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Post-harvest handling practices, moisture content, and aflatoxin levels of cassava from selected hammer milling centers in Uganda

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Abstract

Cassava (*Manihot esculenta*) is a staple crop of significant economic and nutritional importance in Uganda. However, it is highly perishable, and root tubers are prone to rapid post-harvest deterioration due to microbial contamination. Poor handling practices such as drying on bare ground and improper storage, often contribute to aflatoxigenic fungi proliferation. Aflatoxins, secondary metabolites of these fungi are linked to liver cancer, immune suppression, and stunted growth in humans and animals. Thus, regular ingestion of aflatoxin-laden foodstuffs including cassava poses a serious public health risk. Despite awareness, aflatoxin monitoring in food matrices remains limited, especially in developing countries. This study assessed post-harvest handling practices, moisture content, and aflatoxin contamination and concentration levels in 120 randomly collected cassava samples from eight regional districts of Uganda. Post-harvest handling data were obtained through structured interviews with cassava processors at randomly selected milling centers. Moisture content was analyzed using the Hot-Air Oven, while aflatoxin contamination was determined through Thin Layer Chromatography (TLC). The Competitive-ELISA technique quantified aflatoxin concentrations. Handling practices included sun-drying on bare ground (9%), floor storage (44%), and 74 % of the mill caretakers having reported processing of moldy cassava for human consumption. Milling center caretakers relied on ineffective traditional methods [biting, touching, and breaking tests] and none reported the use of a moisture meter to assess moisture content. Moisture content ranged from 7.14% to 27.63%. Aflatoxins were detected in 99.2% of samples with regional variations in contamination levels. However, total aflatoxin concentrations remained within acceptable limits (10 ppb by UNBS; 20 ppb by FDA-USA; 15 ppb by FAO/WHO). A weak positive correlation between moisture content and aflatoxin levels was obtained, suggesting contamination may have occurred during drying. Despite regulatory compliance, widespread contamination highlights the need for improved post-harvest practices and continued aflatoxin surveillance in foods to safeguard public health.

Keywords: *Aflatoxins; cassava; ELISA; hammer mill; handling practices; moisture content*

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Introduction

Cassava [*Manihot esculenta*] production is wide spread across major continents such as Latin America, Africa and Asia with a global production level of approximately 315 million tons in 2021 (Immanuel *et al*., 2024). In particular, Africa accounts for 65 % of the global cassava production with an estimation that 62 % of cassava will come from Sub-Saharan Africa by 2025 (Immanuel *et al*., 2024). Cassava is regarded as a famine-reserve crop due to its drought tolerance and ability to thrive in poor soils, making it particularly valuable in regions with unpredictable rainfall and low soil fertility (Adebayo, 2023; Immanuel *et al*., 2024). Owing to its contribution to famine protection, cassava is also known as the "African bread" on African continent. In addition, it is an important source of farm income contributing 26% of household income in Nigeria and 4.51 % in Uganda (Adebayo, 2023). In Uganda, 88 % of cassava produced is consumed by humans providing a significant portion of the daily caloric intake for millions of people (Buyinza and Kitinoja, 2018; Oloya *et al*., 2023). Notably, cassava is not only consumed as a fresh root but also processed into various products such as flour, chips, and fermented foods (Osakue *et al*., 2023). However, the crop is highly perishable due to its high moisture content leading to rapid post-harvest deterioration, which poses challenges for food security and economic stability in rural communities (Canales and Trujillo, 2023) .

Remarkably, contamination of cassava with fungi has limited its importance largely on the African content due to the adverse effects of fungal metabolites commonly known as mycotoxins (Oyesigye *et al*., 2024). Aflatoxins are a class mycotoxins of major importance due to their carcinogenic, teratogenic, immunosuppression and growth retardation properties in both animals and humans (IARC, 2003; (Jaćević *et al*., 2023). Aflatoxins are toxic secondary metabolites produced by *Aspergillus flavus* and *Aspergillus parasiticus*. These toxins are known to contaminate various food crops, including cassava, particularly when the moisture content is high and storage conditions are poor (Oyesigye *et al*., 2024)).

Moisture content is a critical factor affecting the shelf-life and quality of cassava largely by supporting fungal growth and bacteria. Fresh cassava roots typically contain about 60-70% moisture, which makes them susceptible to microbial spoilage and biochemical changes (Nsiah *et al*., 2023; Tembo *et al*., 2024) . Therefore, controlling moisture levels through appropriate drying techniques is crucial for extending the shelf life of cassava products and preventing fungal contamination.

In Uganda, most cassava farmers use an ineffective sun drying method instead of using a more efficient method-solar drying (Oyesigye *et al*., 2024). Reliance on sun drying more often results into inadequate and gradual moisture removal thereby increasing the vulnerability of cassava to mycotoxin contamination (Menya *et al*., 2020). Properly dried cassava should ideally have a moisture content of less than 14% to minimize the risk of fungal growth and aflatoxin contamination (Mahato *et al*., 2019).

In Uganda, the incidence of aflatoxin contamination in toxic levels in cassava is of growing concern especially in regions where drying and storage practices are suboptimal (Atukwase *et al*., 2024; Omara *et al*., 2020; Oyesigye*et al*., 2024). Studies have shown that cassava products from Uganda have aflatoxin levels exceeding the safe limits of 15ppb established by FAO/WHO international standards, posing a significant risk to public health (de Sá *et al*., 2024). These findings call for regular monitoring of cassava for aflatoxin contamination to safeguard the public.

Methods and materials

Research design

The philosophical underpinning of this study was that of a blended approach exploiting a cross-sectional study design in which qualitative and quantitative data were collected. Key-informant interviews were conducted using a check list of questions to assess the post-harvest handling practices of cassava at hammer milling centers in eight (8) districts of Uganda. Moisture content determination was done using a Hot-air-Oven method described by Mauer (2024). The Thin Layer chromatography [TLC] and

competitive Enzyme Linked Immunosorbent Assay [c-ELISA] techniques were used in the detection of aflatoxin groups and quantification of total aflatoxins in cassava samples respectively as described by Schuller *et al*., (1976) with minor modifications according to laboratory settings. The RidaScreen Total Aflatoxin ELISA Kit- ART No. R4701 used in this study was procured from PerkinElmer. The reagents used in this study were of analytical grade manufactured by LOBA CHEMIE PVT LTD, India and supplied by PubMed Diagnostics- Uganda. Additionally, all tests were done in duplicates alongside the standards for quality assurance and control of the study results.

Study area

Uganda, situated in East Africa, is a landlocked country bordered by Kenya in the East, Tanzania and Rwanda in the South, the Democratic Republic of the Congo in the West and South Sudan in the North (https://en.wikipedia.org/wiki/Uganda). The country is divided into four major regions; Western, Eastern, Northern and Central (Okurut and Odwee, 2020). Each region has unique cultural settings that may influence post-harvest food handling practices. In addition, rural and urban settings irrespective of the cultural practices might influence the food handling practices. Uganda's population is around 45,905,417 million people, with a youthful demographic, as over half are under 15 years old (Uganda Bureau of Statistics [UBOS] 2024). Cassava is one of the stapple foods in Uganda. However, cassava production and consumption in Uganda varies greatly with the eastern region dominating with 37 % followed by northern region at 34 %. The Western and Central regions represent 15 % and 14 % of national cassava production and consumption respectively (Mottaleb *et al*., 2021; Oyesigye *et al*., 2024). In this study, cassava samples were collected from milling centers in eight (8) purposively selected districts largely basing on production and consumption patterns. From each region, two districts were purposively selected to represent urban and rural settings. The amount of cassava produced and consumed were also considered while selecting the rural districts. In southwestern Uganda, Kasese district represented the urban setting whereas Masindi was considered a rural district. Lira and Pader were selected to represent urban and rural districts of Northern Uganda respectively. In Central Uganda, Kampala and Mityana districts were selected to represent urban and rural areas respectively. In Eastern Uganda, Jinja City was urban area while Kamuli district represented the rural setting. From each district, milling centers were identified with the help of field research assistants. A milling center was defined as the mill that processes food for public consumption. Centers processing animal feeds were not selected for this study.

Sample collection procedure

For each sample, 250 g of cassava flour and /or chips were purchased from selected hammer-milling centers in selected eight districts [Kampala, Mityana, Kasese, Masindi, Lira, Pader, Jinja and Kamuli] of Uganda. Samples were immediately divided into two equal subsamples into bags labeled as moisture and aflatoxin samples. An appropriate sample identification number was generated. For instance, a cassava sample from Lira was coded LNC01 where L stands for Lira district, N stands for Northern region, C designating cassava and 01 representing the sample serial number. Samples for moisture determination were placed in a dry container whereas those for total aflatoxin analysis were immediately placed on ice in cool boxes. The samples were immediately transported to Analytical Biosciences Laboratory, College of Veterinary Medicine, Animal Resources and Biosecurity, Makerere University for either immediate processing or storage. In particular, moisture samples that were not immediately processed were stored in tightly closed desiccators until analysis. Conversely, samples for aflatoxin analysis not immediately processed were kept at -30^0C until analysis.

Sample size determination

In this study, the theoretical population was negligibly small as they were fewer cassava hammer milling centers in each district. The number of cassava hammer milling centers for each district was established using purposive and snow balling sampling strategies with the help of community-based research assistants. Thus, an average of 15 cassava milling centers were identified in each of the eight districts from

which one composite sample per center was collected translating into a total 120 cassava samples in selected eight districts.

Assessment of cassava post-harvest handling practices at selected milling centers in Uganda

This was conducted through key-informant interviews. Initially, a verbal consent was obtained from the In-charge of the cassava hammer milling center after explaining the purpose of the study. Using a checklist of questions, information on cassava post-harvest handling practices was obtained.

Moisture content determination procedure

This was done according to the procedure described by Mauer (2024). For each sample, 5 g of cassava flour were transferred in duplicate into labeled pre-weighed crucibles. Crucibles containing samples were transferred into a Hot-air oven set at 105^{0}C and left to stand for 24 hours. Thereafter, samples were cooled in desiccators and reweighed. The procedure was repeated until a constant weight was recorded. The percentage moisture content was calculated using the formula;

$$\% \text{ moisture} = \frac{\text{Loss in moisture (g)}}{\text{Initial weight (g) of sample}} \text{ X } 100 \quad (1)$$

Procedure for detection of aflatoxin groups in cassava samples

This was done in two phases following procedures described by Schuller *et al.*, (1976) as modified by Muzoora *et al.*, (2017). Initially, aflatoxins were extracted from cassava samples by solvent method. The second stage involved screening for aflatoxin groups using Thin Layer Chromatography.

Procedure for solvent extraction of total aflatoxins from cassava samples

For each sample, 50 g of cassava flour were weighed into a labeled conical flask followed by addition of 150 mL of 70% HPLC-grade methanol. The mixture was then shaken for 10 minutes using a multi-flask vortexer at 2500 rpm. The resultant suspension was allowed to separate for 5 minutes and then collected into labeled conical flask. This was followed by addition of 10 mL of deionized water and 10 mL of absolute HPLC-grade chloroform sequentially. The resultant mixture emulsion was then shaken at 2500 rpm for 10 minutes and immediately transferred into a marked separating funnel. The contents were then allowed to stand for 5 minutes and the bottom chloroform emulsion layer was collected into a labeled bijou bottle. Extracts were stored at -20^{o}C until aflatoxin analysis.

Aflatoxin screening using Thin Layer Chromatography (TLC)

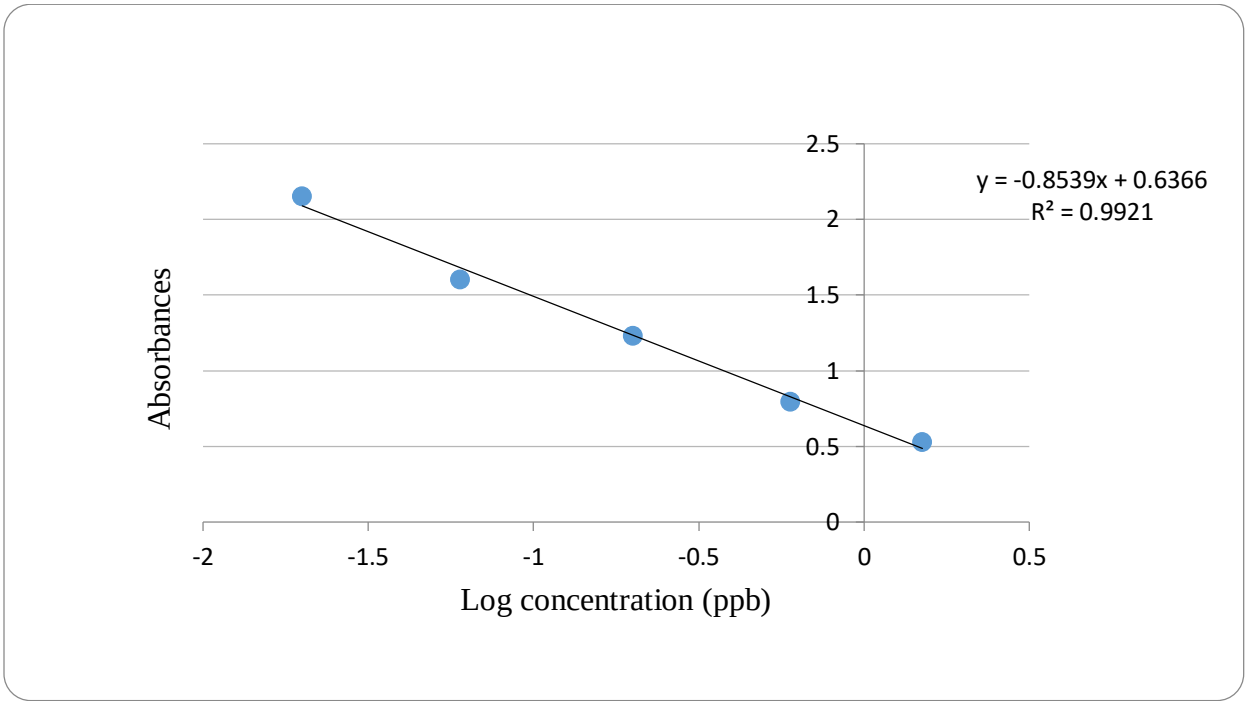
Initially, the TLC plate was activated at 90^{o}C for 5 minutes in an electric oven. For every sample, 10µL of the chloroform extract were spotted onto marked TLC plate and allowed to dry at room temperature (25^{o}C) for 5 minutes. The dried plate was developed in mobile phase of absolute acetone and chloroform [1:9 v/v] until the solvent front moved ¾ of its length. The plate was air-dried and observed at 366 nm using CAMAG®- viewing cabinet for aflatoxin detection.

Procedure for quantification of aflatoxins in cassava using c- ELISA

This was done following instructions in the Manufacturer's Manual- RidaScreen Total Aflatoxin ELISA Kit- ART No. R4701. Briefly, 50 µL of the standard and sample were added into wells in replicates followed by addition of 100 µL of aflatoxin-Horseradish peroxidase (HRP) conjugate into each well. The plate was then rocked for one minute and incubated at 250C for 30 minutes. After incubation, the wells were washed three times by adding 250 µL of the wash solution. Thereafter, 100µL of Tetramethylbenzidine (TMB) substrate were added into each well, plate rocked and incubate at 25^{0}C for 15 minutes. To each well, 100µL of the 0.5 M sulphuric acid solution were put. Reading of absorbance was done at 450 nm using a plate reader. Aflatoxin concentrations in cassava samples were computed from the standard curve (**Figure 1**).

Figure 1

Standard Curve used to determine total aflatoxin content in cassava samples



Data analysis

Data from key informant interviews were grouped into thematic areas and all responses tallied in Microsoft Excel Version 2016. The tallies were then computed into percentage frequencies and presented using a bar graph. Results of moisture content were entered into excel, edited and mean percentages were generated. Similarly, the aflatoxin concentrations were captured into Microsoft Excel Version 2016. The moisture content and aflatoxin results were exported into Graph Pad Prism Version 6 for analysis. The ordinary one-way analysis of variance (ANOVA) and Honest Significant Deference (HSD)-Tukey test were performed to establish variations in means of moisture content and aflatoxin concentration of cassava samples across districts. To evaluate the effect of moisture content on aflatoxin levels in the cassava samples, a linear regression analysis was conducted. The results of moisture content and aflatoxins were presented in figures and tables.

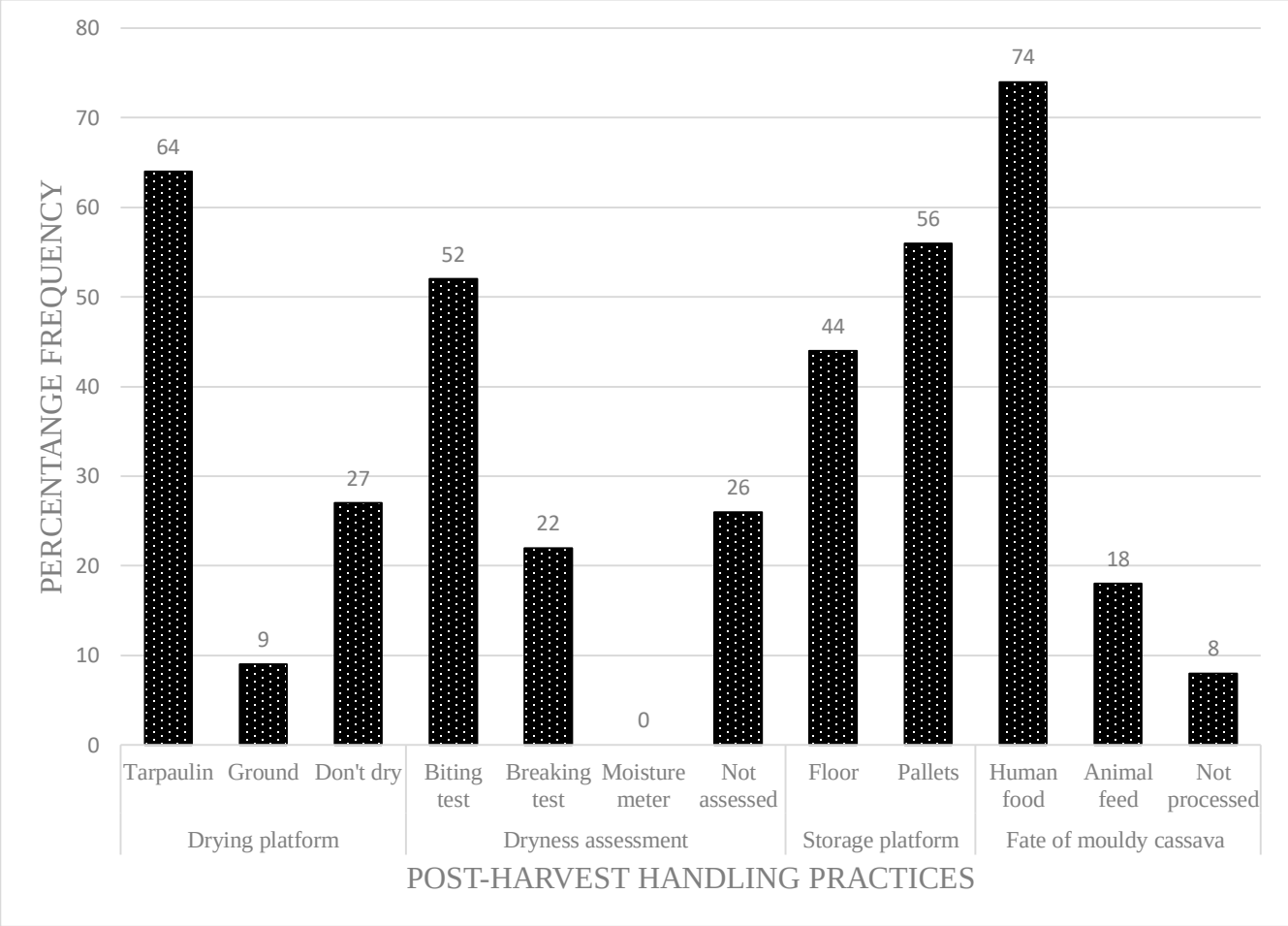
Results

Post- harvest handling practices of cassava at hammer mill centers in Uganda

This study revealed that majority of milling centers (74%) were processing cassava dried from tarpaulins with 27 % of mill center managers reporting that they process cassava as is received from traders and farmers. The biting technique was the most commonly method (53 %) for the assessment of moisture content and none of the respondents reported use of moisture meter. With regard to storage platforms, majority (56%) of the respondents stored cassava in sacks placed on pallets. Astonishingly, 74 % of mill managers reported having processed moldy cassava for human consumption (**Figure 2**).

Figure 2

Post-harvest handling practices of cassava at milling centers in four geographical regions of Uganda



Mean percentage moisture content of cassava samples from milling centers in eight selected districts of Uganda

The mean moisture content of cassava samples ranged from 8.88% to 13.80 % across eight districts. The highest mean moisture content (13.80%) was recorded in samples from Kampala District with Masindi samples registering the lowest moisture content (8.88%). There were statistically significant differences in the % mean moisture content levels across districts ($p = <0.0001$; $F(7, 112) = 6.87$). These findings call for the standardization of post-harvest handling practices of cassava in the country (**Table 1**).

Table 1

ANOVA table on percentage Mean Moisture Content in cassava samples from four geographical regions of Uganda

	Northern Region District		Central Region District		Eastern Region District		Western Region District	
Statistic	**Lira**	**Pader**	**Kampala**	**Mityana**	**Jinja**	**Kamuli**	**Kasese**	**Masindi**
Sample size	15	15	15	15	15	15	15	15
Range	10.29-14.04	8.33-13.92	7.14-27.63	9.38-19.93	10.19-17.00	10.47-16.12	7.97-13.15	7.49-11.52
25 % Percentile	11.28	9.62	11.05	11.99	10.90	11.92	10.80	7.99
Median	12.38	11.86	13.53	12.99	11.75	12.54	11.79	8.72
75% Percentile	13.35	12.63	15.43	15.31	14.15	13.89	12.10	9.16
Mean moisture content (%)	12.34*±0.304	11.41±0.47	13.80*±1.23	13.71*±0.66	12.68*±0.57	12.66*±0.37	11.47*±0.31	8.88*±0.28
95% CI range	11.69-13.00	10.41-12.41	11.16-16.43	12.29-15.14	11.45-13.91	11.87-13.44	10.80-12.13	8.28-9.49
P value	<0.0001							
F value (DFn, DFd)	(7, 112) =6.87							

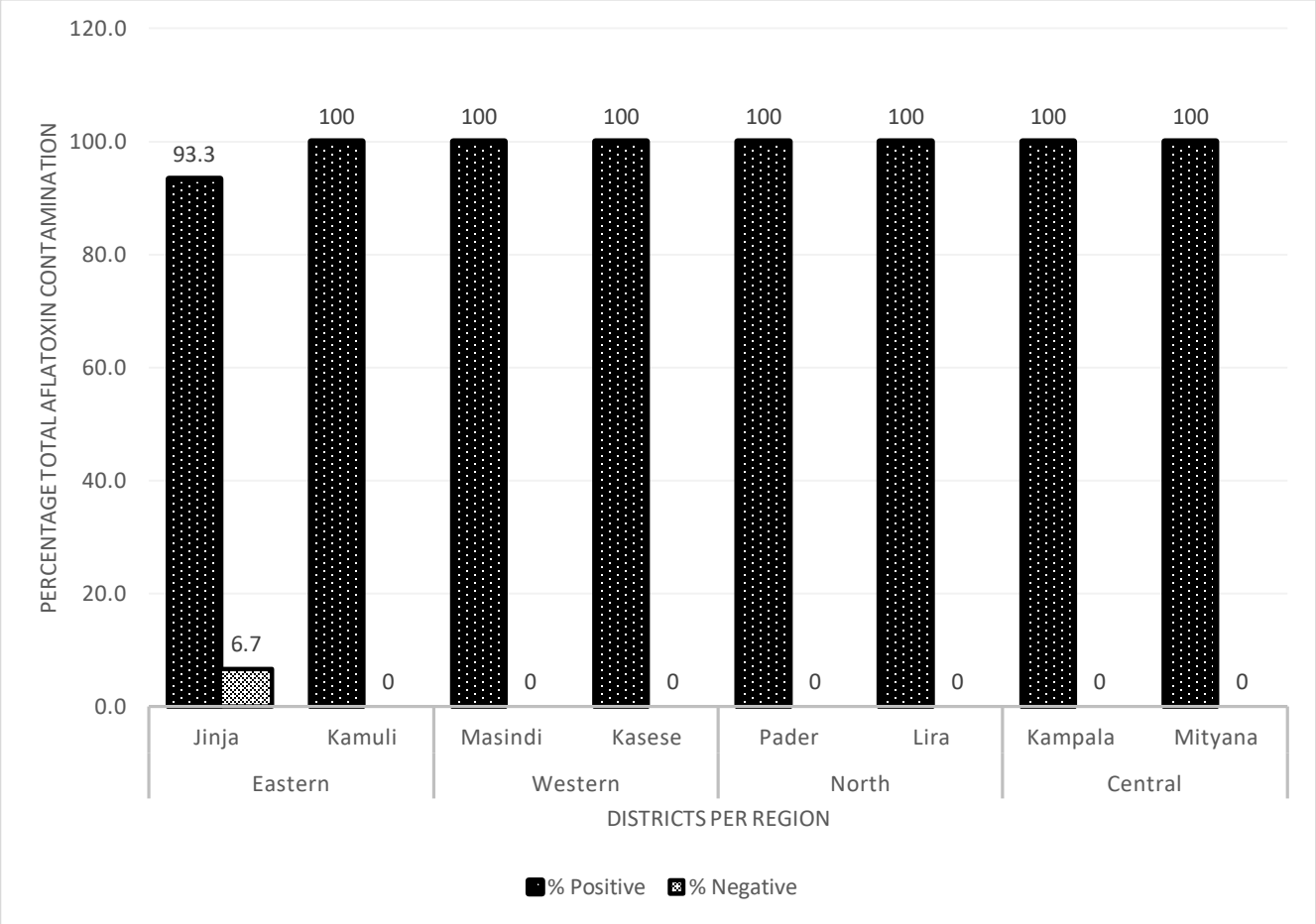
*Key: Percentage moisture content values with * were statistically different.*

Aflatoxin contamination levels of cassava samples

Results indicated an overall contamination level of 99.2% of cassava samples with aflatoxins. With an exception of samples from Jinja that registered 93.3 % aflatoxin contamination, samples from the rest of the districts registered 100 % contamination. These findings allude to the fact that majority of foods in this country could be at a greatest risk of aflatoxin exposure (**Figure 3**).

Figure 3

Aflatoxin contamination levels in cassava samples from 8 districts of Uganda

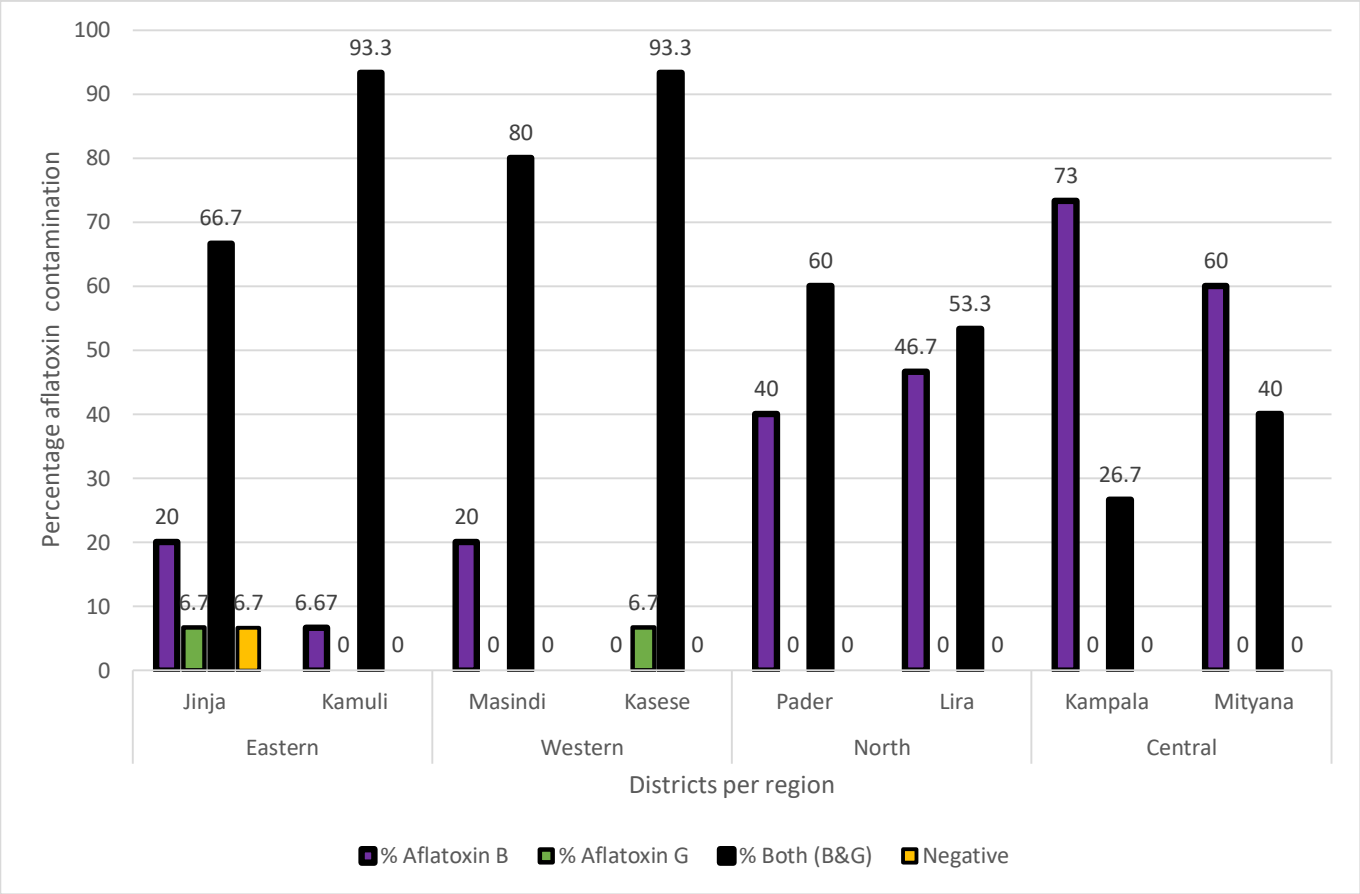


Aflatoxin contamination (by types) in cassava samples from 8 districts of Uganda (n-120)

The results indicate that there were regional differences in aflatoxin contamination levels according to classes. In the **Eastern Region**, Jinja had 20% Aflatoxin B, 6.7% Aflatoxin G, and 66.7% with both, while Kamuli had 6.67% Aflatoxin B and 93.3% with both. In the **Western Region**, Masindi showed 20% Aflatoxin B and 80% with both, and Kasese had 6.7% Aflatoxin G and 93.3% with both. In the **Northern Region**, Pader had 40% Aflatoxin B and 60% with both, whereas Lira had 46.7% Aflatoxin B and 53.3% with both. In the **Central Region**, Kampala recorded 73% Aflatoxin B and 26.7% with both, and Mityana had 60% Aflatoxin B and 40% with both. Overall, there is a high prevalence of aflatoxins, with the Central region having the highest proportion of samples with Aflatoxin B alone, while the Eastern and Western regions have more samples with both aflatoxin B and G **(Figure 4).**

Figure 4

Aflatoxin groups in cassava samples from eight selected districts from the four geographical regions of Uganda



Mean aflatoxin concentration (ppb) in cassava samples from selected eight districts of Uganda

Based on the mean total aflatoxins, Kamuli **(9.77 ppb)** and Pader **(9.00 ppb)** exhibited the highest levels of contamination, while Jinja **(0.29 ppb)** and Masindi **(0.30 ppb)** showed the lowest. Kampala **(2.99 ppb)** and Mityana **(2.07 ppb)** fall in the mid-range. The **P-value of 0.0317** indicates that the differences in aflatoxin levels across these districts are statistically significant, and the **F-value of 2.298** further supports that there is a significant variance between the districts' contamination levels. However, the findings indicate that aflatoxin concentrations in cassava samples were within acceptable limits (**Table 2**).

Table 2

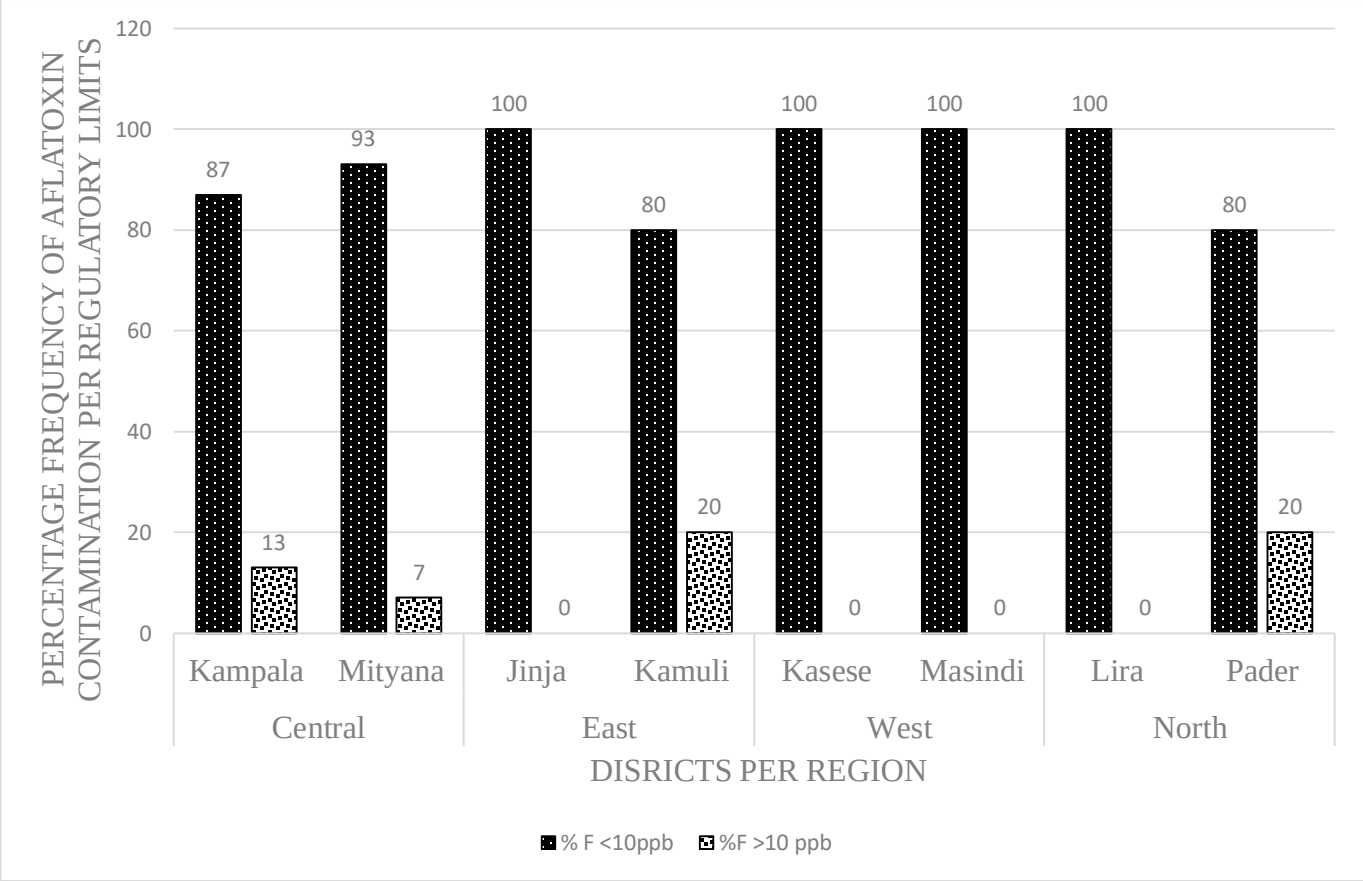
Mean Aflatoxin levels in cassava samples from eight selected districts four geographical regions of Uganda

	Northern Region		**Central Region**		**Eastern Region**		**Western Region**	
	District		**District**		**District**		**District**	
Statistic	**Lira**	**Pader**	**Kampala**	**Mityana**	**Jinja**	**Kamuli**	**Kasese**	**Masindi**
Sample size	15	15	15	15	14	15	15	15
Range	0.26-1.82	0.23-49.84	0.07-25.81	0.06-16.72	0.06-2.45	0.07-57.96	0.09-7.67	0.06-3.11
25 % Percentile	0.35	0.28	0.12	0.09	0.08	0.10	0.28	0.07
Median	0.65	0.37	0.14	0.24	0.10	0.14	0.43	0.08
75% Percentile	1.32	0.73	0.26	1.68	0.18	3.99	0.51	0.10
Mean total aflatoxins (ppb)	0.83	9.00	2.99	2.07	0.29	9.77	0.88	0.30
Standard deviation	0.53	18.10	7.52	4.41	0.62	19.24	1.89	0.78
SEM	0.14	4.67	1.94	1.14	0.17	4.97	0.49	0.20
95% CI Interval	0.54-1.13	-1.03-19.02	-1.17-7.15	-0.37-4.52	-0.07-0.65	-0.89-20.42	-0.17-1.93	-0.14-0.73
P value	0.0317							
F value (DFn, Fd)	(7, 111) = 2.298							

Mean total aflatoxin concentrations in cassava samples as per UNBS regulatory limits (≤10 ppb)
Results indicate that 20 % of cassava samples from Kamuli and Pader districts had total aflatoxins levels above the regulatory limit set by Uganda National Bureau of Standards with Kampala samples registering 13 %. Conversely, none of the cassava samples from Jinja, Kasese, Masindi and Lira districts had total aflatoxin concentrations above the regulatory limit (**Figure 5**). The regional disparities in aflatoxin concentrations with respect to national regulatory limits call for standardization of aflatoxin control strategies in Uganda. This is particularly true given the fact that foods produced in one region are distributed throughout the country and neighboring countries under the East African Community trade protocols.

Figure 5

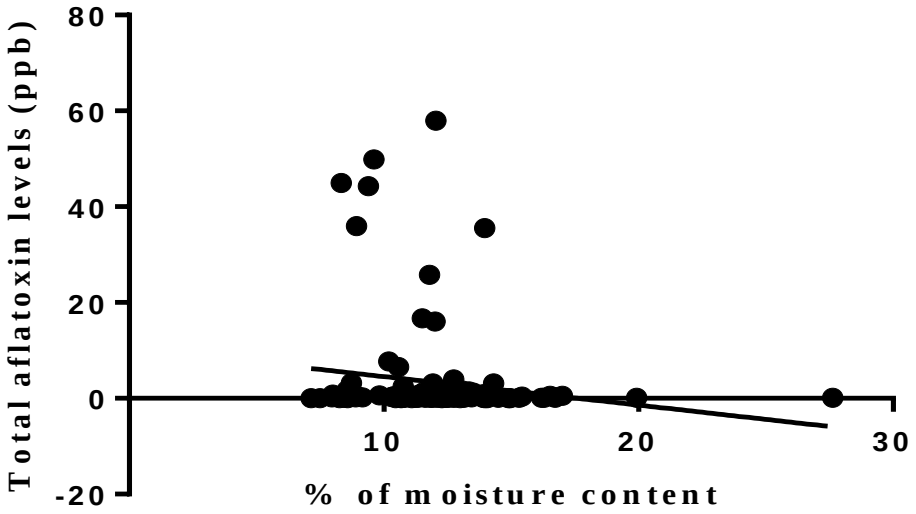
Frequency of cassava samples with lower and higher total aflatoxin levels (Reference = 10ppb as per Uganda National Bureau of Standards-UNBS)



Relationship between moisture content and aflatoxin levels in cassava samples (n=119)
The linear regression curve shows a weak positive relationship between moisture content (%) and aflatoxin levels (ppb) in cassava samples from selected cassava hammer milling centers in eight regionally distributed districts of Uganda (Y=0.1048X+1.996). This suggests that for every 1% increase in moisture content, aflatoxin levels increased by approximately 0.10 ppb. However, the low slope and the flatness of the regression line imply that moisture content had a minimal effect on aflatoxin levels, with significant variability observed in the data (**Figure 6**). Overall, the results suggest that other factors rather than the moisture content likely played a larger role in determining aflatoxin levels in the analyzed cassava samples.

Figure 6

Relationship between % of moisture content and aflatoxin levels in cassava samples from eight selected districts in four geographical regions of Uganda



Discussion

In this study, the post-harvest handling practices of cassava varied greatly across milling centers in Uganda (**Figure 2**). The commonly used practices such as biting the cassava to assess dryness and use of bare ground as a drying platform for cassava are considered ineffective methods. In addition, it was revealed that most of moldy contaminated cassava was processed for human consumption. The above-mentioned practices therefore pose a potential serious public health risk. Of great concern is the processing of moldy cassava in the same mills as animal feed since aflatoxin metabolites are more potent than their parent compounds. Apart from contaminating the human food through the traces remaining in the mills, the aflatoxins in the feed impacts on the food animals that subsequently provide food to humans. The Aflatoxin metabolites readily form adducts with DNA and proteins resulting into growth retardation, anemia, teratogenicity cancer and immunosuppression in both animals and humans (Gerdemann *et al.*, 2023; Zeinvand-Lorestani *et al.*, 2024). Therefore, the practice of processing moldy cassava and other food matrices for either human or animal consumption should be discouraged as it endangers the health of the Ugandan populace. In addition, proper drying and moisture assessment methods such as use of solar dryers and use of moisture meters respectively should be put in place and their usage promoted in Uganda.

Although the levels of aflatoxins were found to be within acceptable ranges, the results of this study indicated variations in percentage moisture content levels of cassava samples demonstrating disparities in handling practices across milling centers in eight districts. In particular, majority of the centers used sun drying method and bare ground as a drying platform. These findings agree with those of the previous studies that reported similar practices. In a study done by Buyinza and Kitinoja (2018) reported that 64 % of cassava farmers in Uganda used improper post-harvest handling practices such as sun drying and use of bare ground as a drying platform thereby increasing the chances of aflatoxin contamination. Conversely, the moisture content and aflatoxin contamination results of this study contradict since higher aflatoxin contamination levels (99.2 %) were

obtained against the lower mean percentage moisture content (8.88% to 13.80 %). This finding could be explained by the fact that use of an improper drying method such as sun drying could exposure food matrices to contamination with aflatoxigenic fungi particularly during the initial stages of the drying process (Adenitan *et al*., 2021; Valente *et al*., 2020).

This study further revealed that the mean total aflatoxin concentrations in cassava samples were within nationally and internationally accepted levels since the highest concentration determined in this study was 9.77 ppb (**Table 2**). This finding collaborates with the findings of Oyesigye *et al*., (2024) who reported 8.91 ppb in cassava samples from wholesalers compared to 78.2 ppb in cassava samples from farmers in Uganda. In this study, cassava samples were collected from milling centers. In addition, significant disparities in aflatoxin concentrations in cassava samples from eight regionally distributed districts in Uganda were recorded (P = 0.0317). The findings of this study imply that variations in total aflatoxin levels in cassava exist along the supply chain. These disparities may be attributed to the variations in post-harvest handling practices at milling centers documented in this study to which cassava was exposed to. This is supported by the findings of previous studies in which it was documented that the growth of aflatoxigenic fungi requires a moisture content of 12.5 % and above and higher temperature of >20^{0}C (Ekpakpale *et al*., 2021; Obong'o *et al*., 2020; Ono *et al*., 2021). Furthermore, these findings could be attributed to regional and annual variations in temperature and relative humidities in Uganda (Buyinza and Kitinoja, 2018; Nuwagira and Yasin, 2022).

On examining the relationship between moisture content and aflatoxin levels, a weak correlation was recorded (**Figure 6**). This finding alludes to the fact that factors other than moisture such as initial fungal contamination during harvesting, poor storage conditions, use of bare ground as a drying platform could have played a more significant role in this relationship. This finding corroborates with results of previous studies in which it was reported that aflatoxin contamination in majority of food matrices occurs during initial stages of sun drying (Adenitan *et al*., 2021; Valente *et al*., 2020). This is because, sun drying reduces moisture content gradually from food matrices facilitating contamination with aflatoxigenic fungi contamination in early stages of the drying process. Given the carcinogenic, immunosuppressive, and growth-retardant nature of aflatoxins, the study underscores the importance of regular monitoring of food safety in Uganda since continuous exposure can lead to accumulation of aflatoxins in the body in toxic levels. This is particularly of critical public health importance in Ugandan regions with cassava aflatoxin levels exceeding national and international safety standards.

Conclusion

This study demonstrates that aflatoxin contamination is a widespread problem in cassava across Uganda, with significant regional variations linked to handling practices and moisture content. However, the mean total aflatoxin levels were within national and internationally acceptable levels. Despite this finding, gradual consumption of aflatoxins will lead to their accumulation to toxic levels that will likely compromise the health of consumers in the long run. The high level of aflatoxin contamination registered in this study might negatively impact on regional trade of this commodity. Notably, there are already instances in which the aflatoxin ladened Ugandan maize and its products were prohibited from entering Kenya and South Sudan- a trend that can be reciprocated to this produce. The weak correlation between moisture content and aflatoxin levels suggests that contamination may occur before total drying, underscoring the need for improved post-harvest handling and storage practices. Regular monitoring of aflatoxins in cassava is essential to ensure food safety and protect public from dangers of these toxins. Targeted interventions in high-risk districts, particularly in Pader and Kamuli, are necessary to reduce aflatoxin exposure and its associated health risks. This study contributes to the growing body of evidence on aflatoxin contamination in staple foods in Uganda and calls for regular monitoring, urgent policy and practical responses to safeguard food safety.

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