African Journal of Rural Development, Vol. 10 (2): pp.174-188 ISSN 2415-2838

Status of Postharvest Handling among Smallholder Farmers in Eastern Uganda

APIL, J.[1]*, KIYIMBA, F.L.[3], SEMBERA,J.[1] TIBAGONZEKA, J. E.[2], YAWE, J.[3], MAKUMBI, G.[3] and ATEKYEREZA, P.[1]

[1]Department of Sociology and Anthropology, School of Social Sciences. Makerere University, P. O. Box 7062, Kampala, Uganda
[2]School of Food Technology, Nutrition and Bio-engineering. Makerere University, P. O. Box 7062, Kampala, Uganda
[3]National Agricultural Organization (NARO), P.O. Box 295, Entebbe, Uganda
*Corresponding Author: jenieapil@gmail.com

ABSTRACT

Postharvest losses remain the major constraint to food, nutrition and income security among majority of households in Sub-Saharan Africa. Studies indicate that appropriate use of improved postharvest handling recommended practices and technologies provide vast opportunities to reduce postharvest losses and improve food safety. However, the status of postharvest handling among agricultural households in Eastern Uganda is unknown. We explored postharvest handling practices and technologies used for maize and cassava among smallholder farmer households in the districts of Pallisa, Kamuli, and Buyende. Data were collected using 36 Focus Group discussions, 285 household interviews and subjected to content analysis and descriptive statistics. Results suggest that majority of agricultural households engage in various postharvest handling activities like transportation, drying, shelling, chipping, storage, and milling. However, most household's use rudimentary technologies at different stages of handling stimulating postharvest loses and consequently leading to food, nutrition and income insecurity. The study recommends that high priority should be placed on increasing accessibility cost friendly simple technologies that suit agricultural households with multiple social-economic characteristics.

Key words: Eastern Uganda, Postharvest handling losses, smallholder farmers

RÉSUMÉ

Les pertes post-récolte demeurent un obstacle majeur à la sécurité alimentaire, nutritionnelle et des revenus pour la majorité des ménages en Afrique subsaharienne. La littérature scientifique souligne que l'usage approprié de pratiques et technologies améliorées de manutention post-récolte offre un fort potentiel de réduction des pertes et d'amélioration de l'innocuité des aliments. Néanmoins, l'état des lieux des pratiques post-récolte parmi les ménages agricoles de l'Est de l'Ouganda demeure mal connu. Nous avons exploré les pratiques et technologies mobilisées pour le maïs et le manioc au sein de petits exploitants des districts de Pallisa, Kamuli et Buyende.

Cite as: Apil, J., Kiyimba, F.L., Sembera, J. Tibagonzeka, J. E., Yawe, J., Makumbi, G. and Atekyereza, P. 2025. Status of Postharvest Handling among Smallholder Farmers in Eastern Uganda. *African Journal of Rural Development* 10 (2):174-188.

Les données, collectées via 36 groupes de discussion et 285 entretiens de ménages, ont fait l'objet d'analyses de contenu et de statistiques descriptives. Les résultats suggèrent qu'une majorité d'exploitations s'engagent dans diverses activités post-récolte comme le transport, le séchage, le décorticage/ égrenage, le tranchage, le stockage, et la mouture. Toutefois, la plupart recourent à des technologies rudimentaires à différents stades, ce qui favorise les pertes post-récolte et, conséquemmant, l'insécurité alimentaire, nutritionnelle et des revenus. L'étude recommande de prioriser l'accessibilité à des technologies simples, abordables et adaptées à l'hétérogénéité des caractéristiques socio-économiques des ménages agricoles.

Mots clés: Ouganda oriental ; pertes post-récolte ; petits exploitants.

INTRODUCTION

Post-harvest losses (PHL) threatens food, nutrition security, and household livelihoods (FAO 2019). Reduction of PHL could reduce the escalating increase in global food demands thus reducing food and nutrition insecurity (Balana *et al*., 2022 ; Strecker *et al*., 2022). Currently, the Food and Agriculture Organization of the United Nations (FAO) estimates that PHLs can reach as high as 20% for cereals, 30% for dairy and fish, and 40% for fruits and vegetables (FAO, 2019). Although loses are registered in high, medium and low-income countries their magnitude and causes vary. In high- and middle-income countries, major losses are registered at consumption stage while in low-income countries, losses are registered more at storage (Kaur and Watson, 2024).

In Sub-sahara African (SSA), experiences of PHL are commonly registered in fruits, vegetables (30-50%) and cereal crops (15%) (Bezabih *et al*., 2022; Makule *et al*., 2022). This explains the persistent food and nutrition insecurity cases (20%) within the region (FAO, 2022). This is exuberated by current projections which indicate that chronic undernourishment could affect approximately 600 million people by 2030, posing an obstacle to achieving the Sustainable Development Goal of eliminating hunger (Tadesse, 2022; Otekunrin 2023; UNICEF 2023).

Uganda, among other countries in Sub-Saharan Africa, is not an exception. Despite its potential in agricultural production, the Global Hunger Index (GHI) (2023) indicates that the country has registered significant food insecurity, ranking the country 95th out of 125 countries with sufficient data on food insecurity (GHI, 2023). Coupled with rising climate vulnerability, inflation, landlessness, and increasing food prices, postharvest losses pose a big challenge accounting to over 40% of the overall yield at the end of the season (Kigozi and Mibulo, 2020). Losses have been recorded in crops like sorghum, cassava and maize (Akumu *et al*., 2020). This has been attributed to poor postharvest handling practices resulting in approximately 22% of losses at harvest, and 74% at storage as a result of insufficient drying, inadequate storage, and infestations by molds, insects, and rodents (Ariong *et al*., 2023).

Extreme food and nutrition insecurity plagues the country with worse case scenarios reported in the eastern region (Nsabagwa *et al*., 2021; Mukulu, 2022). Smallholder farmers in this area typically cultivate less than five (5) acres, and grow both cassava and maize to bolster food and income security. However, a disproportionate amount of their limited land is dedicated to sugarcane production, leaving a meager portion for essential food crops (Kasango, 2015). This

skewed land allocation coupled with the agonizing challenge of postharvest handling loses contributes significantly to widespread poverty and food insecurity among the households (Sheahan and Barrett, 2017**).**
With increase in population size, initiatives to mitigate PHL have been initiated along value chains of transporting, drying, storage and milling (Karoney *et al.*, 2021; Ricker-Gilbert *et al*., 2022; Junaid and Gokce, 2024). As a result, technologies like hand-operated and solar-powered devices (Mayanja and Oluk, 2023), plant-based bio pesticides, silos, and pics bags have been promoted amongst the communities (Akumu *et al.*, 2020; Baributsa *et al.*, 2020; Bezabih *et al*., 2022). However, for a successful integration of the PHL technologies, Wakholi *et al*. (2015) suggested that there is need to first understand the knowledge gaps and the future trajectories in the postharvest handling arena among diverse smallholder farmers. This has not been comprehensively carried out among the small holder farmers in eastern Uganda.

This study therefore aimed at assessing the status of postharvest handling practices, and preferred future technologies among smallholder farmers in Eastern Uganda. The study contributes to the known literature by assessing the status of postharvest handling that stimulate the operationalization and contextualization of postharvest handling loss interventions. We also unveil critical knowledge gaps, and provide information for guiding appropriate interventions within farming communities thus enhancing adoption of appropriate technologies to mitigate postharvest losses. The study contributes to the Sustainable Development Goals (SDGs) targets I, and II, on poverty reduction, and zero hunger.

Research ApproachStudy area. This study was conducted in three districts of Eastern Uganda: Kamuli, Buyende, and Pallisa *(*Figure 1*).* Kamuli district was selected due to its extensive postharvest handling interventions, significant maize production challenged with postharvest handling loses (Akumu *et al.*, 2020). In contrast, Buyende and Pallisa districts, while also notable maize producers, were selected because of the high prevalent rates of malnutrition and food insecurity (Tugume *et al.*, 2024). This concerning situation necessitates an urgent investigation into the postharvest handling practices and technologies currently employed in these regions.

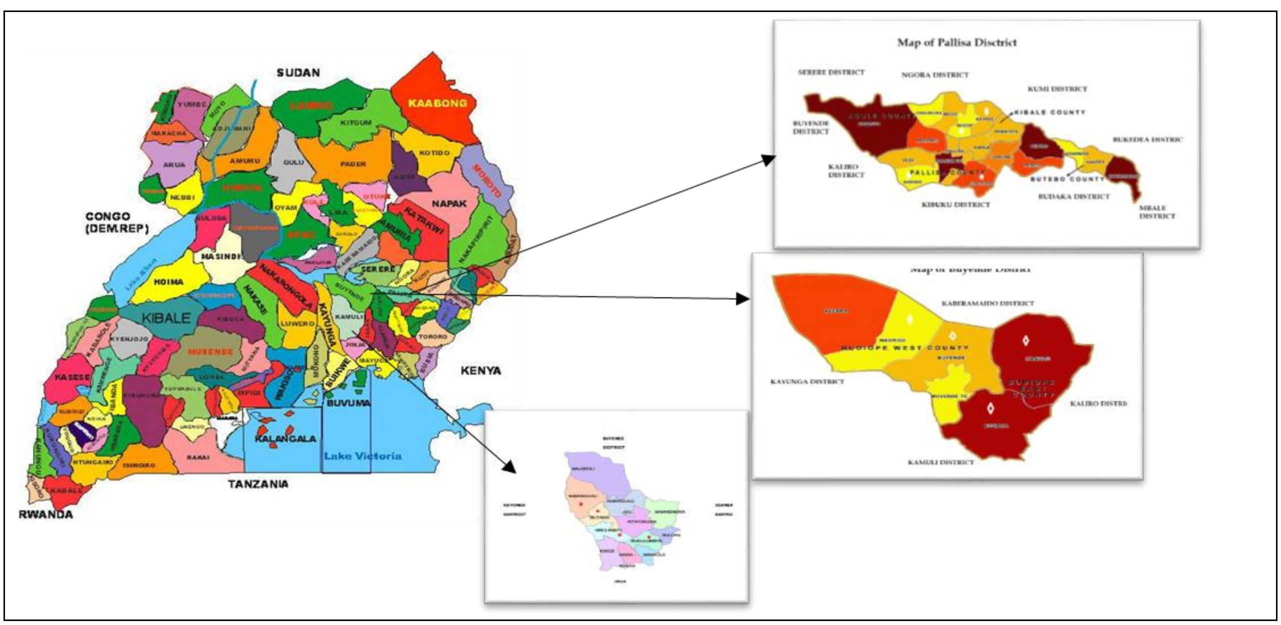

Figure 1. Map of Uganda showing study districts

Study design and sampling strategy. A mixed method cross sectional design was used to assess 1,093 smallholder farmers belonging to 36 farmer groups (each consisting of 20-34 members) in the selected districts. The 36 farmer groups were purposively selected basing on three parameters of registration, production of maize, and gender sensitivity, i.e., inclusion of women, men and youths in Postharvest handling (PHH) activities. These groups were sampled with the help of the office of the District Product and Commercial Officers in the selected districts. The membership of farmer groups was gendered, i.e., it had different numbers of men and women, and this proportionality had to be reflected in selecting the sample of 285. The sample size for the survey was based on Krejcie and Morgan (1970) scientific formula (Equation 1). This scientific formula was used to generate a table that relates the population and the corresponding sample size.

$$s = X^2NP(1-P) \div d^2(N-1) + X^2P(1-P)$$ (Eqn 1)

Where:

s = required sample size

X^2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841)

N = the population size

P = the population proportion (assumes to be .50 since this would provide the maximum sample size)

d = the degree of accuracy expressed as a proportion (.05)

Out of 1,093 farmers, 460 (42.1%) were male and 633 (57.9%) females, and overall, 285 farmers were selected to participate in the survey. To have a representative sample, proportionate stratified random sampling method was utilized to identify 120 males and 165 females from the farmer groups. Prior to selection, the sample size of each selected farmer group was established. A sample proportion formula was adopted to generate the sample size for each stratum as $\hat{p} = {}^{x}/_{n} \times 100$. Where $(\hat{p})$ is the number of successes found in the sample (x) divided by the sample size(n). This procedure was repeated for both males and females in each stratum. The appropriate fraction obtained was thereafter multiplied by the total number of members (male and female) per stratum to get the appropriate sample size per farmer group. From each stratum, a simple random sampling was adopted to select 285 respondents. Simple random was preferred because it provides equal opportunities for all targeted respondents to be selected

Data collection tools and methods. As indicated earlier, this was a mixed methods evaluation, triangulating quantitative and qualitative techniques. Qualitative data were collected using a focus group guide and passive observations. The focus group guide and observation checklist sought information on postharvest handling methods, practices and technologies used by farmers within their farmer groups. Supplementary quantitative data were collected using a structured questionnaire with both open and close ended questions. The questions sought to obtain information on selected household's practices and technologies used during transportation, drying, shelling, chipping, storage and milling.

Data processing and analysis. Qualitative data from the field observations and FGDs were subjected to content analysis to synthesize the emergent issues. The qualitative data were used to offer explanations to the emergent statistical data. Data from the household survey were analyzed using Statistical Product for Social Sciences (SPSS) version 17. Descriptive statistics were drawn and presented in charts to show the level of use and preferred PHH technologies along the maize value chain among the selected households.

Ethical considerations. The study sought consent from all participants before data were collected. All data were treated with confidentiality, and anonymity. The research team and the participants adhered to the

COVID19 standard operating procedures as stipulated by the Uganda Ministry of Health.

RESULTS

Data from the study were arranged in sections of demographic characteristics, farmers' commonly used and preferred PHH technologies through the value chain of transportation, drying, shelling, chipping, storage and milling within different districts. Segmentation of social demographic characteristics and subsequent results are important to understand farmer technology needs hence tailoring future interventions to carter for diverse groups.

Farmers Socio-demographic characteristics Findings show that 61 percent of the respondents were female while 39 percent were male. Majority of them were above 21 years of age, and attended some level of formal education which was sufficient enough to articulate paramount issues concerning postharvest handling of selected crops. The other socio-demographic characteristics relate to marital status, formal education, religious affiliation and age (Table1).

Table 1. Farmer Socio-demographic Characteristics

	District of Residence							
Socio-demographic	Buyende		Kamuli		Pallisa		Total	
Variable	Freq	Percent	Freq	Percent	Freq	Percent	Freq	Percent
Marital Status								
Single	1	*1.1*	9	*8.3*	1	*1.4*	11	*4.1*
Cohabiting	6	*6.6*	4	*3.7*	0	*0.0*	10	*3.7*
Married	80	*87.9*	83	*76.1*	60	*85.7*	223	*82.6*
Separated	2	*2.2*	2	*1.8*	3	*4.3*	7	*2.6*
Widowed	2	*2.2*	11	*10.1*	6	*8.6*	19	*7.0*
Formal Education								
University	2	*2.2*	0	*0.0*	3	*4.3*	5	*1.9*
Other Tertiary institution	3	*3.3*	9	*8.3*	3	*4.3*	15	*5.6*
Secondary	31	*34.1*	43	*39.4*	15	*21.4*	89	*33.0*
Primary	47	*51.6*	49	*45.0*	42	*60.0*	138	*51.1*
None	8	*8.8*	8	*7.3*	7	*10.0*	23	*8.5*
Religious affiliation								
Catholic	22	*24.2*	15	*13.8*	21	*30.0*	58	*21.5*
Protestant	31	*34.1*	53	*48.6*	18	*25.7*	102	*37.8*
Moslem	16	*17.6*	24	*22.0*	15	*21.4*	55	*20.4*
SDA	2	*2.2*	4	*3.7*	0	*0.0*	6	*2.2*
Pentecostal	17	*18.7*	10	*9.2*	14	*20.0*	41	*15.2*
Other	3	*3.3*	3	*2.8*	2	*2.9*	8	*3.0*
Age								
> 20 years	16	*17.5*	1	*0.9*	1	*1.2*	18	*6.3*
21-30 years	21	*23.1*	20	*17.4*	16	*20.2*	57	*20*
31-40 years	12	*13.3*	24	*20.9*	17	*21.5*	53	*18.6*
45-50 years	21	*23.1*	17	*14.8*	12	*15.2*	50	*17.5*
51-60 years	11	*12.1*	30	*26.1*	22	*27.8*	63	*22.1*
Over 60 years	10	*10.9*	23	*20.0*	11	*13.9*	44	*15.4*

Postharvest handling practices and technologies in use. The results indicate that vast majority of the smallholder farmers are involved in different postharvest handling activities of the maize and cassava roots. From the FGDs, it was indicated that postharvest handling activities start from off farm transportation to milling and formulating of nutritious mixtures. Subsequent sections of this article present findings on current technologies in use and future preferred Postharvest Handling technologies.

Transportation. Postharvest transportation typically occurs in two ways: on-farm and off-farm. The most common methods are head portage and bicycles. Head portage was particularly prevalent in Pallisa district (51%), while both methods were observed in Kamuli and Buyende and 40%, *(*Figure 2*)*. Maize is typically packed in old sacks and carried from the fields to homes. Focus group discussions revealed a gendered division of labor: women and children primarily use head portage for on-farm transport, while men utilize bicycles for off-farm activities, such as transporting grain to markets. Given these observations, the study investigated farmers' preferred transportation methods. Remarkably, 100% of the farmers were aware of improved transport technologies, having learned about them through neighbors, relatives, and friends. Motorcycles and tricycles emerged as the most preferred options across all the three districts, irrespective of gender.

Results from the FGDS, explained that during transportation, produce from gardens is collected in sacks and carried home. In this case, PHL occur when produce like maize stocks are piled in old sacks, causing fall off of stalks if unnoticed. This implies that reliance on rudimentary methods like head portage and bicycles has significant implications PHL. Apart from being labor-intensive, time-consuming, the use of rudimentary technologies during transportation increases risk PHL in terms of reduced quantities, ultimately hindering farmers' household food security and income potential. The universal awareness of improved technologies, coupled with the clear preference for motorcycles and tricycles, suggests a strong demand for these more efficient options. Investing in and facilitating access to these preferred technologies could significantly improve postharvest handling, reduce losses, and enhance farmers' livelihoods.

Drying is a critical step in postharvest grain handling. Focus group discussions revealed that farmers are aware of appropriate drying technologies, recognizing that methods like tarpaulins and raised racks improve grain quality and reduce postharvest losses by preventing scattering and protecting against rain. However, despite this awareness, survey data indicates a stark contrast between knowledge and practice. The most dominant drying method is drying on bare ground, prevalent in Pallisa (58%), Kamuli (68%), and Buyende (80%) *(*Figure 3*)*.

Farmers predominantly rely on sun drying on bare ground within their homesteads. A common practice, particularly among women, is drying maize with husks to protect against dust and dirt and presumably this makes the maize to dry faster. These traditional drying practices, often passed down through generations, present significant challenges, especially during the rainy season. Drying on bare ground becomes difficult, forcing many women to leave grains to dry in the field or within their husks to minimize contamination.

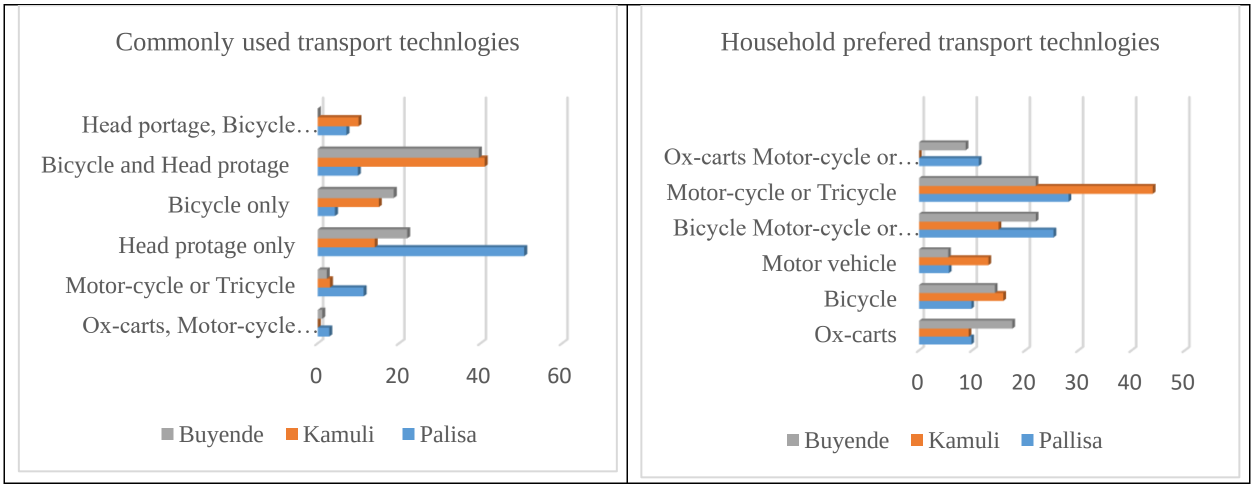

Figure 2. Transport technologies

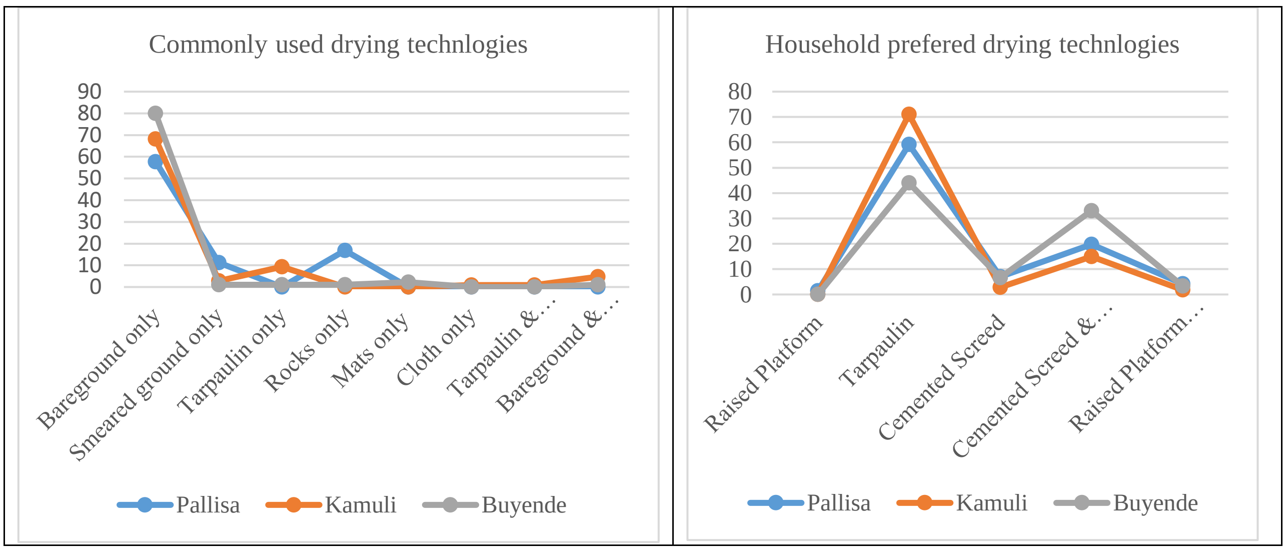

Figure 3. Drying technologies

Despite current practices, the most preferred drying technology across all three districts is by using tarpaulins, favored by 59% in Pallisa, 71% in Kamuli, and 44% in Buyende.

The implications of these findings are substantial. Drying on bare ground exposes grains to contamination from soil, dust, pests, and animals, increasing the risk of spoilage and mycotoxins development, which pose serious health risks. This practice also leads to higher postharvest losses and reduces grain quality, impacting market value and household food security. The preference for tarpaulins, coupled with existing awareness of improved drying methods, highlights a significant opportunity for intervention. Promoting and facilitating access to improved drying technologies, such as tarpaulins and raised racks, could substantially improve grain quality, reduce postharvest losses, enhance food safety, and ultimately improve livelihoods.

Shelling. Shelling is crucial for maximizing both the quality and quantity of harvested grains. In this study, the majority of households rely on manual shelling techniques, primarily using hands and sticks. This practice is prevalent in Pallisa (87%), Kamuli (45%), and Buyende (60%) *(*Figure 4*)*.

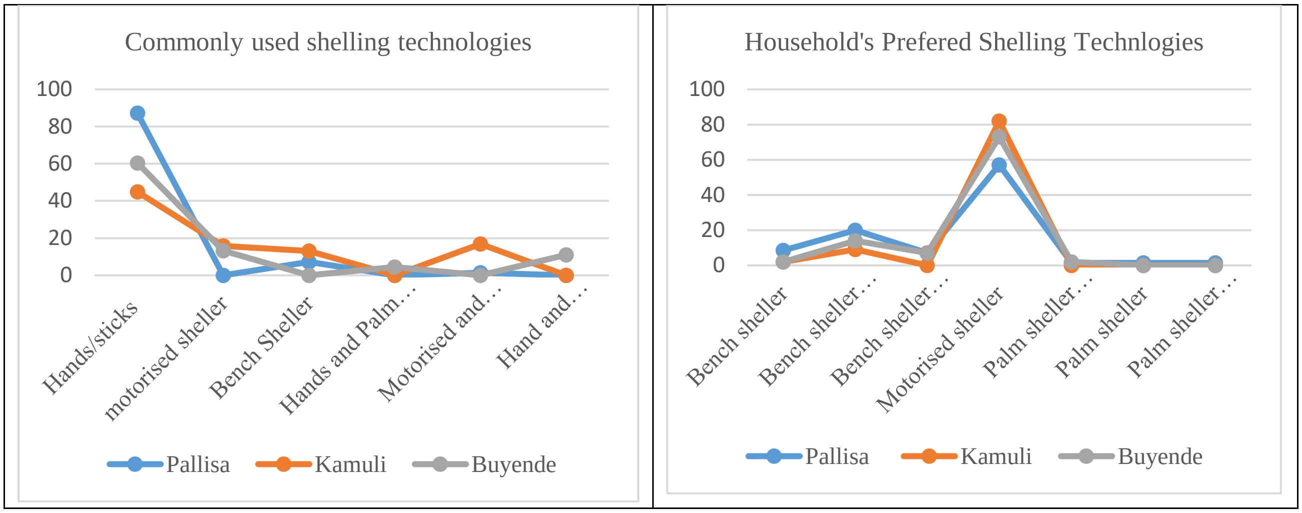

Figure 4. Shelling technologies

Typically, maize is shelled only when needed for consumption or sale. Dry cobs are placed in sacks and beaten with sticks until the grains are removed. This labor-intensive method is commonly performed by women and children. Despite the prevalence of manual shelling, there is a clear desire for change. Households express a strong interest in transitioning to more efficient and effective technologies to improve grain quality and reduce labor. The preferred choice across all three districts is motorized shelling machines, favored by 57% of households in Pallisa, 82% in Kamuli, and 73% in Buyende.

The dependence on manual shelling has several implications. It is time-consuming, physically demanding, and often leads to grain damage, reducing quality and market value. The low throughput of manual shelling also limits the quantity of grain that can be processed, potentially hindering access to larger markets and income generation. The expressed preference for motorized shellers demonstrates a recognized need for improved technology. Facilitating access to these machines could significantly reduce labor, increase shelling efficiency, improve grain quality, and ultimately enhance household incomes and food security.

Chipping. This study further revealed that a substantial number of households engaged in cassava processing rely on basic tools like knives and pangas for this task. This practice was observed in 53% of households in both Pallisa and Buyende, and 66% of households in Kamuli. While these basic tools are readily accessible, preferences for chipping methods varied across the districts. In Pallisa and Kamuli, 37% and 39% of households, respectively, expressed a preference for both manual and motorized chippers, suggesting an openness to adopting more efficient technologies. However, in Buyende, only 13% of households favored manual chippers *(*Table 2*).*

The reliance on manual chipping methods using knives and pangas has several implications. These methods are labor-intensive, time-consuming, and can lead to inconsistencies in chip size and quality. Uniform chip size is crucial for efficient drying and further processing. Inconsistent chip sizes can lead to uneven drying, increasing the risk of spoilage and reducing the overall quality of the final product. Further, the variation in preference likely stems from differences in household income levels. Observations indicated that a larger proportion of households in Buyende faced economic hardship compared to those in Pallisa and Kamuli.

Table 2. Commonly used and preferred chipping technologies

Chipping Technologies	Commonly used chipping Technologies						Household preferred chipping Technologies					
	Pallisa		Kamuli		Buyende		Pallisa		Kamuli		Buyende	
Manual chipper only	1	1%	2	2%	0	0%	11	15%	20	17%	12	13%
Knives only	31	44%	30	32%	41	45%	-	-	-	-	-	-
Pangas only	0	0%	2	2%	2	2%	-	-	-	-	-	-
Knives & pangas	37	53%	61	66%	48	53%	3	4%	8	5%	8	9%
Motorized chipper	-	-	-	-	-	-	15	21%	29	23%	29	32%
Manual & motorized chipper	-	-	-	-	-	-	26	37%	26	39%	2	2%
Manual chipper & knife	-	-	-	-	-	-	8	11%	7	12%	38	42%

While manual chipping has its drawbacks, being labor-intensive and potentially limiting production capacity, it remains the most viable option for economically disadvantaged households who may not be able to afford the costs associated with motorized chippers, such as fuel. The reliance on manual methods underscores the need for interventions that consider the economic realities of these communities.

Storage. The majority of respondents in Pallisa (57%), Kamuli (48%), and Buyende (59%) utilize local bags for grain storage (Figure 5*)*. Farmers storing maize on the cob typically use bare ground, while those storing shelled grains commonly use local bags. A recurring issue highlighted in focus group discussions was weevil infestation during storage, attributed to existing storage practices. Farmers employ various methods to mitigate insect infestations, including locally made insecticides from neem tree leaves. However, there's a clear preference for improved storage solutions. Most households in Pallisa (49%), Kamuli (63%), and Buyende (67%) prefer metallic or plastic storage facilities over traditional methods like local bags or triple bags. A smaller, yet significant, proportion of households in Pallisa (30%), Kamuli (33%), and Buyende (22%) expressed a preference for both metallic/plastic storage and pics bags.

Storing grain on bare ground or in local bags has significant implications for both grain quality and food security. These methods offer minimal protection against pests, moisture, and rodents, leading to substantial postharvest losses. Weevil infestations, as reported by farmers, further compromise grain quality and reduce its market value. The use of traditional insecticides, while demonstrating an effort to address the issue, may not be as effective as modern pest control methods and could pose environmental or health risks. The strong preference for metallic/plastic storage and PICS bags indicates a recognized need for improved storage technologies. These modern storage solutions offer better protection against pests and moisture, preserving grain quality and reducing losses. Promoting and facilitating access to these improved storage technologies is crucial for enhancing food security and improving farmers' livelihoods.

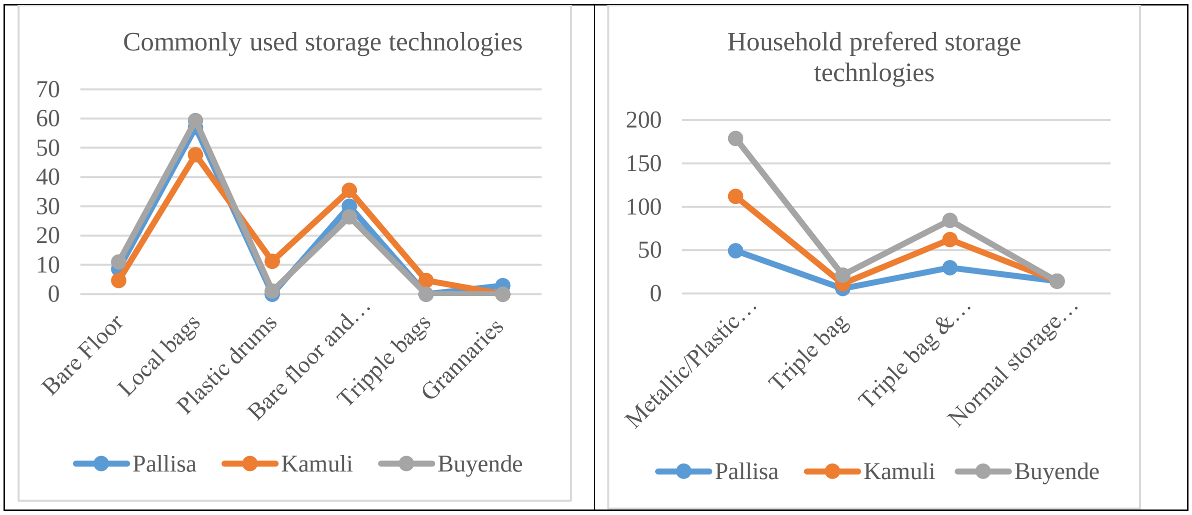

Figure 5. Storage technologies

Milling. Milling is a critical stage in the food processing value chain, often considered the most important link. This study found that the majority of farmers utilize improved postharvest handling and milling technologies, with minimal reliance on traditional grinding methods. While mobile diesel mills offer a degree of convenience, feedback from focus group discussions revealed a significant drawback: the milled flour often retains a foul smell. This undesirable characteristic has led to a strong preference for stationary electric mills among households in the study areas. Specifically, 61% of households in Pallisa, 94% in Kamuli, and 91% in Buyende favored electric mills over other milling technologies (Table 3).

The widespread adoption of improved milling technologies demonstrates a positive shift towards enhanced food processing practices. However, the issue of foul-smelling flour from diesel mills raises concerns about product quality and consumer acceptability. This could limit the market potential of flour produced using these mills and discourage their continued use. The overwhelming preference for stationary electric mills highlights the importance of factors beyond mere convenience. Product quality, in this case, the absence of undesirable odors, plays a crucial role in technology adoption. Promoting access to electricity and supporting the establishment of stationary electric mills could further improve milling practices, enhance flour quality, and contribute to greater food security and market opportunities for farmer

Table 3. Milling technologies

Milling technologies	Commonly used milling technologies						Households preferred milling technologies					
	Pallisa		Kamuli		Buyende		Pallisa		Kamuli		Buyende	
Electric milling machine	43	61%	89	83%	54	59%	-	-	-	-	-	-
Diesel milling machine	16	23%	30	28%	17	19%	-	-	-	-	-	-
Grinding stone	15	21%	4	4%	12	13%	-	-	-	-		-
Electric and diesel milling machine	20	29%	28	26%	2	2%	-	-	-	-	-	-
Stationary electric mill	-	-	-	-	-	-	43	61%	101	93%	83	91%
Grinding stone	-	-	-	-	-	-	4	6%	1	1%	4	4%

Milling stone & stationary electric mill	-	-	-	-	-	-	21	30%	4	4%	2	2%

DISCUSSION

This study sought to assess the current and future preferred postharvest handling practices and technologies within the selected areas in Eastern Uganda. Results indicate that a majorly of farmers are involved in different postharvest handling activities across the value chain of transportation, drying, shelling, storage, and milling dominated by rudimentary technologies. For instance, at transportation, farmers across the three district use elementary forms of transporting produce (on-farm and off-farm) with Pallisa district predominantly using head portage as the main transport form. This result aligns with Elik *et al.* (2019), who indicated that transporting produce from farms to homes presents a challenge for majority of smallholder farmers and results in a considerable amount of PHL. Nevertheless, farmers' preferences for more efficient modes of transport indicates that they are accustomed to and therefore willing to utilize them. However, the preferred modes of transport may also be influenced by other pertinent factors like nature of roads. Given the state of rural roads, this study suggests that postharvest interventions targeting the transportation node should not only target technologies that farmers are accustomed to but government should also address the issue of infrastructure gaps like dilapidated roads**.**

For the drying node, majority of the households across the selected districts have resorted to using locally available resources like bare or smeared ground for drying their produce. Similarly Aworh (2023) also observed the same trend. Drying away on bare ground was mentioned to be commonly of quickening the drying process. Observably, fresh grains would be plucked off the stalk and spread on the bare ground to dry. While these methods may be the most affordable option for farmers, they expose the produce to weather variations, contamination from wind dust, animals, humans, and microbes (Precoppe *et al*., 2020). Consequently leading to quality and quantity loses in produce. Nevertheless, farmers across the three districts showed preference for raised racks. Studies have shown that appropriately constructed raised racks effectively reduce quantity and quality losses (Akumu *et al.*, 2020). It is important to note that promoting farmers' preferred drying technologies may not result into adoption. There is need for behavior change communication strategies that would address myths and perceptions about the effectiveness of drying technologies like the bare ground. We therefore recommend interdisciplinary expertise by involving agricultural extension workers, sociologist and development partners to initiate communication strategies and conduct locally driven trainings on construction of raised racks using available locally made materials across the three districts.

In terms of shelling, it was observed that farmers across the three districts predominantly use basic methods such as beating maize cobs with sticks or sacks. Similar observations have been reported in other studies (Lad *et al.*, 2020; Kigozi and Mibulo, 2023; Mayanja and Oluk, 2023). However, such shelling methods have been criticized for causing grain damage which increases susceptibility to insect infestation and fungal growth (Akumu *et al.*, 2020; Abdullahi, and Dandago, 2021). On the other hand, farmers across the districts especially in Kamuli and Buyende reported preference for motorized shellers. The latter has been recommended for their ability to reduce PHL (Kabenge *et al.*, 2020; Gatkal *et al.*, 2023). Imperative to note, motorized shellers may not exclusively mitigate the challenge of PHL. For example, Nath *et al.* (2024) reported that timely shelling also significantly reduce the PHLs especially on crops like maize and rice.

Moreover, Nsubuga *et al*. (2021) indicated that successful use of motorized shellers should be accompanied by contextual factors like design of the machine relative to maize stalk characteristics and operational factors like transportation of the machine to the shelling point. Given the nature of rural roads within the study districts, this study recommends that government and other stakeholders should not only concentrate in availing technologies to farmers but also work on infrastructural issues like improving rural road networks and training farmers on timely drying and shelling.

Data further suggest that traditional chipping methods are predominantly three by households that process cassava across the districts. Use of knives and pangas to chip cassava roots is often labor-intensive, time-consuming, and often yielding a poor-quality product (Nwakuba *et al*., 2020). Given the level of cassava processing across the three districts, Government and development partners should boost access to more efficient chipping technologies through subsidies, microfinance initiatives, or community-based ownership models. This would enhance product quality**.**

Regarding storage**,** majority of the farmers used local traditional bags to store their produce. These results align with vast literature which indicate that farmers rely on traditional storage facilities and this often leads to significant PHL (Baributsa and Njoroge, 2020, Abdullahi and Dandago, 2021; Sharma *et al*., 2023). Basing on this study's findings, many farmers in the study areas are likely to be experiencing substantial produce losses during storage, which likely contributes to the observed food and nutrition insecurity. Farmers also reported their preference for improved storage facilities like metallic or plastic silos and PICS bags. However, there were variations in preference within and across the districts. For instance some farmers in Kamuli and Buyende preferred only metallic/plastic silos while those in Pallisa and some from Kamuli and Buyende preferred both metallic/plastic silos and PICS bags. This implies that farmers within the districts were not homogenous. Variations could be attributed to the sizes of the produce, sizes of the household and the cost implication on storage technologies. This indicates that although the preferred technologies are commended for their effectiveness in mitigating PHL (Olorunfemi and Kayode, 2021; Zacharia and Baributsa, 2024), accessing them may not lead to adoption. Therefore this study commends that technology promoters and policy makers should first explore the farmer typologies to ascertain their capabilities, and capacities in relation to specific storage facilities before promoting the storage technologies within the target districts.

CONCLUSIONS

This study findings indicate that the majority of farmers predominantly use rudimentary technologies right from transportation, drying, shelling, and storage to milling. Basing on evidence elsewhere, rudimentary technologies cause significant postharvest losses for grains and tubers. This could be one of the factors causing the chronic household food and income insecurity within the studied districts. Further, findings underscore the importance of understanding farmers' preferences and the location-specific factors that influence their adoption of improved postharvest technologies. While farmers demonstrate awareness of improved technologies and their potential benefits, variations in preferred methods exist across different locations due to factors such as produce volume, storage space, cost, and access to resources. Variations in preferred storage technologies emphasize the importance of considering local contexts, including household characteristics and economic factors, when promoting improved storage solutions. Future interventions should prioritize assessing farmers' capacities and tailoring recommendations to their specific needs, ensuring that promoted technologies are appropriate, affordable, can be readily adopted. This approach would contribute to more effective and sustainable improvements in postharvest management, ultimately enhancing food security and livelihoods.

ACKNOWLEDGEMENT

We thank the McKnight Foundation for funding the study. Special thanks go to the farmer groups for participating in the study.

STATEMENT OF CONFLICT OF INTEREST

The authors declare no conflict of interest

REFERENCES

Abdullahi, N. and Dandago, M. A. 2021. Postharvest losses in food grains–A Review. *Turkish Journal of Food and Agriculture Sciences* 3 (2): 25-36.

Abelti, A. L. and Teka, T. A. 2024. Intervening fish post-harvest losses to narrow the gap between demand and supply: A review on magnitude of fish post-harvest losses in some Sub-Saharan African countries. *Aquaculture, Fish and Fisheries* 4 (2): e168.

Adedipe, J.O., Ibiyeye, D.E., Onifade, A.O., Ekaun, A.A., Olatunji, B.T. and Afolabi, R.T. 2020. Development of a hand operated maize sheller. *Australian Journal of Science and Technology* 4 (4): 392-396.

Akumu, G., Atukwase, A., Tibagonzeka, J. E., Apil, J., Wambete, J. M., Atekyereza, P. R. and Muyonga, J. H. 2020. On-farm evaluation of effectiveness of improved postharvest handling of maize in reducing grain losses, mold infection and aflatoxin contamination in rural Uganda. *African Journal of Food, Agriculture, Nutrition and Development* 20 (5): 16522-16539.

Ariong, R.M., Okello, D.M., Otim, M.H. and Paparu, P. 2023. The cost of inadequate postharvest management of pulse grain: Farmer losses due to handling and storage practices in Uganda. *Agriculture & Food Security* 12*:* 1-22.

Aworh, O. C. 2023. African traditional foods and sustainable food security. *Food Control* 145: 109393.

Balana, B. B., Aghadi, C. N. and Ogunniyi, A. I. 2022. Improving livelihoods through postharvest loss management: evidence from Nigeria. *Food Security* 14 (1): 249-265.

Baributsa, D., Bakoye, O. N., Ibrahim, B. and Murdock, L. L. 2020. Performance of five postharvest storage methods for maize preservation in Northern Benin. *Insects* 11 (8): 541.

Bezabih, G., Satheesh, N., Workneh Fanta, S., Wale, M. and Atlabachew, M. 2022. Reducing Postharvest Loss of Stored Grains Using Plant-Based Biopesticides: A Review of Past Research Efforts. *Advances in Agriculture* 2022 (1): 6946916.

Buyukbay, E.O., Uzunoz, M. and Sibel Gulse Bal, H. 2011. Post-Harvest Losses in Tomato and Fresh Bean Production in Tokat Province of Turkey. *Scientific Research and Essays* 6: 1656-1666.

Elik, A., Yanik, D. K., Istanbullu, Y., Guzelsoy, N. A., Yavuz, A. and Gogus, F. 2019. Strategies to reduce post-harvest losses for fruits and vegetables. *Strategies* 5 (3): 29-39.

Food and Agriculture Organization. (FAO). 2019. The State of Food and Agriculture 2019: Moving Forward on Food Loss and Waste Reduction. Rome, Italy: Food and Agriculture Organization of the United Nations (FAO).

FAO, IFAD, UNICEF, WFP and WHO. 2022. The State of Food Security and Nutrition in the World 2022. Repurposing food and agricultural policies to make healthy diets more affordable. Rome, FAO. https://doi.org/10.4060/cc0639en

Gatkal, N. R., Nalawade, S. M. and Pawase, P. P. 2023. Design of a Motorised Maize Sheller and Optimisation of its Operating Parameters. *Journal of Agricultural Engineering (India)* 60 (3): 234-250.

Gebreegziabher, Z. and van Kooten, G.C. 2020. Commodity storage, post-harvest losses, and food security: panel data evidence from Ethiopia. *Journal of Agricultural & Food Industrial Organization* 18 (1): p.20190058.

Hengsdijk, H. and De Boer, W. J. 2017. Post-harvest management and post-harvest losses of cereals in Ethiopia. *Food Security* 9: 945-958.

Index, G. H. 2023 Global Hunger Index: The Power of Youth in Shaping Food Systems.

Kabenge, I., Nsubuga, D., Zziwa, A., Kiggundu, N., Wanyama, J. and Banadda, N. 2020. Performance evaluation and optimization of the maize shelling operation of the multi-purpose farm vehicle. *Agricultural Engineering International: CIGR Journal* 22 (4): 174-183.

Karoney, E.M., Molelekoa, T., Bill, M., Siyoum, N. and Korsten, L. 2024. Global research network analysis of fresh produce postharvest technology: Innovative trends for loss reduction. *Postharvest Biology and Technology* 208:112642.

Kasango, A. 2015. Socio-economic impacts of sugarcane growing on food security in Busoga region. Doctoral Dissertation, Busitema University, Uganda.

Kaur, R. and Watson, J.A., 2024. A scoping review of postharvest losses, supply chain management, and technology: implications for produce quality in developing countries. *Journal of the ASABE* 67 (5):1103-1131.

Kigozi, J. and Mibulo, T., 2023. Post-Harvest Technology Utilization in Uganda: An Overview. *Research Highlights in Agricultural Sciences* 83 pp.

Krejcie, R. V. and Morgan, D. W. 1970. Sample size determination table. *Educational and Psychological Measurement* 30: 607-610.

Makule, E., Dimoso, N. and Tassou, S. A. 2022. Precooling and cold storage methods for fruits and vegetables in Sub-Saharan Africa—A review. *Horticulturae* 8 (9): 776.

Manandhar, A., Milindi, .P and Shah, A.2028. A overview of the post-harvest grain storage practices of smallholder farmers in developing countries. *Agriculture.* 8 (4):57

Mayanja, I. K. and Oluk, I. 2023. Intermediate Technologies: The Key to Eradicating Post-harvest Losses (PHLs) in Sub-Saharan Africa (SSA). *Journal of Advances in Food Science & Technology* 10 (4): 64-74.

Mukulu G. 2022. Participation of smallholder farmers in on-farm tree planting and retention in Buyende Sub-County, Buyende district, Uganda. Doctoral Dissertation, Makerere University, Uganda.

Nath, B., Chen, G., O'Sullivan, C. M. and Zare, D. 2024. Research and technologies to reduce grain postharvest losses: a review. *Foods* 13 (12): 1875.

Nsabagwa, M., Mwije, A., Nimusiima, A., Odongo, R. I., Ogwang, B. A., Wasswa, P. and Musiime, I. 2021. Examining the Ability of communities to cope with food Insecurity due to Climate change. *Sustainability* 13 (19): 11047.

Nsubuga, D., Kabenge, I., Zziwa, A., Kiggundu, N., Wanyama, J. and Banadda, N. 2021. Improving maize shelling operation using motorized mobile shellers: A Step towards Reducing Postharvest Losses in Low Developing Countries. In: *Maize Genetic Resources-Breeding Strategies and Recent Advances*. IntechOpen.

Nwakuba, N., Ndukwu, M. and Gabriel, A. F. A. M. 2020. Development and optimization of a manual fed cassava root chipper for household cassava processors. *Turkish Journal of Agricultural Engineering Research* 1 (2) :283-295.

Olorunfemi, B. J. and Kayode, S. E. 2021. Post-harvest loss and grain storage technology-a review. *Turkish Journal of Agriculture-Food Science and Technology* 9 (1): 75-83.

Otekunrin, O. A. 2023. Countdown to the 2030 Global Goals: A Bibliometric Analysis of Research Trends on SDG 2–Zero Hunger. *Current Research in Nutrition and Food Science Journal* 11 (3): 1338-1362.

Patel, K.K., Khan, M.A., Kumar Y. and Yadav, A.K.2019. Novel techniques in post-harvest management of mango—an overview. *South Asian J Food Technol Environ*. 5 (2):821-35.

Precoppe, M., Komlaga, G. A., Chapuis, A. and Müller, J. 2020. Comparative study between current practices on cassava drying by small-size enterprises in Africa. *Applied Sciences 10* (21): 7863.

Ricker-Gilbert, J., Omotilewa, O. and Kadjo, D. 2022. The economics of postharvest loss and loss-preventing technologies in developing countries. *Annual Review of Resource Economics* 14 (1): 243-265.

Sharma, S., Semwal, A. D., Murugan, M. P., Khan, M. A. and Wadikar, D. 2023. Grain storage and transportation management. Pp. 269-296. In: Cereal Grains.CRC Press.

Sheahan, M. and Barrett, C. B. 2017. Food loss and waste in Sub-Saharan Africa. *Food Policy* 70: 1-12.

Simo-Tagne, M., Tagne Tagne, A., Ndukwu, M. C., Bennamoun, L., Obounou Akong, M. B., El Marouani, M. and Rogaume, Y. 2021. Numerical study of the drying of cassava roots chips using an indirect solar dryer in natural convection. *AgriEngineering* 3 (1): 138-157.

Strecker, K., Bitzer, V. and Kruijssen, F.2022. Critical stages for post-harvest losses and nutrition outcomes in the value chains of bush beans and nightshade in Uganda. *Food Sec*. 14: 411–426 https://doi.org/10.1007/s12571-021-01244-x

Tadesse, D., Masresha, G., Lulekal, E. and Wondafrash, M. 2024. A systematic review exploring the diversity and food security potential of wild edible plants in Ethiopia. *Scientific Reports* 14 (1): 17821.

Tugume, P., Mustafa, A. S., Walusansa, A., Ojelel, S., Nyachwo, E. B., Muhumuza, E. and Ssenku, J. E. 2024. Unravelling taboos and cultural beliefs associated with hidden hunger among pregnant and breast-feeding women in Buyende district Eastern Uganda. *Journal of Ethnobiology and Ethnomedicine* 20 (1): 46.

UNICEF. 2023. The state of food security and nutrition in the world: urbanization, agrifood systems, transformation and healthy diets across the rural-urban continuum. UNICEF.

UNSD Statistics Division.2022. Responsible Consumption and Production. The Sustainable Development Goals Extended Report. https://unstats.un.org/sdgs/report/2022/extended-report/Extended-Report_Goal-12.pdf. 2022.

Urugo, M. M., Yohannis, E., Teka, T. A., Gemede, H. F., Tola, Y. B., Forsido, S. F. and Abdu, J. 2024. Addressing post-harvest losses through agro-processing for sustainable development in Ethiopia. *Journal of Agriculture and Food Research* 101316

Wakholi, C., Cho, B. K., Mo, C. and Kim, M. S. 2015. Current state of postharvest fruit and vegetable management in East Africa. *Journal of Biosystems Engineering 40* (3): 238-249.

Wanjiku, A. N. 2018. Socio-cultural and economic factors influencing household post-harvest cereal loss in Wikililye location, Kitui County, *Kenya*. Doctoral Dissertation. South Eastern Kenya University repository

Yeshiwas, Y. and Tadele, E. 2021. An investigation into major causes for postharvest losses of horticultural crops and their handling practice in Debre Markos,North-WesternEthiopia. *Advances in Agriculture* 2021 (1):1985303.