.5 million tonnes were grown in Asia and 33.2 million tonnes in Latin America and the Caribbean (FAO, 2000). Nigeria is the world's largest producer of cassava. Thailand is the largest exporting country of dried cassava, with a total of 77% of world export in 2005. The second-largest exporting country is Vietnam, with 13.6%, followed by Indonesia (5.8%) and Costa Rica (2.1%) (FAO, 2000).

In Kenya, cassava is grown in Western, Eastern, Central and Coastal regions. It is second only to maize in importance in western and coastal regions of Kenya (Njeru and Munga, 2003). In 1986, FAO estimated that the land area in Kenya under cassava cultivation was 30,000 ha producing 380,000 tons. In 2007, about 54,673 ha were planted with cassava in all areas of Kenya except North Eastern Province (Nweke *et al.*, 2002).

Table 1.0 Cassava production in Kenya in 2007

Regions	Nyanza	Coast	Eastern	Western	R.Valley	Central/ Nairobi	Total
Area (ha)	18010	10745	8101	17144	662	11	54673
Production (MT)	339214	143614	57555	194646	15740	195	750164
Yields (MT/ha)	19	13	7	11	24	18	92
% of Area	32.8	19.7	14.8	31.4	1.2	0.1	100
% of Output	45.2	19.1	7.6	30	2.1	0.02	100

Source: Ministry of Agriculture Kenya (2008).

The crop provides 9% of the total calories in the diet of Kenyans. Studies show that famine rarely occurs in areas where cassava is widely grown (Nweke *et al*., 2002). However its production in Kenya is constrained by Cassava Mosaic Disease (CMD) and high levels of cyanogenic glycosides in some clones. In Nyanza and Western provinces of Kenya, roots are also peeled, chopped into small pieces, dried and milled into flour for "Ugali". It is normally milled in combination with maize or sorghum. In the Coast province cassava leaves are used as vegetable. Cassava in Eastern Kenya is consumed either raw or boiled.

In this survey two varieties with similar names were mentioned by farmers in Msambweni subcounty. *Kibandameno* variety is the traditional cassava variety grown by farmers. On the other hand agriculture –*kibandameno* is the adapted cassava variety which was given to farmers by the department of agriculture.

Removal of cyanogenic glucosides from cassava foods

To prevent cyanide poisoning, linamarin and lotaustralin have to be removed from cassava foods. The most efficient processing procedures include peeling, soaking (fermenting), chopping, grating, drying, and cooking.

MATERIALS AND METHOD

Research design

A semi-structured questionnaire was used as a tool to collect information from cassava growers. The purpose of the study was to collect information on farmers' perception with the new improved cassava varieties. Each farm was mapped using Global Positioning System (GPS) receiver in order to get the exact position of the farm. The sampled areas were selected at random to get a more realistic statistical data on the survey. In total, 300 farmers from Matuga and Msambweni sub- counties were randomly selected and interviewed.

Study area

The study areas were purposely selected as those areas with cassava farmers. 150 farmers each from Matuga and Msambweni subcounties were randomly selected and interviewed using the questionnaire.

Sampling sites, sample size, and sample procedure

A purposive sampling strategy was used in selecting the study areas. These were areas where cassava production was practiced.

The sample size was calculated using the formula reported by Daniel (1999) as shown below.

$n = [Z^2 P (1-P)] / d^2$

Where n = Sample size.

Z = Statistic for a level of confidence (for the level of confidence of 95%, which is convection, Z value was 1.96).

P = Expected prevalence or proportion (in proportion of one; if 80%, P = 0.8).

d = Precision (in proportion of one; if 16%, d = 0.16.

The information required includes cassava varieties grown by the farmers, acreage under each variety, constraints to cassava production, altitude and latitude. Data on sources of cassava planting materials and cassava taste was also collected. Farmers were asked on their choice to grow the particular cassava varieties and for how long. Details on slop and soil texture of the farm was captured as well.

Data analysis

Data analysis was done using Statistical Package for the Social Sciences (SPSS). Descriptive statistics were obtained for various attributes. Such attributes included altitude, soil texture and agro-ecological zones.

RESULTS

Cassava varieties grown by farmers

Kibandameno was found the most popular variety in the visited farms, with 75.7 % of the farms having the variety (Table 2). *Guzo* was the second most popular variety (10.3%). The varieties *Pamba, Marere, Karembo, Bwazo* and *Nzalauka* were the least popular, each found on 0.3% of the farms visited. Other varieties found on the farms were *Sagalato, Kileso, Gushe* (also refered as *Mwafrika*), and *Nambari*.

Table 2: Cassava varieties on farms

S/No.	Attribute	Frequency	Percent
1	*Kibandameno*	227	75.7
2	*Sagalato*	4	1.3
3	*Kileso*	9	3.0
4	*Gushe (Mwafrika)*	5	1.7
5	*Nambari*	7	2.3
6	*Guzo*	31	10.3
7	Agriculture-*Kibandameno*	12	4.0
8	*Pamba*	1	0.3
9	*Marere*	1	0.3
10	*Karembo*	1	0.3
11	*Bwazo*	1	0.3
12	*Nzalauka*	1	0.3
	Total	300	100.0

Reasons given by farmers for choosing a given cassava variety

Majority of farmers (43.3%) chose to grow cassava varieties which were early maturing, followed by farmers who chose cassava varieties either for their sweetness (21.0%), for food security (17.3%) or high yield (10.3%) (Table 3). The least considered reasons for choosing a given cassava variety were high market demand (3.7%) and drought tolerance (4.3%).

Table 3: Reason for choice of cassava variety

S/No.	Attribute	Frequency	Percent
1.	Food security - no specific variety	52	17.3
2.	Early Maturing - e.g. *Kileso, Kibandameno*	130	43.3
3.	Sweet variety- e.g. *Ambari*, *Kibandameno*	63	21.0
4.	Drought tolerant - e.g *Guzo*	13	4.3

5. High yielding - e.g Agriculture-*Kibandameno*, *Ambari*	31	10.3
6. High market demand - e.g *Ambari*, *Kibandameno*	11	3.7
Total	300	100.0

Cassava growing and Agroecological Zone (AEZ)

Out of the 300 cassava farmers interviewed during the survey, majority of them (81.3 %) were found in the Coastal Lowland Coconut-Cassava Agroecological Zone (CL3) while 15.7% of them lived in the Sugarcane Agroecological Zone **(**CL2) (Table 4). Cassava farmers in the Cashewnut-Cassava Agroecological Zone (CL4) were the least, consisting of only 3.0 % of the interviewed farmers.

Table 4: Agroecological Zone (AEZ) and cassava growing

Agroecologial Zone	**Frequency**	**Percent**
CL 2 = Coastal Lowland Sugarcane Zone	47	15.7
CL3=Coconut-Cassava Zone	244	81.3
CL4= Cashewnut-Cassava Zone	9	3.0
Total	300	100.0

Farmers perception of sweet cassava varieties

The results showed that majority (82.3%) of the farmers interviewed recognize *Kibandameno* as a sweet variety (Table 5). A few farmers (17.4%) identified *Nambari*, Agriculture-*Kibandameno*, *Kileso*, *Mpemba* and *Pamba* as sweet cassava varieties. However, 0.3% of the respondents were not able to imagine what a sweat cassava variety was, hence had no comment.

Table 5: Farmers' response on the sweetness of a given cassava variety

Attribute	**Frequency**	**Percent**
Kibandameno is sweet	247	82.3
Ambari/Nambari is sweet	6	2.0
Agriculture-*Kibandameno* is sweet	25	8.3
Kileso is sweet	9	3.0

Mpemba is sweet	8	2.7
Pamba is sweet when young	1	0.3
Sweetness depends on the environment	3	1.0
No comment	1	0.3
Total	300	100.0

Farmers perception of bitterness in cassava

Majority (56.3 %) of the respondents identified *Guzo*, *Gushe*, *Karembo*, *Sagalato* and *Tajirika* as the most bitter cassava varieties (Table 6). Other varieties that some farmers considered bitter included *Bwazo*, *Gogo*, *Boto/Mwaundu* and *Nzalauka*. Respondent farmers had varying explanations regarding bitterness in cassava. While some explained that all cassava varieties stand a chance of becoming bitter when they put new leaves following rains, others thought that it all depended on the variety or one's luck (*mkono wa mtu*). A section of farmers claimed that when human faecal waste in the field contaminates cassava roots, they would taste bitter. Some farmers associated cassava bitter taste to drought, soil characteristics, or pest infestation. A few farmers claimed that bitterness could be attributed to age: young cassava roots are bitter while mature ones are not. Other farmers (28.7%) had not experienced any bitterness in cassava.

Table 6: Farmers' response on the bitterness of a given cassava variety

Attributes	Frequency	Percent
Gushe is bitter	43	14.3
Guzo is bitter	84	28.0
Tajirika is bitter	4	1.3
Bwazo is bitter	1	0.3
Gago is bitter	1	0.3
Boto/ Mwaundu is bitter	1	0.3
Sagalato is bitter	9	3.0
Nzalauka is bitter	1	0.3
Karembo is bitter	29	9.7
All can be bitter at sprouting after rains	3	1.0
Not experienced one	86	28.7
Depends on one's luck (mkono wa mtu)	5	1.7
When contaminated with human faecal matter	1	0.3

Caused by drought	5	1.7
Variety dependent	21	7.0
When cassava still young	2	0.7
Depends on the soil environment/characteristics	3	1.0
Pests infestation on leaves can cause bitterness	1	0.3
Total	300	100.0

What farmers do with bitter cassava roots

The results showed that farmers use various methods to manage bitterness in cassava (Table 7). About 28% of the farmers reported that drying cassava in the sun and grinding into flour was enough to minimize bitterness in cassava. Some farmers (15.7%) boiled the cassava roots, cut them into pieces and soak in fresh water overnight to give a product referred to as mchindiwa by the farmers. While a few farmers reported that they would add soda ash (magadi) or snuff when cooking cassava, others repeatedly boiled and poured off the water before serving. About 10% of the respondent farmers did not consume bitter cassava: they either discarded it or fed it to livestock. Some of the respondent farmers reported that they would rather cook the cassava as bitter as it was without any treatment, while others pealed the root and scraped the surface of the edible tissue with a knife before washing and eating it raw or cooking.

Table 7: What farmers do with bitter cassava

Attributes	**Frequency**	**Percent**
Add soda ash (*magadi*) when cooking	13	4.3
Boil and pour off the water, add water afresh and continue cooking	19	6.3
Drying and grinding into flour	83	27.7
Soak in water for some time	42	14
Add ingredients -coconut oil, little sugar and salt	7	2.3
Boil, cut into pieces and soak in fresh water overnight (Mchindiwa)	47	15.7
Add little snuff when cooking	18	6
Boiling together with the terminal tissue/masala of a doom palm	2	0.7
Cover with cassava leaves when cooking	2	0.7
Scratch the surface of the edible tissue	4	1.3

Cook as it is - no choice	34	11.3
Discard it	25	8.3
Give to livestock	4	1.3
Total	300	100

Why farmers grow cassava

Results of the study showed that 97% of the interviewed farmers grew cassava for subsistence, 62.2% of whom reported that they sold a portion of their crop to earn income for their households (Table 8). Very few of the respondents grew cassava solely for commercial purpose.

Table 8: Reasons for growing cassava

S/No.	Attribute	Frequency	Percentage
1	For subsistence only	110	36.7
2	For commercial purpose only	9	3.0
3	For both subsistence and commercial purpose	181	60.3
	Total	300	100.0

Cassava farming systems

The results showed that farmers grew cassava either as intercrops with other crops or as sole crop (Table 9). Most of the cassava (on 83% of the farms) was grown in association with either tree crops (in the open areas between trees) or annual crops. The tree crops under which cassava was grown included coconut, mango and cashewnut, while the annual crops were mainly cowpea, green gram and maize. Where pulses (e.g. cowpea and green gram) were intercropped with cassava, the latter was the main crop. Maize was considered the main crop whenever it was intercropped with cassava.

Table 9: Cassava farming systems

Farming system	Frequency	Percent
Intercrop	249	83.0
Sole crop	51	17.0
Total	300	100.0

Distribution of cassava by soil texture

The results of the study showed that cassava was grown on soils that were mainly sandy in nature (Table 10). Majority of the interviewed farmers (48.7%) grew their cassava on soils with the sandy loam texture, while 37.3% grew theirs on sandy soil. Cassava was rarely grown on soils that were stony. Very few farmers grew cassava on loamy or clayey soils.

Table 10: Soil textures and cassava growing

Attribute	Frequency	Percent
Sand	112	37.3
Sandy loam	146	48.7
Loam	16	5.3
Sandy clay	16	5.3
Clay loam	9	3.0
Stony soil	1	0.3
Total	300	100.0

Farm sizes in the visited cassava growing sites

The sizes of farms under cassava ranged from 0.1 to 8.0 acres, with an average of 2.2 acres per farm (Table 11). Majority (75.9%) of the interviewed farmers grew cassava on small parcels of land, of not more than one acre. Only very few farmers (5.6%) had planted at least 3 acres of cassava. The analysis of variance (ANOVA) of the data showed that there was no significant difference (at $P \geq 0.05$) in the acreage put under cassava.

Table 11: Sizes of farms under cassava

Attribute (Farm size in acres)	Frequency	Percent
0.1	8	2.7
0.3	64	21.3
0.5	73	24.3
0.8	13	4.3
1.0	70	23.3
1.3	4	1.3
1.5	19	6.3
1.8	1	0.3
2.0	27	9
2.5	4	1.3
3.0	8	2.7
3.5	4	1.3
4.0	4	1.3
8.0	1	0.3
Total	300	100

Multiple regression analysis for key parameters with respect to bitterness in cassava

The effect of the interaction (Y) of the predictors to bitterness in cassava was established. The predictors were soil texture (X_1), cassava variety (X_2), cassava preparation before eating (X_3), time of harvesting cassava (X_4), agroecologial zone (X_5) and elevation (X_6). The equation below represents the predator interaction.

$$Y = 14.6+0 .7 X_1+0.5 X_2- 0.1 X_3 + 0.1 X_4 - 0.8 X_5 +0.01 X_6$$

Agroecological zone, cassava variety and soil texture (as independent variables) had significant contribution to the prediction ($p < .05$). This meant that the regression model was a good fit of the data (Table 12).

The R column on Table 12 represents the multiple correlation coefficients (0.5), a measure of the quality of the prediction of the dependent variable, bitterness in cassava. The value 0.5 indicated a fair level of prediction of bitterness in cassava using the six independent variables on the predictor interaction model (Equation **E1**).

The R^2 is the coefficient of determination, indicating the proportion of variation accounted for by the regression model. In this case 22.9% of the variation in the dependent variable, bitterness in cassava, was explained by the independent variables.

Table 12: Multiple regression model summary

Model	R	R^2	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0.5(a)	0.2	0.2	5.0	0.2	14.4	6	292	0.000

'a' is the predictor constant (14.55) of the following independent variable: Soil texture, Cassava variety, Cassava preparation before eating, Time of harvesting cassava, Agroecologial zone, Elevation.

DISCUSSION

Cassava varieties grown by farmers

Farmers use systems of recognizing plant species and varieties in their communities (Mtunguja *et al*. 2014). Varieties names were given using certain attributes that these varieties possess. The variety Guzo, for instance, has a stem that resembles a building pole, a feature that is used to identify this variety. Similarly, the word *Kibandameno* is associated with the characteristic clicking sound produced when one bites a raw cassava tuber by the teeth ('meno' in Kiswahili language). *Kibandameno* cassava variety, one of the most popular in the study area, took 75.7% of all farms that were visited during the survey (Table 2). The variety is preferred by farmers due to its good culinary quality. According to farmers, *Kibandameno* is among the sweetest varieties cultivated in the region. In the mijikenda ethnicity from the Coastal region of Kenya, the word *Sagalato* means 'relax or sits properly'. Farmers reported that the *Sagalato* cassava variety was named because it is high yielding and cooks well and with the saying that, ''with sagalato the visitor should be relaxed and sit well as he gets prepared to take a good cassava meal''.

The word*'gushe'* is a terminology that refers to a black piece of cloth in the Digo community local language where the study was conducted. This variety is also drought tolerant. The variety was named *Gushe* since the colour of the stems looks dark like a piece of black cloth. This confirms Chiwona-Karltun *et al*. (2001). report that naming criteria of plants such as rice varieties in the Himalayas is based on morphological traits, environmental adaptability, agronomic traits, place of origin and local recipes. Some varieties are named after the person or organizations that brought it to the community Chiwona-Karltun *et al.* (2001). In the study area, the variety 'agriculture *Kibandameno*' was introduced to farmers by the department of agriculture.

Small-scale farmers source planting materials from their neighbors as well as during travels or by collecting seedlings of sexually propagated cassava found in fields left in fallow for several years (Chiwona-Karltun et al., 2001). Farmers use personal experience to determine suitability of a cultivar for cultivation. Cultivar that excel in performance within the local environment and farming system will be adopted, and continue to be cultivated.

Reasons given by farmers for choosing a given cassava variety

The majority of farmers (43.3%) chose to grow early maturity cassava varieties. Some farmers (21.0%) chose cassava varieties which were sweet, for food security (17.3%), and high yield (10.3%) while a few of the farmers chose varieties which were drought tolerance (4.3%) and of high market demand (3.7%). Basically all reasons given by farmers for choice of cassava varieties when critically analyzed show that farmers chose to grow a certain cassava variety of cassava either for subsistence reasons (65%) or commercial reasons (35%).

Farmers grow a multitude of cassava varieties in their farms in order to minimize crop losses. This is in line with Elias *et al*. (2000) who also observed that farmers manage the risk of a calamitous crop loss by keeping several different varieties in production at the same time and often in the same field. While farmers generally prefer high yielding varieties, they may preserve lower yielding varieties in parallel with more productive varieties, due to cultural preferences such as taste or cooking quality (Elias *et al*. 2000). Farmers do cassava bulking as well to get cuttings for coming seasons. Farmers bulk stem cuttings mostly for their domestic requirements rather than preservation of cassava genetic resources (Balyejusa Kizito *et al.* 2006; Elias *et al.* 2001; Mtunguja *et al*. 2014; Akintunde and Obayelu 2016). It is crucial at this point in time to have sensitization campaigns to teach farmer the need to conserve cassava genetic materials. Farmers exchange stem cuttings with neighboring community and amongst themselves for free. This trend is especially true for local varieties.

Cassava growing and Agroecological Zone (AEZ)

The study area fell across agroecological zones CL 2 (1-60 m above sea level), CL3 (1- 450m above sea level) and CL4 (1-250 m above sea level) (Table 4). Agroecological zones CL 2 and CL 3 are Coastal Lowland Sugar Cane Zone and coconut cassava zone respectively which carry 97.0 % of all visited farmers. The altitude 1- 450 m above sea level where majority of cassava cultivation was taking place confirms Gitebo et al. (2009). Cashewnut trees, by and large, have wider and denser canopy than coconut that may intercept relatively more sun light required by cassava plants underneath for photosynthesis. Hence the low population of cassava farmers in Cashewnut cassava zone (CL4) compared to Coastal Lowland Sugar Cane Zone (CL 2) and coconut cassava zone (CL3). Farmers reported that heavy tree canopy effectively suppressed weeds. Weeds can cause poor germination and bad crop stand establishment either through allelopathy or competition (Gitebo *et al*., 2009). Intercropping cashewnut and cassava enhances water retention in the soil as mentioned by Gitebo *et al.* (2009) who observed that intercropping crops results in higher light interception and reduced evaporation hence increase in soil moisture.

Cassava crop has a lower risk of crop failure compared to other crops such as maize, rice and legumes. One of the constraints usually faced with the introduction of new varieties is their adoption by farmers (Gitebo *et al.*, 2009). A number of new varieties have been introduced to farmers in the recent years. Poor adoption to new varieties was evident during the survey.

Farmers still stick to their indigenous varieties which in any case produce lower yields and more susceptible to diseases. The few farmers who have adopted the improved varieties of cassava still retain some of their local varieties mainly because of food security. One of the reasons for poor adoption of new cassava varieties is their poor cooking quality. The new varieties taste bitter despite their potential to yield higher. Bitter cassava varieties are more drought tolerant, more accessible and cheaper (Gitebo *et al.*, 2009).

Farmers perception of sweet cassava varieties

Cassava cultivation was majorly small- scale practice in the area of study. According to the farmers who were interviewed during the survey, cassava could be categorized as ‘sweet’ and ‘bitter’. The categorization is however spurious since cyanide content in the roots varies on a continuous scale among varieties. There is no real distinct demarcation between 'bitter' and 'sweet' varieties.

During the study the respondents gave possible causes of bitterness in cassava. These were related to genotype, pest attack and the environment. These factors corroborate with statement made by Cock (2000) that other than cyanide in cassava, there were many other factors that influence bitterness in cassava: chemicals and environment. The feeding behavior of burrowing bug, Cyrtomenus bergi caused increased cytogenesis in cassava roots (Cock, 2000). Ecological stress factors such as prolonged drought, low phosphorus and potassium levels in the soil and pest attacks coincide with an increase in the levels of cyanogenic glucosides in the roots of cassava (Cock, 2000).

What farmers do with bitter cassava roots

The survey found various ways farmers use to manage bitterness in cassava. These range from drying cassava in the sun, fermentation, boiling, chipping and soaking. Drying is the simplest method of processing cassava. Drying reduces moisture, volume and cyanide content of roots, thereby prolonging product shelf. This can be attributed to the volatile nature of hydrogen cyanide when subjected to heat treatment. This observed decrease in HCN corroborates the earlier report by Cock(2000) that as the temperature of drying cassava chips increased the HCN content decreased progressively in the same fashion. Total cyanide content of cassava chips could be decreased by only 10 - 30% through fast air drying. Slow sun-drying, however, produces greater loss of cyanide. Drying may be in sun or over a fire. The former is more common because it is simple and does not require fuel wood. More than 86% of cyanide present in cassava was lost during sun drying. Some farmers use soda ash and snuff to minimize bitterness in cassava. Snuff and soda ash have similar effects in minimizing cassava bitterness since snuff preparation use soda ash as an ingredient. Some farmers scratch the surface of the edible parenchyma tissue of cassava trying to minimize bitterness as mentioned by Haque and Bradbury (2002) that there is a marked radial gradient in cyanide content exists from the outer peel to the inner parenchyma tissue.. This is because the surface of the parenchyma tissue has a high cyanide concentration as mentioned by Processing of cassava is in line with Nyerhovwo, J.T (2004), Stephen. A, and Eric, K.G. (2009) findings that cassava root tubers processing was important to increase shelf - life and reduce bitterness. The shelf –life of cassava is 24–48 hours after harvest. Cassava roots rarely exceed few days before they go bad because of their high moisture content (62 -65%). The fresh tubers are perishable and therefore need either be consumed immediately or otherwise processed into stable forms such as cassava flour. Apart from processing, most farmers believed that cassava local varieties are better for food security than improved varieties because they have a longer storability in the soil. Farmers grow a given cassava variety either for subsistence reasons (65%) or commercial reasons (35%). The findings are in agreement with The East African Root Research Network (EARRNET, 2006)) which observed that about 30% of the cassava produced in some sub-Sahara regions was for fresh consumption. Cassava requires processing to avoid cyanide poisoning. The respondents use the traditional small scale processing methods which are inefficient. In case of bumper harvest, the surplus is sold to middlemen as evidenced by Stephen. A. and Eric, K.G (2009). Cassava production and processing was practiced by informal sector and dominated by small scale dwellers, a significant sector in economy and food security. The cassava informal sector can take full advantage of opportunities in cassava processing to generate income, employment and raw materials for industries. This is in line with Mtunguja *et al*. (2014)that small scale enterprises can employ over 60 percent of the nation's work force bulk of which fall in the agricultural sector. The small scale sector plays an important role in our developmental continuum thus placing the sector in a critical position in industrial development of our nation. Cassava processing geared towards minimizing bitterness in cassava is a rural women activity. Good quality cassava flour, products of cassava processing, is odourless and white Mtunguja *et al*. (2014. However, farmers noted that bitter cassava varieties are less likely to be attacked by wild life a statement which is in consonant with Mtunguja *et al*. (2014), Akintunde and Obayelu 2016) who made a similar observation that bitterness is a food security measure since bitter cassava varieties are avoided by thieves. These findings underscore the need to incorporate farmer preferences in conservation and breeding strategies in order to improve productivity and sustainable use of cassava genetic resources.

Why farmers grow cassava

The study revealed that the majority of cassava farmers grow cassava for their food security. A few of the farmers grow cassava to earn some income for their family.

Results of the study showed that 97% of the interviewed farmers grew cassava for subsistence, 62.2% of whom reported that they sold a portion of their crop to earn income for their households (Table 8). Very few of the respondents grew cassava solely for commercial purpose.

Cassava farming systems

The study revealed that cassava growers use intercropping and sole cropping in their farms. However those who exercise intercropping were the majority (Table 8). This statement agrees with the findings by Agwu and Anyaeche, (2007) that cassava is consumed in many forms particularly, fresh, boiled or processed but also for its leaves which serve as vegetables and is largely grown by smallholder farmers, with the main production system being intercropping. Intercropping was in principle a crop diversification approach to minimize chances of total crop loss in case of a disaster. Different cassava based intercrops prevailed among farmers in the survey area. Cassava was intercropped with cowpeas, green grams, coconut and cashewnut amongst other associations. Cassava legume associations have the advantage of improving the nutrition status of the family and enriching the soil with legume effects fertilizer efficiency. This agrees with the findings of Alou IN, et al. (2014). Farmers seem to prefer intercropping cassava with other crops because they get more crop residues after harvesting. The residue could be used as livestock feed and when incorporated into the soil as mulch and latter decompose can improve soil fertility, production and productivity (Agwu and Anyaeche, 2007). When cassava was intercropped with crops with a wider foliage cover such as cow peas the heavy canopy intercepts surface run off and direct rainfall from removing the top soil. This is important in soil and water conservation. The foregoing statement confirms Alou IN, et al. (2014). Intercropping cassava with other crops were felt in many ways like reduction in run off and soil losses, and conservation of physical properties as well as maintenance of soil fertility (Alou IN, et al. (2014).

Distribution of cassava by soil texture

Findings from the study revealed that majority of farmers (48.7%) chose to grow cassava under sandy loam soil. A few farmers (37.3%) put cassava in sand soil. Sandy loam soil has organic matter, good drainage and well aerated for root crops growing. Under such soil structures such as sandy loam cassava roots can grow and expand well to optimal size. Through probing farmers it was also observed that loamy soils are rarely used in cassava growing. Loamy soils are very rich in organic matter which favours the vegetative growth of cassava at the expense of roots. Soil textures and soil structural material are the main soil physical properties influencing cassava growth (Chaudhry and Rasul 2004). Soil provides physical support to plant as well as supplies water and necessary nutrient elements for plant growth and development (Injura, 2004). Water and nutrient holding capacity, soil aeration, drainage conditions and soil compactness are influenced by soil texture (Nambia, 2013). The soil organic component contains fungi, bacteria, virus, nematode that affect plant growth and yield of cassava directly. Such microorganisms play important role in maintaining soil fertility (Asibey, 2010; Awuku, 2005).

Farm sizes in the visited cassava growing sites

Cassava production is predominantly in small holdings as subsistence ventures with minimal commercial orientation. The average farm size in cassava production was found to be 2.2 acres (Table 9). The cassava growing households consume virtually all of the produce and sell the surplus for additional income to meet household needs. This confirms Ohene-Yankyera (2004) findings that cassava production was dominated by small holdings subsistence farmers. Low technology and managerial skill characterize these subsistence ventures. Both men and women play a prominent role in cassava production. Overall, women play a central role in cassava production though. Farmers could sell their cassava all at once or sell in the soil to middle men who dispose the cassava from the farm at their own convenience to the market. Farm labour was majorly provided by family members. It was observed that there was an increase in the area under cassava as household size increased. This was probably due to increased family labour and most probably with family incentives. This positive relationship between hired labor and farm size was supported by Ohene-Yankyera (2004) who revealed that households that have the ability to mobilize labor to fulfill the extra demand for weeding and other post-soil preparation activities can operate larger farms. Education level of farmers has an influence on farm sizes. As farmers acquire additional years of education, they tend to drift toward paid jobs which consequently compromise the amount of time available for farm activities. However commercial cassava production where farmers opt for farm mechanization farm sizes was advantaged. This statement confirmed Ben-Chendo, Korie, Essin, and Uhuegbulem (2014) who observed that cassava farm income was shown to have a positive correlation with land holding size. As income from cassava selling increased, farmers got motivated to increase the area allotted to cassava production in the next season. These findings were attributed to hired manual labour force besides family members. These findings were supported by OheneYankyera (2004) who observed in his study that so long as family labor was expected to be relatively abundant on small farms, any increase in hired labor can only suggest farm expansion. The circumstances observed in the study area may be that following an increase in access to other livelihood opportunities, farmers divert resources to non-farm activities or production of other crops. Cassava is a crop that is susceptible to perishability and as such most farmers probably grow cassava on a small scale to avoid losses. The distance from the farm to the major roads is a crucial factor in agriculture. As the distance increased, the probability of up-scalling the farm size decreases. With increased distance from the roads, this may prompt farmers to reduce their farms to suit subsistence venture (Katchova and Ahearn, 2015). The analysis of variance shows farm size is however insignificant in this study (Table 10).

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The following statements can be considered as conclusions following the results obtained from this research work:

i. Majority of farmers consider the improved cassava varieties such as *karembo*, *tajirika*, *nzalauka* , *guzo* as bitter cassava varieties. Farmers have strong passion for the local varieties such as *kibandameno, kaleso*, and *ambari* which are known to farmers as sweet varieties. At the same time, farmers use indigenous methods to minimize bitterness in cassava.

Recommendations

i. The public should be sensitized and made aware on the critical HCN equivalents/ kg as recommended by WHO preference standards.
ii. Cassava processing is essential. Farmers must be sensitized on effective cassava processing techniques to improve cassava quality before consumption.

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