Analysis of Post-Harvest Losses in Cassava Value Chain. Causes and Strategies to reduce them in Uganda.

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Abstract

Many resource-poor countries are putting a lot emphasis towards improving food security but their efforts are still constrained by post-harvest losses. This paper focuses on cassava to expose the causes of post-harvest losses at household level; the stage at which farm households experience losses and the strategies used by farmers to reduce losses. Data from the National Agricultural Advisory Services were used and were analyzed using Probit model. Results indicate that post-harvest losses occur due to absence of storage facilities, pest invasion and lack of market information. Also, post-harvest losses occur at different stages even within a single household and too, households use differing strategies to reduce losses. Thus, interventions aiming at promoting food security need to supplement the efforts with enhanced mechanisms for post-harvest handling. The study recommends establishment of community ware houses for farmers' output as well as improved agro-processing processes to reduce on wastage at household level.

Key words: *Post harvest losses, cassava, value chain, Uganda*

JEL Classification : *O13, Q13, Q18*

1.0 Introduction

After experiencing food crisis in 2006/2007 across the globe, countries renewed their focus on the control of postharvest losses (PHL) as a key strategy of increasing food availability thus global food security became a key target for all countries in the world (Gustafsson, 2013). Reducing PHL is seen as a measure with a great advantage of increasing food availability because countries will not be affected with the demand for more resources and agricultural inputs. This study therefore examines and identified the factors responsible for post-harvest losses of cassava at household level so that

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possible interventions can be undertaken to curtail postharvest loses of cassava in the study area.

Cassava is one of the most important food crops for many resource-poor households across the world. Literature suggests that over 600 million people of the world's population depend on it for food (Asogwa et al, 2013; FAO, 2019; IFAD, 2013). The popularity of cassava in some regions can be explained by its potential of doing well under conditions of low soil fertility and less rainfall drops. Cassava is also known for being a little more resistant to droughts, pests, and diseases if compared to some cereals (Obisesan, 2013). In the recent past, demand for cassava has steadily increased because of the rising demand for starch, livestock feeds and raw material for industrial production (Nuwamanya et al, 2016) and to this effect, its production has also increased. For instance, in 2010, world cassava production was estimated at 240 million Metric Tonnes but rose to 278 million Metric Tonnes in 2018 (FAO, 2020). This could potentially provide some hope for food security in some countries more so, developing countries.

The potential of many resource-poor countries to improve their food and nutritional security is still constrained by post-harvest losses which include the food losses across the food supply chain from harvesting of crop until its consumption (Kumar & Kalita, 2017). Such post-harvest losses are categorised by Kumar & Kalita, (2017) as weight loss resulting from spoilage, quality loss, nutritional loss, seed viability loss and commercial loss. Post-harvest losses have four great implications to world economies. First, related to consumption, post-harvest losses in form of quality loss makes the crops unsuitable for human consumption (Kumar & Kalita, 2017; Recha et al. (2013). Tseng & Mau, (1999) found a change in taste of mushrooms, Agaricus and bisporus during post-harvest storage especially regarding the contents of total sugars, mannitol and fructose during storage. Looking at cassava, a change in its quality in form of discoloration (change of colour for cassava tubers) tends to harden the tuber and in extreme cases turns bitter. Second, post-harvest losses reduce the economic value of the crops and it is estimated that losses range between 20 percent and 40 percent. This a significant impact on the low agricultural productivity in several regions of Africa with Sub-Saharan Africa alone losing about USD 4 billion from food grains (Kumar & Kalita, 2017). Tröger et al., (2020) reports post-harvest losses in pineapples resulting from damages which causes reduced market prices paid to pineapple actors. Additionally, Strecker et al.

(2022) reports severe physical and quality losses for bush beans during post-harvest handling which causes high economic losses. Third, the price of the crop is likely to increase due to under supply resulting from post-harvest losses (Tefera, 2012). Kumar & Kalita, (2017) documents a range of 20 - 40% of post-harvest losses in African countries while Obayelu & Obayelu, (2014) associates post-harvest losses with food waste which results in food shortage. Forth, post-harvest losses in agricultural products increases the pressure imposed on natural resources more so, land as farmers must expand their farm sizes to cater for more production.

There is a general consensus in the empirical literature that post-harvest losses occur along the entire value chain (Kiaya, 2014; Kumar & Kalita, 2017; van Gogh et al., 2017) but, it is important to note that the extent of losses is also crop-specific. For instance, cereals can easily be lost during drying (placing and removing from the drying yard) than tubers like cassava which are relatively big in size. Thus, a thorough understanding of the causes of post-harvest losses and how such losses can be reduced requires a crop-specific analysis. To be more specific, this study focusses on cassava and we explore: (1) the causes of post-harvest losses in cassava at household level in Uganda; (2) the stage at which farm households experience post-harvest losses within the cassava crop enterprise in Uganda and (3) the strategies used by farmers to reduce the post-harvest losses in the same enterprise. Cassava is the second primary staple food for Uganda's population — providing 20 percent of calories in the diet and contributing 22 percent of household income (Waigumba et al., 2016). Moreover, cassava is recognised as a backbone for Agro- Industrialisation (AGI) and food security for the country's populace (NPA, 2020). In developing countries, cassava is the most efficient source of energy and it second grown food crops (Nanda et al., 2010).

The authors are pretty aware that post-harvest losses in cassava occurs along the entire value chain (as stipulated in Kiaya, 2014; Kumar & Kalita, 2017; van Gogh et al., 2017) but, due to data limitations, the analysis in this paper is affixed to household level. The study analyzed data using Probit model to determine the factors leading to post-harvest losses at household level in Uganda.

2.0 Literature Review

2.1 Stages of post-harvest losses

Cassava value chain is categorized along production, transportation, processing, marketing, and consumption. Although losses are bound to occur at pre-harvest stage (when tubers can decay due to pests and diseases), during harvesting and post-harvest periods, most of the losses are experienced through post-harvest handling and to some extent at harvesting i.e. when some tubers are left underground unharvested. With post-harvest handling, small pieces can be selectively dropped by buyers which brings a loss to farmers. Moreover, some losses are also experienced during transportation to the farmers' homes, during storage at the farmers' homes while waiting for buyers, during transportation to the market, at retailers' market stalls, in stores for agro-processors (before and after processing into flour) and through food wastes. Daramola et al., (2010) and Opara, (2013) believe that stages like storage of fresh roots, processing, packaging and storage of processed products need great attention in post-harvest handling of cassava[1]. This is supported by Abas et al., (2013) which outlines the stages of post-harvest losses to start with harvesting, transportation, drying, threshing, processing and storage. Oguntade, (2013) observed that when GIZ was assessing cassava PHL in Nigeria, most of the losses were experienced at the processing phase of cassava.

2.2 Causes of post-harvest losses

The causes of post-harvest losses are widely documented in literature (Abong et al., 2016; Atanda et al., 2011; Daramola et al., 2010; Kader, 2002; Kiaya, 2014; Opara, 2013; Tröger et al., 2020). For instance, the Food Wastage Foot print Project report published by Food and Agricultural Organization in 2013 indicates that post-harvest losses are mainly caused by application of inappropriate harvesting practices including rough handling, premature harvesting, deficiency of proper or poorly planned harvesting instruments, equipment, harvesting containers and storage facilities, distance to market and poor weather at harvesting time. Kiaya, (2014); Kader, (2002) and Gross et al., (2002) suggest that post-harvest losses especially in developing countries are caused by limitations in harvesting techniques that are linked to financial, managerial and technical incompetence, inadequate storage and cooling facilities in difficult climatic conditions, poor infrastructure in terms of bad roads, bridges, poor packaging and marketing systems, microbiological factors like fungi and bacteria, lack of suitable transport systems, environmental factors like humidity, altitude, temperature, and time of food storage. Relatedly, Ashaye, (2018) associates post-harvest losses to interactions between abiotic and biotic factors like pests while food is in store. The study also points to the inter-granular atmospheric changes in a sense that the poor post-harvest storage management can result in significant loss

[1] For instance, Opara, (2013) documents that poor storage facilities like using paper, makes the facility unsuitable for long time storage.

of dry matter and accumulation of mycotoxins which contribute to post-harvest losses. Kereth et al., (2013) attributes post-harvest losses to mechanical damage, microbial damage, poor infrastructure from farm to the market and absence of knowledge on post-harvest management on the side of farmers. While studying the risks associated with climate changes in eastern Kenya, Recha et al., (2013) attributes post-harvest losses to weather variations while yields are in store.

For studies which are crop specific, Tröger et al., (2020) reports post-harvest losses in pineapples resulting from damage, rough handling at harvest, packaging and transportation. Such damages manifest in form of bruises which allows for entry of disease microorganisms. While reviewing production, post-harvest handling and marketing of sweet potatoes, Abong et al., (2016) observed that the tubers are highly perishable and post-harvest losses are caused by lack of appropriate post-harvest handling knowledge and information on available cultivars, technologies and other post-harvest handling facilities. Relatedly, Kannan et al., (2013) finds incidence of insect infestation, rodents, birds and physical changes in stores like temperature, moisture content to be main causes of post-harvest losses in rice and red gram while Parmar et al., (2018) reports drop during sun drying and insect damage infections as the major causes for post-harvest losses.

2.3 post-harvest loss mitigation strategies

Global food security is a key target for all countries in the world (Gustafsson, 2013). To achieve this target, reducing post-harvest losses is of paramount importance (Aulakh et.al., 2013; Zorya et al., 2011). Different agricultural value chain players adopt different mitigation strategies. Many small-scale farmers adopt easiest technologies such as drying of crops. With drying, crops are laid under sunshine or are dried by movement of atmospheric air. Kiaya, (2014) upholds that if grains have been properly dried and properly kept, farmers are likely to reduce the post-harvest losses resulting from moisture content. Reducing of post-harvest losses through drying is also documented in Ashaye, (2018). However, the approach of crop drying is weakened by weather variations more so, during the rainy season. By implication, this can cause serious post-harvest losses.

Besides drying, Kiaya, (2014) also observes other farmers reduce post-harvest losses through peeling and washing, grating, fermentation and sieving. Processing curtails the perishability of crops, increases nutritional value and adds economic value to the crops. Another way of reducing post-harvest losses is through better storage. For a case of cassava, literature points to three ways through which successful storage of fresh roots and tubers can be done. These include prudently selecting only top-quality roots and tubers minus any signs of handling or pest or disease damage for storage, keeping them in particularly designed stores and checking the stores consistently. Timely and proper transportation of cassava to high-end markets and adding value to products by industries can equally provide an avenue for reducing post-harvest losses (Wanda et al., 2014; Zidenga et al., 2012).

Further, Opara, (2013) observes that packaging using improved technologies does not only improve the quality of food but also reduced post-harvest losses. The study highlights different types of packaging materials including glasses, plastics, metals and cardboards but, furthers points out that the material used depends on the nature of the food product. For example, bottles and glass jars are good for packaging liquid food stuff while solid food products are mostly packed in plastics and cardboards (Opara, 2013). In a similar way, Daramola et al., (2010) finds packaging a key ingredient in prolonging the shelf life of fermented cassava and also, improves the demand of the product. The expansion in demand was observed from fermented cassava that was packed in high density polyethylene.

Putting that aside, Olorunfemi & Kayode, (2021) recognizes plastic bins as key containers that can reduce insect pests ‘infestation while Purdue improved crop storage bags and wooden silo are good and viable management tools for preventing aflatoxin accumulation in storage and moisture migration.

3.0 Data and Methods

3.1 Data

This paper uses primary data obtained from the National Agricultural Advisory Services (NAADS) secretariat and School of Economics, Makerere University. To start with data obtained from NAADS, these data were collected from eight (8) districts of Uganda i.e, Arua, Apac, Gulu, Nebbi, Oyam, Lira, Kibuku and Masindi between March, 2020 and June, 2020. Although, data were collected from a total of 348 respondents (including 241 cassava farmers/producers, 64 Agro-input dealers, 8 District Agricultural Officers, 16 agro-processors, 16 extension workers and 3 officers (1 from NAADS secretariat, 1 from Ministry of Agricultural Animal Industry and Fisheries (MAAIF) and 1 from Operation Wealth Creation—OWC), the analysis in this paper is based on data collected from 239 farmers because two subjects were dropped due to missing information on key variables. The data contains information on demographic characteristics of the farmers’ households, cassava varieties, climate variabilities, post-harvest management, information and market accessibility. During the analysis, post-harvest losses are indicated by a constructed dummy that takes 1 if a household reported having experienced a post-harvest loss in a year preceding the field survey, 0 otherwise. Table 1 presents the summary statistics for the variables and Table 2 presents the correlation matrix between explanatory variables.

Table 1: Summary statistics of the data.

Variables[2]	**Obs.**	**Mean**	**Std. Dev**
PH_Loss	239	0.494	0.501
Educ_HH	239	0.180	0.385
Male	239	0.854	0.354
Married_	239	0.904	0.296
Household_size	239	8.326	4.641
New_variety	239	0.603	0.490
Store_Pests	239	0.230	0.422
Store_humidity	239	0.343	0.476
Excess_rains	239	0.791	0.408
Storage_space	239	0.808	0.395
Distant_mkt	239	0.682	0.467
Tport_Cost	239	0.799	0.401
Lack_mktinfo	239	0.653	0.477
Male_market	239	0.615	0.488

Source: *Author's computations*

The results in Table 1 indicate that post-harvest losses were reported by 49.4 percent of the households. In terms of education attainment, only 18 percent of the household heads finished advanced level of education while 85 percent and 90 percent of the respondents are males and married respectively. The household size is relatively big with an average number of 8.3. In relation to adoption of improved cassava varieties, over 60 percent of the households reported adoption with over 65 percent of the respondents reporting lacking adequate market information while marketing is mostly done by males (62 percent). This is supported by many farmers (68.2 percent) reporting distant markets for their cassava which puts women at a disadvantage of marketing their produce.

Although data from NAADS can help to expose the determinants of post-harvest losses in the cassava value chain, it was found to miss some information related to mitigation approaches used by farmers to address the

[2] For variable descriptions, please, refer to appendix 1.

challenge of post-harvest losses. To address this data gap, School of Economics, Makerere University conducted a follow-up through the project focal persons in respective study areas and a total of 202 formally interviewed were surveyed[3]. From the follow-up, data on mitigation strategies and the stage at which post-harvest losses occur were obtained.

3.2 Theoretical Foundation

This theoretical foundation is constructed on the assumption that farm households aim at maximizing their net income through minimising of farm yield losses. When losses increase and exceed household income, the net income of the farmer will be reduced. A farmer thus, can maximize his/ her income only when the Marginal Cost of reducing harvest losses equals the Marginal income. It is assumed that a farmer's Marginal Cost is the increase in subjective cost for an individual farmer to reduce post-harvest losses.

The cost function is given as;

$$MC = \beta X_i + \varepsilon_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where X_i Vector of factors affecting subjective cost judgement of farmer i, β is the vector of coefficient to be estimated and ε_i is the error term which is assumed to be normally distributed. Thus, any household farmer who wish to maximize net income, will strive to minimize losses and this comes with increasing costs which translate to increases in income. However, it is not easy to observe subjective costs. In this study, I use post-harvest losses in cassava sub sector as reported by farmers. The extent of the losses to farmer i indicates a greater loss in income as shown in the frame work below.

$$\begin{cases} Y_i = 1, when\, MC_i \leq \mu_1 \\ Y_i = 2, when\, \mu_1 < MC_i \leq \mu_2 \\ \quad \ldots \\ \quad \ldots \\ Y_i = n, when\, \mu_n < MC_i \end{cases} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where μ_{in} is that point when a farmer's subjective cost changes. A probit model in this study is used to quantitatively assess the factors that determine post-harvest losses at the household level.

[3] We failed to meet the previous sample size due to logistical reasons but, the summary statistics for the new sample are robustly similar to the first sample.

3.3 Estimation procedure.

Post-harvest losses occur at different stages in the cassava value chain. First, at the farm level, losses are experienced when cassava deteriorates at maturity stage[4]. When losses are identified at the farm level, further losses at the other stages of the value chain can be minimized say through better storage or quick processing or selling. Second, losses can be experienced during transportation or at processing and third, they can occur at consumption level i.e. through food waste. However, due to data availability, our analysis is anchored at household level and follows Basavaraj et al., (2007) and Adewumi et al., (2009) probit estimations to determine the factors leading to post-harvest losses at household level. The regression model is stated as:

$$Post - harvest\ loss = f(X_i) \quad (3)$$

Where X_i are the factors affecting losses at household level? Equation (1) can be specified in general form as:

$$Post - harvest\ loss = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \cdots + \alpha_k \quad (4)$$

Where $X_1, X_2 \ldots . X_k$ represent the variables that are likely to cause post-harvest losses in the cassava value chain and ε is the error term. $Post - harvest\ loss$ is the dependent variable which is a constructed dummy that takes 1 if a household reported having experienced a post-harvest loss in a year preceding the field survey, 0 otherwise.

To estimate equation (4), we used the Probit model because it can solve problems that can arise under the linear probability model (LPM). For example, under LPM, fitted probabilities can be below or beyond the limits (less than zero or greater than one) and the partial effect of any explanatory variable is constant (Wooldridge, 2012). Because the dependent variable is a binary response, probit model can overcome such problems. The probit regression model takes the form:

$$\Pr\ (Post - harvest\ loss = 1/X) = \varphi(X'\beta) \quad (5)$$

Where Pr is probability, φ is cumulative distribution function of the standard normal distribution, X is a vector of explanatory variables assumed to influence the outcome ($Post - harvest\ loss$) and β are parameters estimated

[4] The loss occur from discoloration, drops of small pieces or from selectivity of cassava dealers by leaving hard or broken pieces with the farmers.

by maximum likelihood. Our estimation model is obtained from the underlying latent variable model:

$$Post - harvest\ loss = X'\beta + \epsilon \tag{6}$$
$Where \sim N(0,1)$ and,

$$Post - harvest\ loss = \begin{cases} 1 & if\ Post - harvest\ loss > 0 \\ 0 & Otherwise \end{cases} \tag{7}$$

$Post - harvest\ loss$ is the latent variable; X holds the same as in equation (5) above while ϵ is the error term. The error term is assumed to be normally distributed (Cameron & Trivedi, 2010).

4.0 Empirical Results and Discussion.

4.1 Causes of cassava post-harvest losses among farmers in Uganda.

To explore the causes of post-harvest losses in the cassava value chain, a Probit model was estimated and results are presented in Table 3. In column (1), we present results from estimating a model that includes only household characteristics to check whether they account for post-harvest losses. We then follow Kiaya, (2014); Kader, (2002) and Gross et al., (2002) which argue that post-harvest losses sometimes occur due to absence of a ready market for farmers' output and include market attributes. The results are reported in column (2). In column (3) we include the intensity of rain during the harvest and post-harvest period. This is based on Bartz et al., (2015a) which argue that some post-harvest losses are a result of weather vagaries. Precisely, these studies suggest for more losses especially at household when it excessively rains and farmers may fail to have enough sunshine to dry their yields.

Table 2: Causes of post-harvest losses in cassava value chain

Variable	***Post-harvest loss = 1***		
	(1)	(2)	(3)
Educ_HH	0.757 (0.201) **	0.841 (0.228) **	0.853 (0.226) ***
Male	0.340 (0.330)	0.358 (0.327)	0.308 (0.335)
Married	0.252 (0.266)	0.228 (0.258)	0.271 (0.238)
Household_size	-0.026 (0.024)	-0.024 (0.025)	-0.023 (0.025)
New_variety	0.145 (0.233)	0.160 (0.239)	0.234 (0.249)
Store_Pests	2.015 (0.328) ***	2.067 (0.343) ***	2.150 (0.350) ***
Storage_space	0.678	0.601	0.729

	(0.267) **	(0.270) **	(0.321) **
Distant_mkt		0.005 (0.210)	0.031 (0.212)
Tport_Cost		-0.309 (0.249)	-0.295 (0.256)
Lack_mktinfo		0.371 (0.201) *	0.539 (0.202) ***
Excess_rains			-0.553 (0.256) **
_cons	-1.438 (0.337) ***	-1.434 (0.349) ***	-1.311 (0.335) ***
Observations	239	239	239
Pseudo R^2	0.268	0.282	0.295

Source: *Author's computations*

Note: *P < 0.01 = ***; P < 0.05 = **; P < 0.10 = **

The results in Table 2 across all columns indicate a higher probability of experiencing post-harvest losses when a household head completes advanced secondary level of education. To be more specific, higher education level of the household head is associated with a higher likelihood of experiencing post-harvest losses in own household. This result seems not strange but can be attributed to two potential reasons. First, highly educated individuals have a higher chance of possessing other income generating activities. This suggests that farmers who are highly educated allocate some of their time to optional activities (e.g. formal employment and other businesses). As a result, farmers reduce their time allocation to agriculture more so to cassava enterprise which is associated with low returns yet, weighty. The previous result is supported by Vetráková et al., (2018) which document a higher correlation between education level and formal employment. Second, highly educated household heads are more likely to send their children to school (Korupp et al., 2002) which reduces the household labour force. The implication for this is that when children are at school, the household experiences reduced number of workers who would help during the harvest period and when drying cassava. As such, with unprecedented weather changes, some cassava can get wasted especially during the rainy season.

Putting that aside, the invasion of pests while cassava tubers or dried slices are kept in stores is likely to cause post-harvest losses. Many farmer households lack adequate storage facilities for their harvests. The store facilities are either too small to accommodate large yields or are in poor condition that allow for the invasion of pests. Kiaya, (2014) found high correlation between poor storage and lack of storage facilities and post-harvest losses. The study argues that the poor conditions of storage facilities allow for the invasion of pests and various diseases, contamination and spillage or natural dying out of the crops.

Similarly, lack of market information by a household is associated with a higher likelihood of experiencing post-harvest losses. The implication for this result rests on the fact that one of the strategies used by farmers to mitigate post-harvest losses is selling their farm produce; timely. This applies not only to cassava tubers but also to dry cassava. Hodges et al., (2011); Kader, (2004); Kaminski & Christiansen, (2014) document the importance of markets to post-harvest losses. For example, Kader, (2004) argues that lack of markets causes post-harvest losses and can consequently affect food availability.

Turning to weather vagaries, our results indicate a lower likelihood of post-harvest losses during times of excessive rains. Although this result seems strange since some studies have documented post-harvest losses during rainy seasons (for example, Abedin et al., 2012), one should note that such losses mainly occur at the drying stage of crops (due to low sunshine intensity) but, for cassava tubers, the reverse can occur. Through interrogating of our respondents, two possible explanations were revealed that can explain our result. First, some farmers believe that leaving cassava unharvested during a rainy season, cassava tubers expand in size. This is attributed to water availability in the soils. Per se, during the rainy season, some farmers may prefer to leave their cassava unharvested to allow for tuber enlargement. Daryanto et al., (2017) demonstrates a positive impact of water abundance to root/tubers. Second, farmers may also prefer to leave cassava tubers unharvested to avoid losses they would experience when it fails to dry or when they fail to transport their harvests to market. This is mainly due to impassability of roads.

4.2 Post-estimation of the Probit estimation model.

After estimating the Probit model, wald tests were conducted to check for the best fit of the estimated regression models about the likely causes of post-harvest losses. The wald test is relevant when testing the significance of variables in the set of predictors with models of binary outcomes. Column (1) of Table 3 represents the wald test results for the model in column (1) of Table 2 while column (2) and (3) represent the wald test results for the models in column (2) and (3) of Table 2. The wald test results indicate the prob > χ^2 =

0.0000 of $\chi^2(7) = 62.64$, prob > $\chi^2 = 0.0000$ of $\chi^2(10) = 62.51$ and prob > $\chi^2 = 0.0000$ of $\chi^2(11) = 64.47$ for the three models in Table 2 respectively. The results imply that explanatory variables that explain the outcome variables in the three models are non-zero. By implication, those variables should be included in the model.

Table 3: Wald test results for the fit of the regression models

	Post-harvest loss = 1		
	(1)	(2)	(3)
Value	$\chi^2(7) = 62.64$	$\chi^2(10) = 62.51$	$\chi^2(11) = 64.47$
prob > χ^2	0.0000	0.0000	0.0000

Source: *Author's Computation*

4.3 At what stage do farmers experience post-harvest losses?

Although post-harvest losses occur along the entire value chain (Minten et al., 2021) i.e. from harvesting to consumption of processed cassava, the scope of this paper is limited at household level. In more specificity, our survey data tries to provide some insights about the post-harvest stage at which losses occur. These stages are summarised in figure 1.

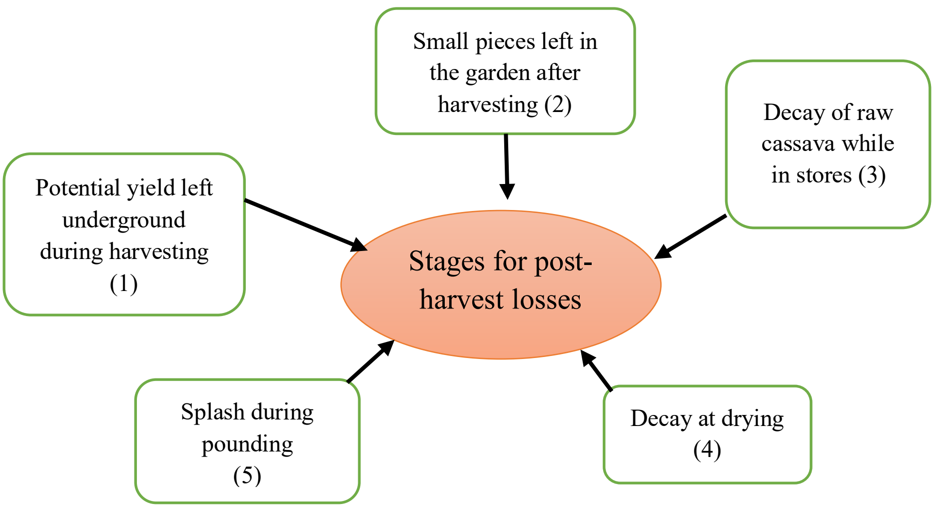

Figure 1: *Stages at which farmers experience post-harvest losses*

Source: Field Survey,2020

The results from figure (1) show that some losses are incurred during harvests when some potential (would be harvested) cassava yields are left underground (unharvested). This occurrence normally occurs when harvesting is done by hired labour on piece rate terms. During harvesting especially when the farmer hires labour on piece rate terms[5], some workers are driven by harvested quantity since it defines their total pay. In this regard, some workers target the number of sacks of cassava which potentially causes them to ignore a thorough check for the tubers remaining underground during harvesting.

Further, after harvesting, some buyers tend to be selective in terms of size for the cassava tubers. The small sized tubers are not bought from farmers yet, already harvested[6] and at times, these leftovers are too much to be wholly consumed by the household thus, becoming a waste especially in households that lack animals that could consume such leftovers. The re-use of food wastes can provide sustainable ingredients for animal feeds (Pinotti et al., 2021). Precisely, food leftovers can significantly contribute to animal feeds thereby, increasing livestock sustainability as well as reducing food wastage.

Besides, some cassava dealers/buyers make a deposit with farmers and guarantee timely collection of cassava after harvesting. In case of any delay by the buyers to collect the harvests, some tubers decay or experience discoloration which culminates into reduced value of the tubers. Timely, post-harvest handling of freshly harvested cassava tubers is essential because of their rapid physiological deterioration after harvest (Uchechukwu-Agua et al., 2015). In quite a similar way, many farmers handle post-harvest losses through drying of their produce (Bradford et al., 2020, Hasan et al., 2019; Tröger et al., 2007). Cassava farmers normally cut cassava tubers into small pieces (slices) for drying. However, during the drying process, some losses are experienced which include rotting (mainly caused by absence of enough sunshine during the wet months), consumption by birds and animals. Too, some slices drop during daily placement and removal from the drying yards. This is supported by Parmar et al., (2018). Putting that aside, when cassava dries, it is processed into flour using relatively simple technology and due to logistical constraints or absence of agro processing factories (cassava milling plants) many farmers process the dry cassava through pounding which at times, is associated with flour drops.

4.4 Strategies used by farmers to mitigate post-harvest losses

Solving the problem of food shortage which is a common occurrence in developing countries requires minimising of post-harvest losses (Kasso and Bekele, 2018; Kumar & Kalita, 2017; Neme et al., 2021; Tefera, 2012). For

[5] Some farmers pay for hired labour basing on per sack of harvested cassava terms.
[6] Too, some buyers are found of leaving damaged tubers claiming quick decay of such pieces.

instance, Kasso and Bekele, (2018) and Kumar & Kalita, (2017) observe that minimizing of losses in the supply chain of cereals can enhance food security hence, improving the farmers' livelihoods, economic development and sustainable combating of hunger. Neme et al., (2021) documents that implementing of better post-harvest losses minimizing technologies does not only benefit farmers' households through enhanced food production but also, benefits industrialists through adding market value on their products, elevating nutritional and food safety. Similarly, Tefera, (2012) observes that one of the key constraints to improving food and nutritional security in Africa is the poor post-harvest management. Further, the study demonstrates occurrence of hunger resulting from a 14 - 36 % loss in maize grains. Therefore, countries should not only target increasing the productivity in the agricultural sector but also, reduce on losses (Tadesse et al., 2018). In this paper, we extend our analysis and focus on the strategies that are employed by cassava farmers to minimize post-harvest losses[7] at household level.

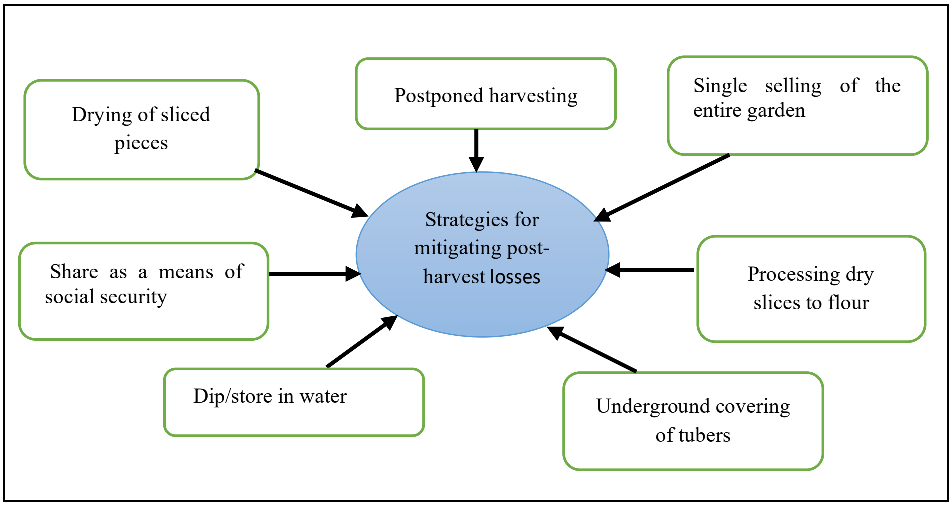

Figure 2: *Strategies for reducing post-harvest losses*

Source: *Field Survey (2020*

4.4.1 Drying of sliced pieces

One of the fundamental strategies for reducing post-harvest losses is drying. Drying of farm produce reduces the moisture content which allows for expanded storage of the produce. Kiaya, (2014) maintains that if the grains

[7] The authors are aware that a number of post-harvest loss minimising strategies exist along the entire value chain but the scope of this study ends at household level.

have been properly dried and properly kept, the farmer is likely to reduce the post-harvest losses resulting from moisture content. Kiaya, (2014) recommends for less than 14 percent moisture in cereals and less than 10 percent in pulses and oilseeds. Specifically, for this study, farmers reported that drying of sliced cassava is one of the approaches used in minimising post-harvest losses. After harvesting of the tubers, the cover is removed and the fresh is sliced into small pieces which is laid under direct sunshine either on tarpaulin, bare ground or on tarmac (for those who are near the main roads). Farmers argued that if cassava slices are dried and properly stored especially in a moisture free place, it can last for an average period of three months. This assures them of food availability when they are out of the harvest period.

4.4.2 Postponement of the harvesting

Although, drying of cassava slices was reported as the key strategy employed by farmers in reducing post-harvest losses, our respondents also pointed out that during the rainy seasons drying of slices becomes problematic because of the limited sunshine hours and this can cause delayed drying of the slices and consequently decomposition of cassava tubers. Under such circumstances, some farmers choose to postpone the harvesting date of the tubers holding to two beliefs as proposed by Amedor et al., 2020. First, they believe that cassava tubers cannot get spoiled before harvesting and second, they believe cassava tubers expand in size during the rainy season. Asked if they are not scared about the wild animals that can feed on their cassava, many of the respondents believe that during the rainy seasons, animals have a lot of food in the wild to feed on. By implication, the probability of damaging their cassava during the rainy season is low. Howeler et al., (2013) reports that cassava can be harvested for a period of up 2 years and at times, farmers can harvest one root or a few roots leaving the rest underground for future harvest.

4.4.3 Whole selling of the entire garden

Evidence in figure 1 shows that farmers experience some post-harvest losses when hired workers leave some potential harvests underground and also when buyers become selective in terms of size (small pieces are selectively left by buyers after harvesting). Moreover, some farmers reported decay of tubers in form of discoloration especially when buyers delay to collect the harvest. To counteract these aforementioned causes of post-harvest losses, some farmers choose to sell their entire cassava garden at once. The implication for this is that in case of any possible post-harvest losses, the risk is transferred onto the buyers. This is supported by Cho & Tang, (2013) who examined the selling strategies a farmer can use to dispose of their produces. Results from their study revealed that selling at once has more opportunities to the producer in terms of minimising losses.

4.4.4 Processing dry slices to flour

Over 23.1 percent of the farmers reported that processing dry slices to flour is the second highly used method by household farmers when minimising post-harvest losses. Gardas et al., (2017) observe that post-harvest losses can significantly be reduced if farmers have access to the farm's proper processing, packaging, loading and unloading facilities. Farmers in this study revealed that processing cassava roots into flour helps them avoid losses. They also reported that improved agro-processing technologies are necessary for reducing post-harvest losses. This is in line with Abass et al. (2014), which document those farmers who acquire knowledge and skills in improved processing technologies have a higher chance of reducing post-harvest losses.

4.4.5 Underground covering of harvested tubers or dipping them in water

29.7 percent of the the farmers reported that covering cassava underground or keeping it in water is one of the most common traditional methods used by farmers to reduce post-harvest losses. It includes storing harvested cassava underground[8] or simply dipping the fresh tubers in water. A study conducted by the Consortium of International Agricultural Research Centers (CGIAR) on how to expanding the utilization of Root Tuber (RTB) crops and reducing their post-harvest losses, indicates that if cassava is dipped in water with high humidity, its useful shelf-life ranges between 7 – 10 days. However, farmers reported that this method is quite cumbersome if they are to handle large volumes of harvests. Howeler et al., 2013 and Sánchez et al. 2013 found that there is a high chance of reducing post-harvest losses when farmers decide to keep their tubers underground.

5.0 Conclusions

Post-harvest losses are common occurrences in many farm households and as a result, the positive contributions of the agricultural sector remain limited not only at household level but also at national level. In many developing countries, post-harvest losses cause significant wastage especially in the food subsector thus leading to food shortage and too, affect the household's economic welfare. This is mainly so, because farmers normally fail to store their yields as buffer to safeguard against future food shortage or even store them for a while waiting for prices to increase and sale expensively to boost their household incomes.

Although, post-harvest losses persistently affect all agricultural crop enterprises, in this paper, attention is paid to cassava. In the context of Uganda, cassava is the second staple food next to maize and cassava is

[8] Commonly done when the harvested quantity exceeds what a household can consume at a given time. The remaining tubers are then, covered underground and water is poured on top of the covered ground. This keeps the ground cool and cassava can remain fresh for a number of days.

recognised as a key input in Agro-Industrialisation and food security for the country's population. As such, it is important to understand the causes of post-harvest losses in the cassava subsector, the stages at which losses occur and also, learn about the strategies used by farmers to reduce on such losses. All these are exposed in this paper. Consistent with other studies, we document absence of storage facilities, pest invasion and lack of market information to be the key causes of post-harvest losses. We also document a higher association between education attainment and post-harvest losses.

The broader policy implication for these results is that interventions aiming at promoting food security and poverty eradication especially within rural households need to supplement the efforts with enhanced mechanisms for post-harvest handling. Effective postharvest management is necessary to ensure that losses are minimised. Providing community/cooperative stores that can act as warehouses for farmers' output or improving agro-processing can reduce on wastage or post-harvest losses of cassava products especially at household level.

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Appendices

Appendix 1: Description of variables

Variable	Variable Description
PH_Loss	Post-harvest loss, takes 1 if a household experienced harvest losses in the previous year preceding the field survey, 0 otherwise.
Educ_HH	1 if a household head completed advanced secondary,0 otherwise
Male	1 if a household head is a male, 0 otherwise
Married	1 if a household is married or engaged, 0 otherwise
Household_size	Number of people living in a household
New_variety	A dummy that takes 1 if a farmer grows at least a modified cassava variety, 0 otherwise
Store_Pests	A dummy that takes 1, if a household reported pest invasion while cassava is kept in a store, 0 otherwise
Excess_rains	A dummy that takes 1, if a household reported excessive rains during the harvesting season, 0 otherwise
Storage_space	A dummy that takes 1, if a household has no specific store for cassava harvests, 0 otherwise
Distant_mkt	A dummy that takes 1, if a household reported a distant market for cassava products, 0 otherwise
Tport_Cost	A dummy that takes 1, if a household reported high transport costs of cassava to the market, 0 otherwise
Lack_mktinfo	A dummy that takes 1, if a household lacks information on distant markets for cassava, 0 otherwise

Appendix 2: Proportion of farmers using specific strategies for mitigating post-harvest losses