Commodity Systems Assessment of Cassava in Uganda

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1. Introduction

This report is an example of the kind of data PEF e-learners can collect and the general results/findings that can be provided when implementing a simplified CSAM study, using a semi-structured survey. The process is a rapid assessment and requires few resources. The main feature of a CSAM report is that it is based on interviews of the actors and your observations of the postharvest handling system, so published references are generally not required. The results allow the researcher to provide information to various stakeholders on the types and volumes of losses, the causes and sources of losses, and the local research needs, training needs and advocacy issues that must be addressed in order to reduce postharvest losses for those producing and handling the crop in the location that was studied. These results can be used to design postharvest training programs, write research grant proposals, or design postharvest development projects. Each CSAM study is a bit different, and during 2019 PEF will be publishing additional examples of studies that have been implemented by PEF e-learners.

Cassava (*Manihot esculenta* Crantz) provides a reliable and inexpensive source of carbohydrates in Uganda. About 88% of cassava produced in Uganda is consumed by humans, 50% of which is processed. In addition to the starchy root, the leaves of the cassava plant are edible and rich in protein.

Peeled sweet cassava roots are eaten raw, boiled, fried, roasted, or after drying and pounding, they are turned into a paste. Peeled bitter cassava is turned into flour after a solid-state fermentation process, or after steeping in water (wet fermentation) and subsequent sun drying. Also, the whole pieces can be boiled, immediately after soaking. Especially bitter cassava is preferred for brewing local beer and distilling *waragi*. It is estimated that in some parts of Uganda, nearly 60% of the people grow cassava and nearly 90% of the people consume cassava in different forms at least once daily. Boiled fresh cassava is regarded as the most important product, followed by flour and then fermented drinks. Local gin such as *enguli* and *waragi* are produced from dried cassava chips ground into flour, fermented and distilled.

2. Methodology - Commodity Systems Assessment Methodology (CSAM)

2.1. Description of the study population:

The population studied consisted of cassava farmers in Nakasongola (Central Uganda), Kamuli (Eastern Uganda) and Arua (Northern Uganda) districts of Uganda. Respondents also included other key informants such as technical personnel involved in commercial cassava processing, leaders of Community-Based Organizations (CBOs) like District Farmers' Association (DFA) and local governmental leaders.

2.2. Research design:

The research was done using a cross sectional study design involving a field survey in April 2018. During the survey, information was collected by interviewing participating cassava farmers, leaders of cassava Community Based Organizations and cassava processing personnel with semi-structured questionnaires (see Annex). Additional data was collected by direct observation of cassava value chain operations and interaction with the chain actors.

2.3. Sampling method and sample size:

The Chairperson of District Farmers' Association (DFA) provided a list of 20 farmers involved in cassava farming including at least two farmers from each of the sub-counties in each of the three districts (Nakasongola, Kamuli and Arua). These farmers were the primary respondents for the survey. The farmers were supplemented by other key cassava value chain stakeholders such as commercial and domestic cassava processors, traders, village council leaders and leaders of the Farmer groups so as to ensure inclusion of participants from varying socio-economic backgrounds. In total, 80 cassava value chain actors and stakeholders were surveyed.

2.4. Data collection:

A wide range of primary data was collected via semi-structured interviews including socio-economic characteristics of farmers (sex, education level, marital status, household population size, farm size and land tenure status), knowledge, attitudes, practices concerning pre-harvest activities

involved in cassava production, harvesting, transportation, processing, storage, and consumption of cassava and/or its products. In addition, data was collected from the farmers concerning harvesting and postharvest losses in cassava, their causes and possible control measures. The information was obtained as responses by respondents on the semi-structured questionnaire. The data collected was both qualitative and quantitative.

2.5. Data analysis:

The data obtained from all respondents sampled was compiled, coded and then analyzed using a statistical package, SPSS version 16.0 and then used to calculate percentage responses of options and answers given by the respondents in the semi-structured questionnaire.

3. Findings on the 26 CSAM components, results and discussion

CSAM studies are organized into 4 major categories: Pre-production, Production, Postharvest and Marketing. Summary findings are presented here for each of the 26 CSAM components.

3.1. Pre-Production (Components 1-7)

Component 1: Relative importance of crop

Cassava is a perennial woody shrub in the *Euphorbiacea*e (spurge family) native to South America but now grown in tropical and sub-tropical areas worldwide for the edible starchy roots, which are a major food source in the developing world.

The national average cassava yield in Uganda is 5059 kg per acre compared to 16,187 to 20,235 kg/acre achievable in good growth conditions. The main cassava growing regions based on production volumes as of 2008/ 9 fiscal year were the eastern at 37%, northern (34%), western (15%) and the central (14%) regions.

NAROCASS 1 was the dominant variety of cassava grown by over 86% of the farmers surveyed. Other varieties include NASE 3, NASE 12 and NASE 14 (Table 1)**.** The farmers select

the variety based on time taken from planting to harvesting, yield potential, resistance to pests and diseases, and taste of cassava root.

Table 1: Cassava varieties and their maturity period

Cassava variety grown*	Time from planting to harvesting (months)	Percentage response
NAROCASS 1	9	86
NASE 3	9	68
NASE 12	8-10	52
NASE 14	8-10	60

*Multiple responses

All farmers studied currently grow cassava, maize, sweet potatoes and groundnuts as main food crops and mangoes and oranges as cash crops. Also, 20% of the farmers grow *Matooke* (cooking banana) and 2% cotton, as food crops and cash crops respectively. These results showed more diversification in food crop production compared to cash crop. All farmers reared animals and only 10%, 2% and 2% (multiple responses) of the farmers engaged in bee keeping, consultancy services and salaried jobs respectively as another income activity.

Component 2: Public sector policies

There are no public policies specific to cassava in Uganda. Generic policies exist under the Uganda Agricultural Policy and the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF).

Component 3: Relevant institutions

A number of national and international institutions exist in Uganda involved in cassava value chain including:

- ✓ National Crops Resource Research Institute (NaCRRI)
- ✓ National Agricultural Research Organization (NARO)
- ✓ Uganda National Farmers Federation (UNFFE)

Component 4: Facilitating services

Transport and mini warehousing facilities exist but under private arrangements, not as public services. Most of the farmers carry cassava in basins or sacks on their heads from gardens to home, factories or local markets. Others use bicycles, wheelbarrows, or motorcycles and only a few use tractors to transport cassava.

Cassava (fresh/minimally processed) is normally stored in private kitchen or house stores originally built for human accommodation. Standard commercial stores are very few in Uganda and are owned by large commercial cassava processing and exporting companies.

Component 5: Farmer organizations

There is no farmer organization in Uganda specifically for cassava farmers. A major farmers umbrella organization (Uganda National Farmers Federation- UNFFE) exist in Uganda that is composed of many District Farmers Associations (DFA).

Other Farmers Organizations with cassava operations include:

- ✓ Young Farmers Coalition of Uganda (YOFACO)
- ✓ Uganda Sustainable Agricultural Support Organization (USASO)

Component 6: Environmental requirements and constraints

Cassava requires warm temperatures for optimal growth. The plants require at least 8 months of warm weather, thriving in regions with warm, moist climates with regular rainfall. Root production is maximized when temperatures are between 25 and 32 °C (77–90 °F). Cassava should be planted in full sun and is very sensitive to shading, which leads to low yields.

Cassava can be grown in many types of soil, producing even in poor soil but will be more productive in well-draining, sandy clay loam with a pH between 5.5 and 6.5. Cassava is drought resistant. The crop does not tolerate waterlogged soils.

Component 7: Availability of seeds and planting materials

Since cassava is a "food security" staple food crop, farmers normally produce cassava all year around and have ready access to planting materials. Planting materials for newly introduced varieties are normally supplied either free or at subsidized fees to farmers by governmental or non-government agencies dealing in agriculture.

3.2. Production (Components 8-11)

Component 8: Farmers' cultural practices and socio-economic characteristics

Social characteristics of respondents: The findings on the social characteristics of the respondents are represented in Table 2. The results indicate that 64% of the farmers were aged between 29 and 39 years and 60% were female. Majority (60%) of the farmers had household size of 11-14 and only 8% had 5 or fewer members. Most of the farmers (84%) did not complete primary level education and only 4% reported to have attended tertiary education.

Table 2: Characteristics of the respondents

Characteristics*	Options	Percentage response
Age distribution (Years)	18-28	22
	29-39	64
	40-50	10
	51-61	2
	62-72	2
Sex	Male	40
	Female	60
Marital status	Single	20
	Married	80
Size of household	5 or less	8
	6-10	32
	11-14	60
Highest level of education	Primary	84

Table 2: Characteristics of the respondents

Characteristics*	Options	Percentage response
	Secondary	12
	Tertiary	4

*Multiple responses

Economic characteristics of the cassava farmers: All the farmers owned land and over 62% reported to use more than 7 acres of their land for farming. This shows a big potential for agricultural development and improvement in income and food security of the farmers. However, practically this is not the case since 88% of the farmers reported daily income of less than Uganda shillings 5,000 which is less than US$ 1.50 (Table 3).

Table 3: Economic characteristics of respondents

Characteristics*	Option	Percentage
Main occupation	Farmer	94
	Business	4
	Private company/NGO employee	2
Acres of farm land owned	1-3	10
	4-7	28
	>7	62
Daily income in Ugandan shillings	<5,000	88
	5,000-<10,000	6
	10,000-<20,000	0
	15,000-<20,000	4
	20,000 and above	2

*Multiple responses

(US $1 = 3750 Ugandan shillings)

Farmers' cultural practices about cassava: Most of the farmers only do primary clearing of the land like cutting trees or tall grasses using *pangas* (machetes, long knives) or axes and then the field becomes ready for planting cassava. Only a few farmers cultivate the field for cassava planting using ox-plough or tractors. Usually fields with poor soil nutrients are considered for cassava

planting. Cassava is cultivated on small farms often in fields to be set aside as fallow and often cropped on marginal soils, replacing crops that require greater soil fertility and cultivation. Cassava also is associated with mixed cropping systems.

Component 9: Pests and diseases

Cassava pests and their control:

i. Whiteflies *(Bemisia tabaci)*:

Whiteflies are the most damaging insect pests in all cassava-producing regions. Some farmers use insecticide to control whiteflies, but spraying is not usually very effective. Not spraying insecticide, on the other hand, allows biological control by the whitefly's natural enemies.

ii. Cassava mealy bug (*Phenacoccus manihoti*):

These pests mainly attack the growing points of the plant causing stunting, leaf and shoot deformation. Severe damage leads to tuber quality deterioration. Farmers commonly use clean and resistant varieties like NASE 1 as a control measure for mealy bug.

iii. Cassava green mite (*Mononychellus tanajoa*):

Cassava green mite is a sucking pest that causes reduced growth, scorching of leaves, tiny leaf production, leaf drop and eventually a plant without leaves. This causes great yield reduction or loss. The mites are controlled culturally by planting resistant cassava varieties, crop rotation and planting early at the onset of rains.

iv. Cassava scale *(Aonidomytilus albus*):

When stem surfaces appear covered with white waxy substance they are infected with scale. This insect is a flattened oval scale with an elongated white cover. Scale results in leaves wilting and dropping from plant. Severe infestations may result in stunted plants and poor tuber yields. Cuttings from infected plants do not sprout and grow normally. Scale is controlled by planting cassava materials that are completely free of the insects, removing and destroying infested stems, and applying organic matter to soil to improve fertility.

v. Others: Other pests include domestic animals, wild pigs and termites.

Cassava diseases and their control:

i. Cassava mosaic disease (CMD):

This is a viral disease which is usually transmitted through infected planting material and by whiteflies. Infected leaves are yellow, mottled and distorted. If leaves are yellow or brown all over but are a normal size that does not indicate CMD. CMD can cause total crop failure. CMD is controlled by strict enforcement of quarantine procedures and cultural practices, especially the use of resistant or tolerant cultivars and virus-free planting material as well as removing and destroying any plant showing symptoms of the virus.

ii. Cassava brown streak disease:

This virus is also transmitted through whiteflies and stem cuttings. Symptoms include necrosis of roots, roots developing knots, and internal tissues of roots are brown. Roots may rot due to secondary fungus infection. To control the disease, farmers use only healthy and disease free cuttings for planting, plant cassava varieties that are more tolerant of brown streak virus, remove and destroy any plants which are symptomatic of the disease including alternative hosts, harvest crop early to avoid severe losses due to necrosis of tubers, and follow proper plant quarantine practices to avoid spread of virus to new region.

iii. Cassava root rot disease:

This is a fungal disease that is favored by waterlogged, poorly-draining soil. Leaves on affected plants turning brown and wilt, and plant has a scorched appearance. Leaves may remain attached to the plant or drop to the ground. Plant death usually occurs. The roots of infected die back and there is swelling of roots. Cassava root rot disease is controlled by planting cassava crop in well-draining soils, removing and destroying all crop debris by burning, and by sanitizing all garden tools after use.

Component 10: Preharvest treatments

A small proportion of farmers surveyed irrigate cassava in the garden when rainfall is short. Only a few farmers spray cassava with pesticides to control pests. Some farmers mulch their cassava during the last weeding before harvesting so as to increase moisture retention around the crop.

Component 11: Production costs

Production costs in Uganda are summarized in Table 4.

Table 4: Estimates for one acre of cassava garden

Item/activity	Cost (Uganda shillings)
Rent of land for 1 year	100,000
Land clearing/primary cultivation	60,000
Buying and transport of planting materials	50,000
Planting of cassava	20,000
Weeding (3 times)	180,000
Harvesting	60,000
Total	**470,000**

(US $1 = 3750 Uganda shillings)

3.3.Postharvest (Components 12-21)

Component 12: Crop harvest

Identification of mature cassava fit for harvesting: All farmers surveyed harvested based on cracking of ground cover and sound produced by beating on the ground. Using a hand hoe, farmers beat on the ground around cassava crop where production of a deep sound implies mature cassava roots. Besides, cracked ground around cassava crop implies that its roots have grown bigger enough for harvesting according to the farmer. However, these two identification methods are not scientifically proven and are inaccurate since cracking can also be caused by dryness of ground especially for soils with a high clay content (Bell & Maud, 1995). Only 2% of the framers interviewed checked maturity of cassava from records by reviewing the date of planting. Only farmers who had attained tertiary education reported this method.

Methods of harvesting: Harvesting was done by uprooting using hand hoe aided by hand pulling according to all farmers studied. The farmers reported difficulty in harvesting using this method, especially in the dry season, as it causes severe damage to the root, some parts of root not

harvested and breaking of cassava root. For these reasons many opt to wait for the rainy season before harvesting.

Yield: The quantities of cassava harvested per acre depend on the variety, climatic and soil factors according to all farmers surveyed. The majority of the farmers (90%) obtain about 14,000 kg/acre (34.6 t/ha) while 10% harvest about 12,000 kg of fresh cassava per acre (29.7 t/ha). These quantities harvested are enough for feeding all household members and a lot remaining for sale if no or minimal losses are experienced during and after harvest. Unfortunately, farmers reported significant losses (Table 5).

Table 5: Estimated quantity of cassava lost per acre during harvesting.

Category of loss*	Mean quantity lost (kg/acre ± S.D)
Some root parts not harvested	237.5±25.0
Broken cassava roots	241.7±33.3
Bruised cassava roots	150.0±27.6
Damaged by Rodents	187.5±37.5
Molded	100.0±27.5
Diseased	100.0±5.0
Rotten	187.5±37.5
Entirely fibrous	162.5±27.5
Abnormally small roots	15.0±3.5

*****Multiple responses

Losses of fresh cassava experienced when harvesting: Main losses (kg/acre) were due to some parts of cassava not being harvested and extreme breaking during harvesting. Each of these categories contributes to loss of over 230 kg (1.5%) of fresh cassava harvested per acre according to the interviewed farmers. Other losses incurred were due to bruises, wrinkling, immature roots, damage from rodents and/or domestic animals and moldy roots.

Causes of the harvesting losses: All farmers surveyed reported hard ground, poor harvesting tools and rough handling as the main causes for harvesting losses. They added that throwing cassava across the field during harvesting or piling for transport is another cause for its breaking.

Bacteria, fungi and virus were the major causes for mold growth and rotting reported by all studied farmers. According to the farmers, of the cassava varieties they know, some are tolerant while others are vulnerable to fungi, bacteria and viruses which cause rotting. Farmers also reported limited soil moisture and an overgrown, poorly pruned garden causes abnormally small roots, and damage by rodents were responsible for poor yields and losses. This is particularly due to inadequate water availability for the cassava crop compared to that required for appropriate growth.

Possible control of losses when harvesting: Mulching, watering, and waiting for rainfall were the main measures reported by all the farmers to reduce losses during harvesting. These measures ensure moisture availability in the soil thus the ground is not hard when harvesting. All the farmers mentioned selecting varieties tolerant to fungi, bacteria and virus such as NAROCASS 1, as the main control for mold growth, diseases and rotting. The same measure was also recommended by Otim-Nape et al. (1994).

Component 13: Selection, sizing, grading and inspection

All of the surveyed farmers taste the cassava after peeling by biting and chewing or by licking the cut surface to find out if it is bitter or sweet and to determine if it is watery or not. Cassava that is too bitter to be eaten is sliced and dried for making cassava flour whereas sweet cassava (not bitter) is normally consumed fresh by farmers or sold to customers. These activities and practices were also reported by Nabawanuka-Oputa & Agona (2006).

Component 14: Postharvest chemical and physical treatments

Farmers did not report chemical treatment for cassava, both fresh and dried. Waxing of fresh cassava to extend shelf life is currently being promoted by some organizations.

Component 15: Packaging

Packaging of fresh cassava and dried cassava chips: Fresh and dried cassava for supply to local markets is normally packaged in single layer polythene sacks, basins, baskets or wooden trays. Cassava flour for sale to local markets is packaged in double layered polythene bags, then in sacks according to the farmers and traders surveyed.

Packaging of cassava flour: The materials for flour packaging vary among the surveyed farmers. About 36% and 40% of the farmers reported use of interwoven polythene bags and baskets respectively, and 14% and 10% of the farmers pack the flour in used jerry cans and basins respectively (Figure 1). Good quality paper or double layered high-density polythene packaging was reported by larger commercial companies that manufacture and supply high quality cassava flour to corporate markets and for export.

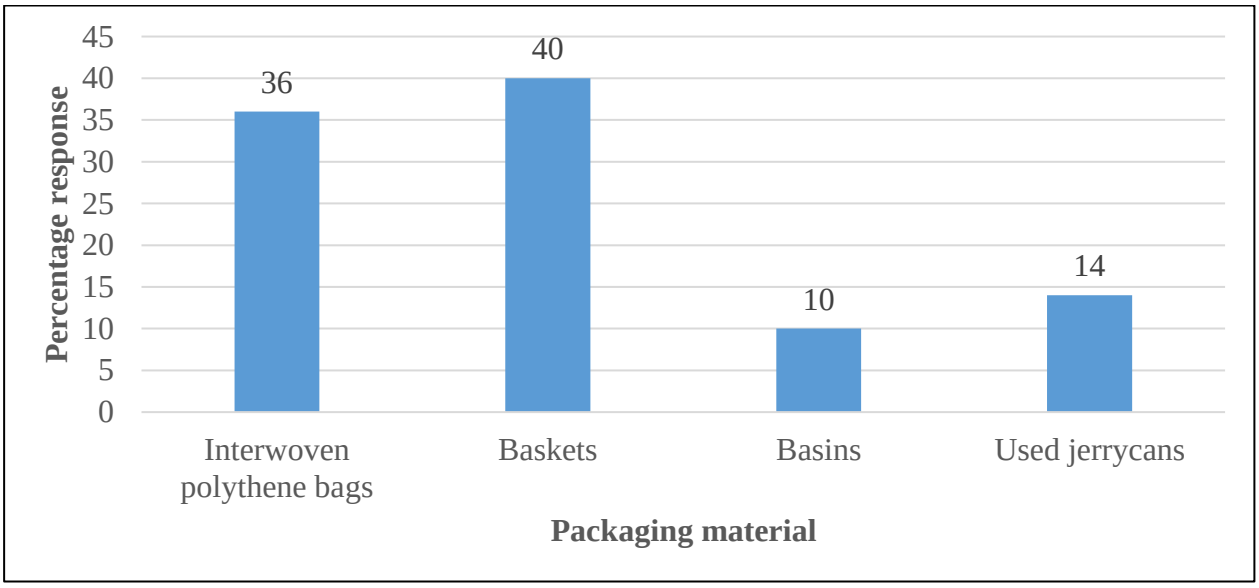

Figure 1: Packaging material for cassava flour

Component 16: Cooling

No cooling operations were reported to be practiced by cassava farmers.

Component 17: Storage

Storage of fresh cassava roots: According to the farmers and traders surveyed, fresh cassava is stored in the shade of trees, at home or in the local markets.

Storage facility for dried chips: The majority (64%) of the farmers store the chips in kitchen whereas 26%, 5% and 5% store the chips in bedroom house, house store, and metallic barrel respectively. The reason given by farmers for storing chips in kitchen and bedroom was to protect them from thieves since they could not afford to construct separate house stores. However, chips

stored in the kitchen could be contaminated by smoke, resulting in browning or darkening, hence dark-brown flour obtained on milling. This was also reported by Bbemba et al. (2014). Only 4% of the farmers had dedicated storage facilities with well-designed features for maintaining quality and quantity of stored chips.

The storage facilities of the remaining 96% of the interviewed farmers were in poor conditions (Table 6). The features of a good storage facility, as used by only 4% of the farmers, included well-cemented floor with strong walls, leak-proof roof, proper ventilation, and protected from rodents. These were all missing on the poor storage facilities begin utilized by 96% of the farmers studied.

Table 6: Storage facilities for dried chips

Parameter*	Options	Percentage (%) response
Storage facility	Kitchen	64
	Bedroom house	26
	House store	5
	Metallic barrel	5
Standard of storage facility	Good	4
	Poor	96

*Multiple responses

Losses during storage of dried cassava chips: According to the farmers, mold/rotting, development of abnormal smell and spillage, contribute to loss of over 20 kg (about 0.13%) of the cassava harvested per acre. Other losses are due to insect, rodents, birds and domestic animals damage or eat up, extreme breaking and foreign matter attachment (Table 7).

Table 7: Quantity of dried chips lost per acre during storage of dried chips

Category of loss *	Mean quantity lost/acre (Kg ± S.D)
Rodents damage or eat up	5±2
Domestic animal damage	10±3
Birds eating up	5±2
Molded chips	20±4

Category of loss *	Mean quantity lost/acre (Kg ± S.D)
Extreme breaking of chips	5±2
Insect damage or eat up	5±2
Spillage	5±2
Development of abnormal smell	25±5
Change of colour (browning or darkening)	25±5
Rotten chips	20±4.5
Foreign matter attachment	5±2

*****Multiple responses

Causes of the losses during storage of dried chips: Inadequate drying of chips and wetting of chips from leaks in the roof of the store, contaminated or dirty stores and poorly ventilated stores were the main cause of losses during storage of chips reported by all studied farmers. Microorganisms, especially bacteria and fungi e.g. Rhizopus oligosporus, rapidly grow on moist chips stored in a poorly ventilated room resulting into rotting, browning or darkening and change of colour of the chips (Sparringa et al., 2002). Also, wastes released by insects and rodents, such as urine, stain the chips and change their colour and odor which under extreme conditions become unfit for consumption hence losses according to all studied farmers

Control of losses during storage of dried chips: Loss of dried chips under storage was minimized by adequate drying of chips, thorough cleaning and proper ventilation of store according to all farmers surveyed. These measures are efficient but need to be complemented by disinfection of the store before putting the cassava chips so as to significantly minimize rotting due to microbial activities as was reported by Davies & Breslin (2003). Only 4% of the farmers studied mentioned use of chemicals (fungicides) to control spoilage by fungi. All the farmers control domestic animals by keeping them tied or indoor and 10% control rodents by keeping cats around store. These measures are very effective at reducing significant losses if consistently maintained by the farmers.

Losses during storage of the cassava flour: All farmers surveyed reported that they incur losses during storage of cassava flour. Over 20 kg (about 0.13%) and 10 kg (about 0.07%) of cassava harvested per acre is lost due to caking and spillage of flour respectively. Other losses experienced are due to insect, rodents and domestic animal damage or consumption. In addition,

development of abnormal smell, browning/darkening and foreign matter attachment can also occur (Table 8).

Table 8: Estimated quantity lost per acre during storage of flour

Category of loss *	Mean quantity lost (kg/acre ± S.D)
Caking of flour	20.5±2
Rodents damage or eat up	3.0±2
Domestic animal damage	3.0±2
Birds eating up	3.0±2
Molded flour	3.0±2
Insect damage or eat up	8.0±2
Spillage	5.5±2
Browning or darkening	11.5±2
Foreign matter attachment	3.0±2

*Multiple responses

Cause of losses during storage of cassava flour: Moist environment in store, leakage of roof, waste from insects and rodents, humid conditions, and dirty packaging material or stores are the major causes for losses during storage of flour. Flour cakes when molds grow on it and when it gets wet. This kind of flour cannot be easily mingled. Rotten and brownish flour is unappealing for consumption. It is poured away by many farmers or fed to animals. Spillage of flour was reported by all surveyed farmers as being caused by over filling of packages, damaged packages, rough handling, and insects or rodents getting into the packages.

Control of losses during storage of flour: Storage of flour in dry, waterproof packing material and preventing or repairing leaks in the roof of the store were the main measures reported by all surveyed farmers for controlling losses during cassava flour storage. Avoiding moist conditions during storage minimizes spoilage microbial activities. However, over 80% of the farmers/traders/small scale local processors surveyed had stores with leaking roofs. Spillage of flour was minimized by avoiding over filling of packages according to all farmers surveyed. Only 4% of the farmers reported control of insects and rodents in the store by fumigation.

Component 18: Transport

Methods of transportation for fresh cassava: Interwoven polythene sacks are used by 92% of the farmers interviewed while 8% use basins when carrying cassava from the garden. The used sacks and basins often have damage which result in dropping or spillage of cassava and the farmers do not cushion these materials before loading the cassava roots. These practices altogether cause losses. Most (54%) of the farmers surveyed transport cassava from garden to home or market using sacks carried on their head or back, and 42% use a bicycle (Figure 2).

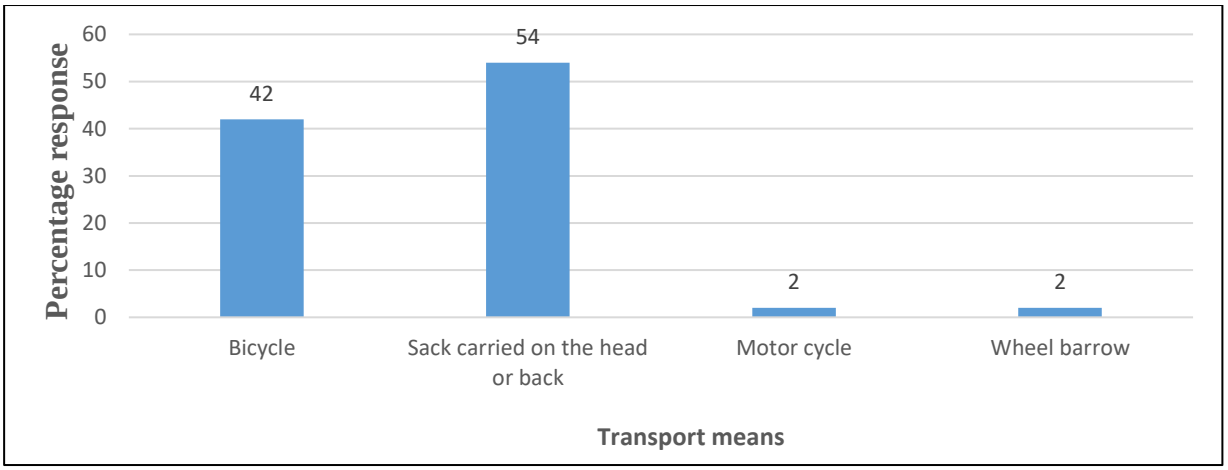

Figure 2: Transport means for fresh cassava

Losses during transportation of fresh cassava: All farmers surveyed reported that they incur losses when transporting cassava from the garden and these losses are due to spillage, bruises and breaking of cassava roots. Most losses are incurred through bruising, which result into estimated loss of over 100 kg (1%) of the total fresh cassava harvested per acre. Other losses during transportation of fresh cassava are due to pest damage, abnormal smell development, change of color, cassava becoming bitter and foreign matter attachment (Table 9).

Table 9: Estimated quantity of cassava lost per acre during transportation

Category of loss*	Mean quantity lost (kg/acre ± S.D)
Spillage	22±5
Bruising	50±5

Category of loss*	Mean quantity lost (kg/acre ± S.D)
Wrinkling	5±2
Breaking of cassava	12±2
Pest damage	15±5
Abnormal smell	5±2
Change of colour	5±2
Foreign matter attachment	5±2

*Multiple responses

Causes of the losses during transportation of the fresh cassava: Poor packaging, inappropriate loading into containers (rough handling), higher transporting speed, not covering top surfaces and not cushioning of transporting surfaces were the major causes of losses during transportation reported by all the farmers surveyed. Although the commonest means of transport were foot and bicycles, playful children who mostly transport the cassava spill some along the way if the carrying containers are damaged or when the children decide to run, according to the farmers. All farmers studied also reported bitterness of cassava which is a variety characteristic but is also induced by throwing or dropping cassava and bruising.

Control of the losses during transportation of the fresh cassava: All farmers control loss during transportation through appropriate loading into containers, good transporting speed and adequate covering of top surface of the load to prevent spillage.

Component 19: Delays or waiting

According to the farmers and traders, delays occur when transporting cassava to markets. Transport facility owners or operators usually arrive later than expected. This causes some losses of fresh cassava due to physiological deterioration. Delays also cause loss of trust from farmers by their customers.

Component 20: Other operations

Preparation of fresh cassava for consumption: All the farmers studied peel, trim, slice and remove internal longitudinal fibers from cassava before boiling it which causes some additional

losses. According to the farmers, trimming is done to remove the next layer after the peel which is usually too watery, slicing is for reducing boiling time and increase convenience when eating while the inside fiber is removed to eliminate the watery flesh in which the fiber is embedded.

The time of boiling fresh cassava varies from 60-120 minutes depending on the age and variety of the cassava as well as the temperature of water in which the food is boiled according to all farmers. The higher the temperature (which can be adjusted by adding salt), the shorter the time cassava takes to get ready. Cassavas harvested at age of less than one year take less time of cooking to get ready compared to that harvested at two years. This is due to increase in the strength of binding forces in the cassava starch molecules with increasing age (Moorthy & Ramanujam 1986).

Losses when boiling fresh cassava for consumption: All the farmers studied experienced losses during boiling of the cassava for consumption. For fresh cassava harvested per acre, over 75 kg and 25 kg were estimated to be lost through burning and extreme wetting of the cassava respectively when boiling. Burnt cassava appears yellow or even darker and has a stronger burnt flavor which is not appealing for consumption. Most (62%) of the farmers throw away the burnt cassava while 38% reserve it for feeding their animals.

Table 10: Quantity lost per acre during preparation for boiling activities.

Activity*	Mean quantity lost (kg/acre ± S.D)
Trimming	75.0±25
Slicing	17.5±5
Removal of inside fiber	75.0±25

*Multiple responses

Causes of losses experienced when boiling cassava: The farmers stated that losses during boiling are caused by poor monitoring of the boiling process, cooking on a high boil, using too much water and not putting cushioning in the cooking pot before putting in the cassava slices.

Control of losses of cassava during boiling for consumption: Cassava consumers surveyed reported control losses during boiling by close monitoring of the boiling process and putting adequate amount of water in the boiling dish. They all reported putting adequate cushioning, e.g. banana fibers, can minimize extreme wetting while cooking cassava.

Component 21: Agro-processing (drying and domestic processing) of cassava

Fermentation of peeled and sliced cassava before drying: Most (84%) of the farmers fermented the cassava before drying to achieve a desirable flavor, remove bitterness and ease mixing of flour in boiling water to produce a thicker, sticky product. Related findings were also reported from Eastern-Uganda by Kaaya and Eboku (2010).

Method and site of drying: All farmers surveyed dry the cassava in direct sunshine after peeling and slicing into chips. The drying process is sometimes interrupted by rainfall during the day or made inefficient by cloudy weather. This usually results into mold growth onto the chips. Over 88% of respondents put their cassava slices on bare swept ground while only 10% and 2% dry the cassava on old iron sheets and interwoven poly then bags respectively in open sun shine (Figure 3). Drying on bare ground can expose the cassava chips to aflatoxin contamination (Bbemba et al., 2014). Consuming cassava flour from aflatoxin-contaminated chips can cause serious illness and sometimes death (Kaaya & Warren, 2005). Very few (2%) of the farmers surveyed had fenced cassava-drying sites. The remaining 98% of the farmers reported that their sites were not fenced. All farmers studied reported that they usually remove the cassava chips from the drying sites during rainfall and keep them in specific places to protect them from being wet by the rainwater.

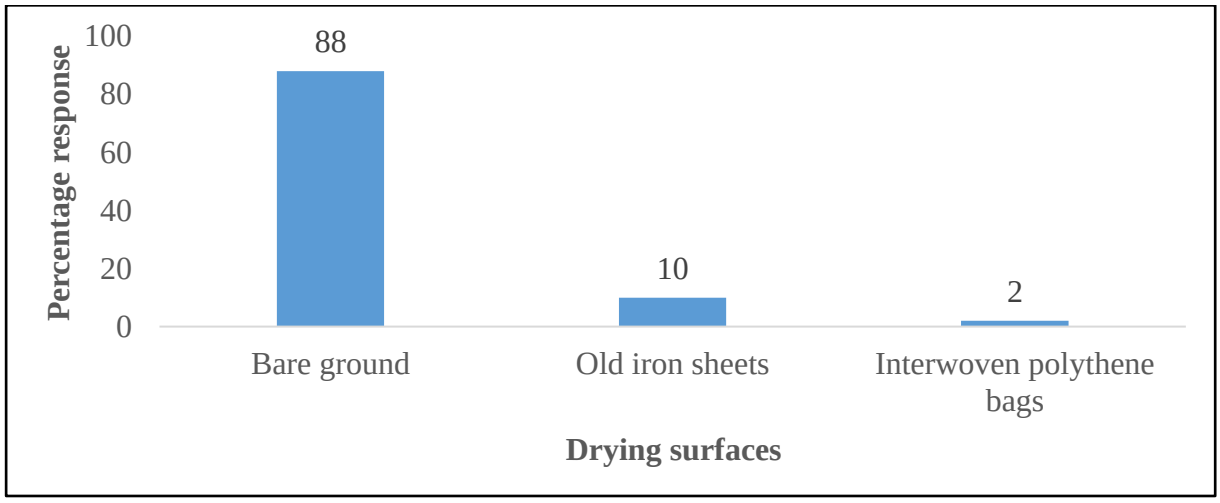

Figure 3: Cassava drying surfaces.

Figure 4: Farmer drying cassava chips on the bare ground.

Determination of sufficient drying of cassava chips: The farmers determined that cassava chips were well-dried chips when they produce a sharp sound when rubbed against each other and easily break when forcefully bent, according to the farmers. This is because brittleness of the chips increases with decrease in their moisture content as they dry.

Yield of dried cassava chips: Most of the farmers (90%) obtain about 4,000 kg/acre of dried cassava per acre while 10% get about 3,000 kg/acre, depending on the variety of cassava and processing practices.

Losses during drying of cassava chips: All farmers interviewed reported that they incur losses when drying their cassava chips. Over 150 kg/acre (1%) of cassava is lost through spillage when processing (drying). In addition, rotting, development of abnormal smell and extreme breaking of cassava chips, each contribute to loss of over 75 kg/acre (about 0.5%). Other losses incurred were due to insect, rodent and/or domestic damage and/or consumption, browning/darkening, abnormally small dried cassava, and foreign matter attachment (Table 11).

Table 11: Estimated quantity of cassava lost per acre during drying.

Category of loss*	Mean quantity lost (kg/acre ± S.D)
Spillage	150±15
Abnormal smell	75±5
Browning or darkening	7±2
Wrinkling	7±2
Extreme breaking of chips	85±5
Insect damage	25±5
Domestic animal damage	45±5
Rodents damage	25±5
Abnormally small dried chips	15±5
Rotting of chips	81.7±5
Foreign matter attachment	7±2

*Multiple responses

Causes of losses when drying cassava chips: Poor handling, over loading of containers, and wetting of chips by rain were the major causes of loss during processing (drying) according to all surveyed farmers. The farmers reported that cloudy weather and rainfall during the drying process influence rotting of the drying chips and that flour from such chips is not to appealing most consumers. Poor monitoring of the drying site and existences of bush around the site favor to domestic animal, rodents, insects and birds consumption according to all farmers studied.

Control of losses during drying of chips: All farmers studied reported that the control loss of chips during drying by scheduling drying only in sunny seasons. Only 2% of the surveyed farmers reported drying chips on raised floor so as prevent unnecessary wetting of drying chips. Rodents and insect eat up is controlled by clearing bush around drying site while loss from domestic animals is controlled by keeping them indoors or tied according to all farmers studied. The majority (98%) of farmers studied reported control of foreign matter attachment onto chips through thorough cleaning of the drying site floors (bare ground). However, this measure is made ineffective by wind that repeatedly blows foreign objects onto the chips.

Milling of dried cassava chips: Majority (96%) of the farmers studied own milling equipment while the remaining 4% do not have the equipment and usually hire someone with the equipment to mill the cassava chips for them. Of those owning milling equipment over 92% have a manual mortar and pestle, 6% have traditional grinding stones, and only 2% have hammer mills (Figure 5). Those without a hammer mill sieve by using their hands.

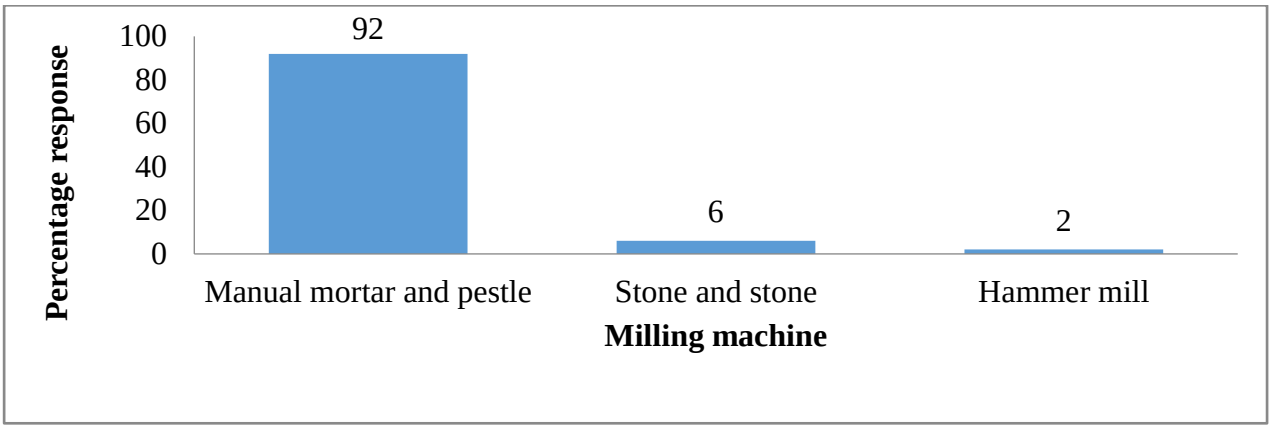

Figure 5: Milling equipment owned and used by farmer (stone and stone is a grinding stone)

Losses of cassava during milling: The farmers lose over 20 kg (about 0.13%) and 15 kg (about 0.10%) of the cassava harvested per acre due to flour escape and spillage respectively when milling. Other losses incurred are due to abnormal color of flour and insect consumption (Table 12).

Table 12: Estimated quantity of cassava lost per acre during milling

Category of loss*	Mean quantity lost (kg/acre ± S.D)
Flour escape	18±2
Spillage	18±2
Abnormal colour of flour	5.5±2
Insect eat up or damage	8±2

*Multiple responses

Figure 6: Manual milling of dried cassava via mortar and pestle.

Figure 7: Processors milling dried cassava chips using a movable hammer mill.

Causes of losses during milling: Pressure when milling, leakage in pipes or receiving containers, over filling of the containers and wind blowing away flour during milling were the major causes for loss flour during milling according to all surveyed farmers. When pounding in a pestle over-filled with cassava chips, some chips spill over if pounding is done vigorously. Also, damage to the flour-receiving containers results into leakage of flour. All studied farmers reported that abnormal color of flour was caused mixing of foreign matter, like dust and remains of previous milling, into the flour and insect consumption caused by milling in an open area in the evening.

Control of losses during milling: Escape and spillage of flour during milling was controlled by repairing leakage in containers or pipes, avoiding over filling of containers or milling equipment. Receiving containers commonly used were baskets. Farmers mentioned that they fill the inter-spaces with cow dung to prevent leakage of flour.

3.4.Marketing (Components 22- 26)

Component 22: Marketing intermediaries

Market intermediaries exist who normally buy the fresh or dried cassava from farmers at the farm and then sell the food to local or regional markets. These intermediaries usually buy the cassava from the farmers at much lower prices than appropriate and then sell the food at higher prices. In this way the farmers earn less from their cassava enterprise than they would if they were to sell their cassava directly to the markets

Component 23: Market information

Only medium scale or educated farmers organized into groups or companies receive timely and appropriate market information for the cassava. These reported taking advantage of the information and sell their cassava at good prices in such markets.

Peasant/uneducated poor farmers reported lack of capacity needed to transport their cassava to good market places even when they receive information about market availability. Efforts by Government and many Non-Government organization is directed towards organizing the peasant farmers into groups so as to enjoy collaborative marketing of their cassava.

Component 24: Consumer demand

Consumer demand for cassava and its products in local and regional markets fluctuates with seasons. During harvesting seasons for most foods in Uganda, the demand for cassava and other foods is very low due to higher level of food supply. The reverse happens during planting seasons when food supply is very low.

Component 25: Exports

No farmers or traders reported exporting fresh cassava. Some traders export dried cassava chips and cassava flour to neighboring countries e.g. South Sudan. A few available large commercial food companies in Uganda export high quality cassava flour or flour products to international markets.

Component 26: Postharvest and marketing costs

Table 13: Estimates for a one acre cassava garden.

Item/activity	Cost (Uganda shillings)
Peeling and slicing of cassava into chips	80,000
Tarpaulins for drying on the cassava chips	80,000
Labor for drying the cassava chips	40,000
Milling of cassava chips into flour	250,000
Double layered polythene sacks for packaging cassava flour	90,000
Transport to market	80,000
Minimal advertisement	60,000
Total	**680,000**

(US $1 = 3750 Uganda shillings)

4. Research needs

The causes of losses and their control measures mentioned by most farmers relate to what are scientifically documented but not all. Those not scientifically documented, need further research so as to prove or disapprove them. For example, the determination of the maturity of cassava roots based on cracking of ground surface around the cassava crop, and harvested cassava becoming too bitter to be eaten when thrown down under much pressure (rough handling in the field causes bruising, and compression damage is experienced during transport). The current practices reported by the farmers need further research, and there is a need to develop a simple and practical maturity index to determine the right harvest period to maximize yield and quality.

5. Training and extension needs

Many of the harvesting and postharvest handling practices reported by the farmers are inefficient and ineffective in protecting the cassava crop resulting in losses or delays. For example, farmers have to delay harvest until they have rainfall, or they have to harvest from dry soil which results in high losses from breakage of cassava. This practice of harvesting when the soil is hard can expose the cassava roots to breakage and underground fungal infection causing losses, especially when curing is not practiced to heal harvesting wounds and cuts before packing and shipping. Also, the farmers often lose their potential markets because they are unable to supply their customers until it rains, and harvest is easier. Only 2% of farmers used maturity indices to determine when to harvest the crop mainly due to lack of necessary skills and knowledge about the method thus there is a need for training.

Some practices, such as filling gaps of local flour packages with cow dung are a food safety concern. Current practices therefore need to be complemented by improved recommended practices and measures coupled with sensitization and training of the farmers in order for them to reduce cassava losses. For example, encouraging waxing, cushioning of fresh cassava before transportation to market, drying cassava chips on raised platform, constructing simple leak proof and rodent-guarded sheds for storage of cassava chips and flour, and promotion of better processing methods such as using hammer mills as opposed to the common manual pestle and mortar, each have the potential to reduce losses in a cost-effective manner.

6. Advocacy issues

Since the daily income for over 88% of the farmers was less than 5,000 Uganda shillings (US $1.06), they cannot afford most of the recommended cassava harvesting and postharvest handling practices. Therefore, subsidized tools, supplies and training should be provided to the farmers as an incentive for them to adopt the good practices.

7. CSAM study conclusions

All farmers studied had traditional knowledge about cassava harvesting and postharvest handling activities. The farmers had interest in modern recommended cassava handling practices like drying cassava chips on wire mesh raised floor although only 2% of them practiced the drying method. Results indicated that farmers lost a substantial amount of cassava during and after harvesting, and curing was not practiced. Most losses in cassava were incurred during harvesting (9.2%), processing (drying and milling; 4.9%) and storage (1.3%) of dried chips and flour. The main causes for the losses during harvesting was the hard ground, which makes digging difficult. The causes of loss after harvesting were spillage, poor methods of transportation, packaging and storage. The use of raised platforms for drying would have multiple benefits, including improved quality, increased shelf life and market price.

8. Recommendations for postharvest training

There is need for interventions specifically promoting proper cassava postharvest handling practices efficient at minimizing postharvest losses. For example, encourage the use of maturity indices prior to harvesting, curing, waxing and cushioning of fresh cassava before transportation to market, drying cassava chips on raised platform (a few cm up off of the floor to allow for improved ventilation), construction of simple leak proof and rodents-guarded houses for storage of cassava chips and flour and promotion of better processing methods like using a hammer mill as opposed to the common use of manual pestle and mortar.

Farmers should be trained to adopt the available and affordable modern cassava postharvest handling practices as opposed to the traditional ones that are associated with higher losses.

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ANNEX

Questionnaire for knowledge, attitude and practices (KAPs) among cassava farmers about cassava production, domestic processing, storage, transportation, consumption, marketing and the losses in cassava in Nakasongola, Kamuli and Arua Districts of Uganda

I am Thomas Buyinza, an e-Learning student at The Postharvest Education Foundation and a Postharvest Technology Specialist at Iowa State University - Uganda Program, carrying out a study about the cassava pre- and post-harvest practices and losses in Nakasongola, Kamuli and Arua Districts in Uganda. This research is only for study purpose. Therefore, I kindly ask for your voluntary participation and I promise that this information will be kept confidential (no names will be shared). Thank you!

Date……..……

1. Socio-economic profile of farmers/participant

Respondent ID…… Age…….

Sex: (1) Male……. (2) Female…….

Marital status: (1) Single…… (2) Married…….

i. What is your highest level of education? a) Primary b) secondary c) tertiary d) not stated

ii. What is your occupation?

(1) Farmer (2) civil servant (3) business (4) private company/NGO employee
(5) others specify…….

iii. Tell me about the size of your household. Tick from the following options

(1) 5 or less (2) 6-10 (3) 11-14 (4) more than 15

iv. Do you own farm land? Tick (1) Yes or (2) No

v. How many acres of land do you have for farming purposes?

(1) < 1acre (2) 1 -3 acres (3) 4 -7 acres (4) > than 7 acres

vi. Could you give me a rough estimate of your daily income (Uganda shillings)?

(1) <5,000 (2) 5,000-<10,000 (3) 10,000-<15,000 (4) 15,000-<20,000 (5) 20,000 and above

vii. Which food crops and cash crops do you grow currently?

Current food crop	Current cash crop

viii. List your other main income generating activities, if any.

……
……
……

2. Cassava primary production activities/ pre-harvest practices

i. Which varieties of cassava do you grow?

ii. What do you base on to select a given cassava variety for growing? Tick from the following

(1) Time taken to harvest the cassava from planting (2) yield ability (3) resistance to pests and diseases (4) taste of cassava root i.e. sweet or bitter (5) others specify……

iii. How long do the cassava varieties take to produce mature roots ready for harvesting?

Cassava variety	Time taken to produce mature roots (months)

3. Cassava harvesting

i. How do you identify cassava with mature roots ready for harvesting?

(1) Cracking of ground cover around cassava crop (2) beating ground cover around cassava crop (3) check maturity period of the variety from record (4) other specify…….

ii. How do you harvest your cassava roots from the garden? Tick

(1) Uproot using hand hoe (2) Uproot using a tractor (3) hand pulling (4) other method (specify)……

iii. How much fresh cassava roots do you harvest on average per acre?

……Kg

iv. Is there any loss you experience when harvesting your fresh cassava from the garden?

(1) Yes (2) No

v. If yes, what are the losses? Tick besides the loss experienced. What causes the loss and which attempt have you made to control the causes of the loss.

Loss experienced during harvesting	**Quantity lost (Kg)**	**Causes of the loss**	**Control**
Some parts of cassava root not harvested			
Broken cassava roots			
Bruised cassava roots			
Rodents damaged or eaten			
Moulded cassava			
Diseased cassava root			
Rotten cassava root			
Dried cassava root			

Entirely fibrous cassava root			
Abnormally small cassava root			
Others (specify)……			

4. Transport of fresh cassava from garden

i. In which container or material do you carry your fresh cassava after harvest? Tick

(1) Interwoven poly then sacks (2) basins (3) metallic containers (4) I carry my cassava directly without container (5) others (specify)……

ii. Do you cushion your fresh cassava during transportation? Tick (1) yes (2) no
If yes, which material do you use to cushion your cassava and why do you cushion the cassava?
(1) Cassava leaves (2) banana leaves and fiber (3) grasses (4) tree leaves (5) others specify…….

iii. By what means do you transport your fresh cassava from the garden to the store/market place? Tick

(1) Using a sack carried on the head or back (2) using a wheelbarrow (3) using a tractor (4) using bicycle (5) using a tractor (6) other means
(specify)……

iv. Is there any loss you experience when transporting your fresh cassava from the garden? Tick

(1) Yes (2) no (3) I don't know

v. If yes, what are the losses? Tick besides the loss experienced. What causes the loss and which attempt have you made to control the causes of the losses

Loss experienced during transportation	Quantity lost (Kg)	Causes of the loss	Control
Spillage			
Bruises			
Wrinkling			
Breaking of cassava root			
Pest damage			
Abnormal smell			
Change of colour			
Becoming bitter to taste			
Drying of cassava root			
Foreign matter attachment			
Others (specify)……			

5. Preparation of fresh cassava for consumption

i. What do you use for peeling your fresh cassava prior to cooking?

(1) Knife (2) *panga* (3) hand hoe (3) stick (4) teeth (5) peeling machine (6) others (specify)…….

ii. Do you taste your fresh cassava as soon as you peel it? Tick (1) yes (2) no

iii. If yes, why and how do you taste the cassava?

Why.....?

How……

iv. What do you do if you realize your fresh cassava is too bitter to be eaten on cooking?

(1) I through the cassava away (2) I reserve the cassava for feeding animals (3) I slice and dry the cassava (4) I ferment the cassava (5) I boil the cassava and eat it like that

v. On average, how much of your harvested cassava per acre do you through away because it is too bitter to be eaten?.....Kg

vi. Do you trim, slice and remove inside longitudinal fiber from your cassava before cooking? Tick beside what you do and tell me quantity of cassava lost through the activity

Activity	**Quantity of cassava lost through the activity (Kg)**
Trimming (removal of layer next to the peel)	
Slicing	
Removal of inside longitudinal fiber	

vii. How long do you usually boil your fresh cassava to get ready?

……minutes

viii. Is there any loss of cassava you incur when preparing the food for consumption?
(1) Yes (2) no

If yes, what are the losses? Tick besides the loss experienced. What causes the loss and which attempt have you made to control the causes of the loss?

Loss experienced during preparation/cooking	**Quantity lost (Kg)**	**Causes**	**control**

6. Processing (drying) of fresh cassava

i. What do you base on when selecting cassava for drying? Choose from the list below by ticking

(1). variety of cassava (2) taste of cassava (3) amount of cassava harvested (4) need to preserve my cassava (5) I dry my cassava if price of fresh cassava is very low (6) all of the above from i) to v)

ii. What is your usual method of drying cassava? Tick

(1) Direct sunshine (2) solar drying (3) freeze drying (4) roasting on fire (5) others (specify)……..

iii. Do you ferment your cassava slices before drying? Tick (1) yes (2) no.

iv. If yes, please tell me why you ferment the cassava?

……

v. On which surface/ material do you put your cassava when drying? Tick

(1) Bare dusty ground (2) bare swept ground (3) papyrus (4) Interwoven polythene (5) iron wire mesh (6) stainless steel (7) wire mesh (8) old iron sheet (9) others (specify)……..

vi. Do you leave your cassava in the drying site till complete drying? Tick (1) yes (2) no

vii. If no, where do you store the cassava in between drying?

(1) on the veranda (2) in kitchen (3) in a house store (4) in metallic barrel (5) in a silo (6) others specify……

viii. Is your cassava drying site fenced? Tick, (1) yes (2) no

ix. How do you know that your cassava is completely dry?

……..

x. How much dried cassava do you usually get on average from one basin of fresh peeled and sliced cassava?

(1) Half a basin (2) a quarter a basin (3) three-quarter a basin (4) less than quarter (5) more than three-quarter (6) other quantity (specify)……

xi. Is there any loss you experience when drying your fresh cassava?

(1) Yes (2) no

xii. If yes, what are the losses? Tick besides the loss experienced. What causes the loss and which attempt have you made to control the causes of the loss?

Loss experienced during drying	**Quantity lost (Kg)**	**Causes of the loss**	**Control**
Spillage			
Development of abnormal smell			
Browning/darkening			
Extreme breaking			
Insect damage/eating up			
Rodents damage/eating up			
Domestic animal damage/ eating up			
Dried cassava becoming abnormally small			
Rotten cassava			
Foreign matter attachment			
Others (specify)……			

7. Storage of dried cassava chips/slices

i. Where do you store cassava chips/slices after drying?

(1) On the veranda b) in kitchen (2) in a house store (3) in metallic barrel (4) in a silo (5) others specify……

ii. Do you think your store is of good standard to maintain the quality and quantity of cassava stored? Tick (1) yes (2) no

iii. If yes, list down the features of your store, which makes it of good standard.

……
……
……

iv. If no, which features of a good store is yours missing?

……
……
……....

v. Is there any loss of cassava you experience during storage?

(1) Yes (2) no

vi. If yes, what are these losses? Tick besides the loss experienced. What causes the loss and which attempt have you made to control the causes of the loss?

Loss experienced during storage	**Quantity lost (Kg)**	**Causes of the loss**	**Control**
Rodents damage/eating up			
Domestic animal damage/ eating up			
Birds eating up			
Mould growth			
Extreme breaking			
Insect damage/eating up			
Spillage			
Development of abnormal smell			
Browning/darkening			
Rotten cassava			
Foreign matter attachment			
Others (specify)……			

8. Milling of dried cassava

i. Do you own any equipment that you use for milling cassava? Tick (1) yes (2) no

ii. If yes, which equipment is that?

(1) Manual mortar and pestle (2) stone and stone (3) hammer mill (4) others (specify)……

iii. If no, what do you do when you want to mill your cassava? Tick

(1) hire milling equipment and bring it home (2) I take my cassava to anyone to mill for me and I pay (3) I just sell my dried cassava (4) others (specify)……

iv. Briefly tell me how you mill your cassava using the milling equipment

……

v. Is there any loss you experience when drying your dry cassava?

(1) Yes (2) No (3) I don't know

vi. If yes, what are the losses? Tick besides the loss experienced. What causes the loss and which attempt have you made to control the causes of the loss?

Loss experienced during milling	Quantity lost (Kg)	Causes of the loss	Control

vii. In which material do you always put your cassava flour?

(1) Paper bags (2) interwoven polythene bags (3) bags made from clothes (4) jerry cans (5) metallic cans (6) others specify……

9. Storage of cassava flour

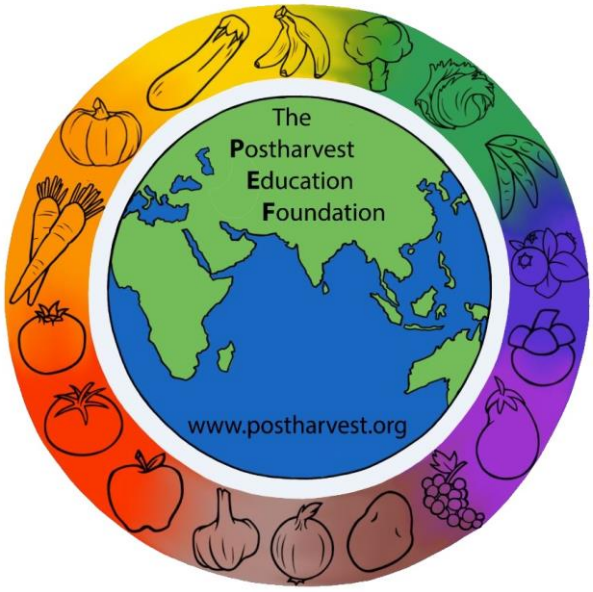
i. Is there any loss of cassava you experience during storage?

(1) Yes (2) no (3) I don't know

ii. If yes, what are these losses? Tick besides the loss experienced. What causes the loss and which attempt have you made to control the causes of the loss?

Loss experienced during storage	**Quantity lost (Kg)**	**Causes of the loss**	**Control**
Caking of flour			
Spillage			
Birds eating up			
Mould growth			
Rodents damage/eating up			
Insect damage/eating up			
Domestic animal damage/ eating up			
Development of abnormal smell			
Browning/darkening			
Foreign matter attachment			
Others (specify)……			

--- Thanks for your participation ---



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