



MAKERERE UNIVERSITY

**AFLATOXIN CONTAMINATION STATUS IN SELECTED ANIMAL FEEDS
AND CONCENTRATES SOLD IN FEED STORES IN KAMPALA, UGANDA**

BY

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DECLARATION

I, **Ogwang Paul Oscar**, hereby declare that this Special Research Project is my original work. To the best of my knowledge, it has not been submitted, either in whole or in part, to any institution of higher learning for the award of any academic qualification."

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APPROVAL

This research report has been submitted for examination with my approval as the academic supervisor.

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DEDICATION

I dedicate this report to my family, and most especially to my wife, Mrs. Akullu Judith Ogwang, for the moral, spiritual, emotional, and motivational support that greatly contributed to the success of this work.

A special dedication goes to my academic supervisor, Dr. Muzoora Saphan (BVM, MSc, PhD Cand.), and Mr. Owor Joseph, whose knowledge, guidance, and encouragement made this accomplishment possible.

Finally, I dedicate this research to my colleagues and friends, with special recognition to Mr. Ssentumbwe Peter and Mr. Kajjumba Keberi.

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Above all, I give glory to the Almighty God for His mercy and grace that enabled the successful completion of this research project.

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LIST OF ABBREVIATIONS

AFB1: AflatoxinB1

AFB2: AflatoxinB2

AFG: AflatoxinG

FAO: Food and Agriculture Organization

GDP: Gross Domestic Product

HPLC: High-Performance Liquid Chromatography

ID: Identification

MAAIF: Ministry of Agriculture, Animal Industry and Fisheries (MAAIF)

nL: Nanolitre

nm: Nanometer

ppb: Parts per billion

TLC: Thin Layer Chromatography

USDA: United States Federal Department of Agriculture

UNBS: Uganda National Bureau of Standards

UV: Ultraviolet

LIST OF FIGURES

Figure 1 : Overall contamination status	12
Figure 2 : Contamination by aflatoxin type	12
Figure 3 : Contamination by feed type.....	13
Figure 4 : Contamination by month of manufacture.....	14

TABLE OF CONTENTS

DECLARATION	i
APPROVAL	ii
DEDICATION	iii
ACKNOWLEDGEMENT	iv
LIST OF ABBREVIATIONS.....	v
LIST OF FIGURES	vi
ABSTRACT.....	ix
CHAPTER ONE	1
INTRODUCTION	1
1.1. Background	1
1.2. Statement of the problem	2
1.3. Objectives of the study.....	3
1.3.1. General objective.....	3
1.3.2. Specific objectives.....	3
1.4. Research questions	3
1.5. Significance of the Study	3
1.6. Justification	4
CHAPTER TWO.....	5
LITERATURE REVIEW.....	5
2.1. Occurrence of aflatoxins in feeds.....	5
2.2. Importance of aflatoxins.....	5
2.3. Factors for feed contamination with aflatoxins.....	5
2.4. Control measures of aflatoxins.....	6
2.5. Methods of analyzing aflatoxins	6
CHAPTER THREE	8
MATERIALS AND METHODS.....	8
3.1. Research design.....	8
3.2. Study Area.....	8
3.3. Sample Size	8
3.4. Sampling Strategy	9

3.5. Procedure of extracting aflatoxins.....	9
3.6. TLC detection of aflatoxins.....	9
3.7. Data analysis	10
3.8. Ethical considerations	10
CHAPTER FOUR.....	11
RESULTS.....	11
4.1. Prevalence of aflatoxin contamination in selected commercial animal feeds.....	11
4.2. Aflatoxin contamination status by feed type.....	12
4.3. Aflatoxin contamination status across different manufacturing periods.....	13
CHAPTER FIVE	14
DISCUSSION	14
CHAPTER SIX:.....	16
CONCLUSION AND RECOMMENDATIONS.....	16
6.1. Limitations of the study.....	16
6.2. Conclusion.....	16
6.3. Recommendations	17
References.....	19
Appendices.....	22
Appendix 1: Photos of the researcher and sample handling during the study	22

ABSTRACT

This study was conducted to evaluate the status of aflatoxin contamination in commercial animal feeds and concentrates sold in feed stores in Kampala, Uganda. Aflatoxins are toxic metabolites produced by *Aspergillus* species, known to reduce animal productivity and pose public health risks through residues in milk, meat, and eggs. Despite existing regulatory limits, there has been limited systematic surveillance of commercial feeds in Kampala, where most livestock farmers source their feeds. A cross-sectional analytical design was employed, and 60 feed samples were collected across five divisions of Kampala, representing four feed categories (layers mash, dairy meal, pig concentrate, and fish feed). Thin Layer Chromatography (TLC) was used to detect aflatoxins. Findings showed that 48.3% of samples tested positive for aflatoxins. Among the contaminated samples, 70% contained aflatoxin G, while 30% contained aflatoxin B. Layers mash recorded the highest contamination (66.7%), followed by dairy meal (53.3%), fish feeds (46.7%), and pig concentrate (33.3%). Contamination levels also varied by manufacturing period, with prevalence rates of 35%, 45%, and 80% in May, June, and July, respectively. These findings indicate that aflatoxin contamination is widespread in Kampala's feed stores and influenced by both feed type and season of manufacture. The high levels observed, particularly in poultry and dairy feeds during wetter months, raise concerns about food safety and livestock productivity. Furthermore, according to the Uganda National Bureau of Standards (UNBS, 2018), the maximum permissible level of aflatoxins in animal feeds is 10 µg/kg; however, there is limited data on the extent to which feeds on the Ugandan market comply with this standard. The study concludes that aflatoxin contamination poses a significant threat to the livestock sector and recommends nationwide surveillance and quantitative assessments to strengthen evidence for policy and interventions.

CHAPTER ONE

INTRODUCTION

1.1. Background

Livestock production is a cornerstone of Uganda's agricultural economy, contributing significantly to household incomes, food security, and national GDP. The livestock sector accounts for approximately 17% of the agricultural GDP and 4.3% of the national GDP (UBOS, 2022). Kampala, being the largest urban center, is a major hub for animal feed distribution, providing feeds for poultry, dairy, piggery, and aquaculture enterprises. Beyond its economic contribution, livestock production also supports rural livelihoods through employment, manure for crop farming, and cultural values associated with animal ownership. In Kampala and other urban centers, the rising demand for livestock products has stimulated increased reliance on commercial feeds (Kwiringira et al., 2024). This makes the safety and quality of these feeds critical, since contamination directly affects productivity and public health, thereby influencing both local consumption and Uganda's competitiveness in regional markets.

Aflatoxins, secondary metabolites produced primarily by *Aspergillus flavus* and *A. parasiticus*, are among the most harmful mycotoxins contaminating animal feeds (Wu et al., 2021). Aflatoxin B1, the most toxic and prevalent form, is a proven carcinogen and immunosuppressant (Li et al., 2022). Contamination of animal feeds not only reduces animal productivity and feed efficiency but also results in carryover of aflatoxin residues into products such as milk, meat, and eggs, thereby posing public health risks (Matumba et al., 2021). The health implications of aflatoxin exposure are particularly severe in developing countries like Uganda, where regulation and monitoring systems are not yet robust. In livestock, chronic exposure to low aflatoxin levels may go unnoticed but gradually reduces productivity, making it harder for farmers to achieve profitability (Benkerroum, 2020). For consumers, even minimal residues in milk and meat contribute to long-term cancer risks and immune suppression. Therefore, aflatoxin contamination represents both an economic and a public health burden that necessitates targeted investigation.

In Uganda, studies have reported widespread contamination of feed and feed ingredients. For example, Nakavuma et al. (2021) reported aflatoxin levels exceeding national and international limits in poultry feeds and maize bran collected in central Uganda. However, there remains limited systematic data on the prevalence and concentration of aflatoxins in feeds sold in Kampala feed stores, where large volumes of feeds from diverse sources converge and are distributed. Despite several studies highlighting the problem in maize, and other raw ingredients the dynamic environment of feed distribution in Kampala creates great risks due to aflatoxin exposures. Feed stores handle products from multiple manufacturers and regions, often without standardized storage practices (Shurson et al., 2022) which increases the likelihood of contamination hotspots that may not be detected by studies limited to raw materials. Hence, an assessment that specifically targets feeds at the point of sale in Kampala is essential for capturing the real exposure risk faced by livestock keepers and consumers.

1.2. Statement of the problem

Although Uganda has established limits for aflatoxin in food and feed (10 µg/kg total aflatoxins in feed, UNBS, 2018), compliance and enforcement remain weak. Contaminated feeds pose economic losses to farmers through reduced livestock performance and rejection of animal products in formal markets. Recent research has focused mainly on maize and dairy milk contamination (Muzoora *et al.*, 2020; Mutegi et al., 2022), while systematic surveillance of commercial livestock feeds in Kampala remains limited. Since Kampala acts as the main aggregation and distribution point for feeds across the country, the lack of updated data compromises evidence-based interventions for feed safety.

1.3. Objectives of the study

1.3.1. General objective

To assess the status of aflatoxin contamination in commercial animal feeds and concentrates sold in feed stores in Kampala, Uganda.

1.3.2. Specific objectives

To determine the prevalence of aflatoxin contamination in selected commercial animal feeds sold in Kampala.

1.3.2.1. Outcomes

- i. Compare aflatoxin contamination status among different categories of commercial feeds sold in Kampala.
- ii. Evaluate aflatoxin contamination status across different manufacturing periods

1.4. Research questions

- i. What is the current status of aflatoxin contamination in commercial animal feeds and concentrates sold in feed stores in Kampala, Uganda?
- ii. What is the prevalence of aflatoxin contamination in selected commercial animal feeds sold in Kampala?
- iii. How does aflatoxin contamination differ among various categories of commercial animal feeds sold in Kampala?
- iv. How does aflatoxin contamination vary according to different manufacturing periods?

1.5. Significance of the Study

This study will generate scientific evidence on the extent of aflatoxin contamination in commercial feeds in Kampala. Findings will be useful to policymakers such as the Uganda National Bureau of Standards (UNBS), the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), and feed manufacturers to strengthen feed quality monitoring systems. Additionally, results will guide livestock farmers and value chain actors in making informed feed-purchasing decisions, thereby reducing risks of economic losses and food safety hazards.

1.6. Justification

There is limited empirical data on aflatoxin contamination levels in Uganda's commercial feeds, especially within Kampala. While some studies have highlighted aflatoxin

contamination in raw materials like maize, systematic surveillance of processed commercial feeds remains scarce (Nakavuma et al., 2021; Kaaya et al., 2020). This study will fill this knowledge gap by providing batch-specific, feed-type-specific contamination data using scientifically validated methods, contributing to safer feed practices and improved public health outcomes.

CHAPTER TWO

LITERATURE REVIEW

2.1. Occurrence of aflatoxins in feeds

Globally, aflatoxin contamination of animal feeds is a persistent issue, particularly in warm, humid regions. In sub-Saharan Africa, prevalence rates in livestock feeds often exceed international safety limits (Matumba *et al.*, 2021). A study by Nakavuma *et al.*, 2021, reports that in Uganda, maize bran and oilseed cakes, commonly used as feed ingredients, are frequently contaminated, with practices that predispose to mold/aflatoxin contamination. Further indicating that forty feed samples from feed processing plants had aflatoxins in the range $7.5 \leq 0.71$ to $393.5 \leq 19.09$ parts per billion (ppb) with only twelve samples being within the generally acceptable limits of 20 ppb as recommended by the Food and Agriculture Organization and the United States Federal Department of Agriculture, and adding that all 27 feed samples obtained from the farmers had aflatoxins in the range of 19.0 ± 1.41 to 188.5 ± 2.12 ppb and were above the acceptable limits.

2.2. Importance of aflatoxins

In the livestock feed industry, aflatoxins compromise animal health by causing reduced growth rates, immunosuppression, reproductive failures, and increased mortality (Kebede *et al.*, 2020). In addition, aflatoxins are transferred into milk as aflatoxin M1, and into eggs and meat products, creating a direct public health hazard. Economically, contamination leads to losses due to reduced feed efficiency, rejection of products, and international trade restrictions (Erdaw, 2023). Countries with strict residue monitoring reject contaminated products, reducing Uganda's potential to expand its agricultural exports. Besides, the costs of veterinary care for aflatoxin-induced illnesses increase production expenses, further constraining profitability.

2.3. Factors for feed contamination with aflatoxins

Factors contributing to aflatoxin contamination include pre-harvest conditions (drought stress, pest damage), post-harvest practices (poor drying and storage), and supply chain

handling (transport, milling, and prolonged storage)(Gachara et al., 2024). Kampala’s humid climate and inadequate storage facilities in small-scale feed stores exacerbate contamination risks (Wacoo *et al.*, 2019). In addition to environmental and storage factors, socio-economic conditions also play a role (Tai et al., 2020). Many feed store operators and smallholder farmers lack awareness of aflatoxin risks, leading to poor handling practices such as reusing old bags, inadequate aeration, and mixing of new and old feed batches (Wanjiru, n.d.). Limited investment in modern storage infrastructure further adds to the existing problems, making education and awareness key components in reducing contamination.

2.4. Control measures of aflatoxins

Control strategies include good agricultural practices, use of biological control (*A. flavus* competitive strains), proper storage (low moisture and aeration), and detoxification methods such as binders and enzymatic degradation. However, implementation in Uganda remains inconsistent due to limited farmer awareness and weak regulation (Matumba *et al.*, 2021). Innovations such as the use of aflatoxin-binding agents and bio-control technologies (e.g., non-toxigenic strains of *Aspergillus flavus*) have shown promise in other regions. However, their adoption in Uganda is constrained by cost, accessibility, and lack of farmer training. Integrating these approaches with community-level awareness and stronger regulatory enforcement could enhance the effectiveness of control measures and reduce contamination along the feed supply chain.

2.5. Methods of analyzing aflatoxins

Several analytical methods are used, including thin-layer chromatography (TLC), high-performance liquid chromatography (HPLC), liquid chromatography–mass spectrometry (LC-MS/MS), and immunoassays such as ELISA (Karabat et al., 2023). In a comparative study, ELISA results showed strong correlation with HPLC for aflatoxin detection in animal feeds, supporting its application in resource-limited settings (Maggira *et al.*, 2022). Advances in portable testing kits are expanding opportunities for rapid, on-site aflatoxin detection (Kyalo, 2024)(Singh & Mehta, 2020). While laboratory-based methods like HPLC remain the gold standard, portable ELISA and fluorescence-based kits allow field

testing, enabling faster decision-making in feed stores (Singh & Mehta, 2020). Such innovations could support routine monitoring in Kampala, provided there is adequate training and institutional support for widespread use.

CHAPTER THREE

MATERIALS AND METHODS

3.1. Research design

A cross-sectional analytical design was employed to assess the status of aflatoxin contamination in commercial animal feeds and concentrates. This design was appropriate as it enabled comparison of contamination levels across feed types and manufacturing periods at a single point in time.

3.2. Study Area

The study was conducted in Kampala, Uganda's largest urban center and the country's main hub for animal feed distribution. Feed stores were selected from each of Kampala Capital City's five administrative divisions: Central, Kawempe, Makindye, Nakawa, and Rubaga. Selection was based on the presence of well-kept supply records (including month of manufacture) and the availability of targeted feed types.

3.3. Sample Size

Sample size was determined to provide adequate representation of feed types for estimating prevalence, using the standard single-proportion formula:

$$n = \frac{Z^2 p(1 - p)}{d^2}$$

Where;

$Z = 1.96$ for a 95% confidence level, $p = 0.483$ (expected prevalence), and $d = 0.05$ (desired precision of $\pm 5\%$).

Due to resource constraints, this study utilized 60 samples as part of an exploratory survey, resulting in a 95% margin of error of approximately $\pm 12.6\%$. This sample size is consistent with comparable studies on aflatoxins in Uganda and Kenya, which analyzed 40 to 80 samples (Nakavuma et al., 2021; Kemboi et al., 2020), and was therefore considered

adequate for meaningful analysis given the study's limitations. Nevertheless, future research aiming for policy-level accuracy should consider larger sample sizes.

3.4. Sampling Strategy

A stratified random sampling approach was adopted. Four feed categories were considered: layers mash, dairy meal, pig concentrate, and fish feed. In each division, three replicates per feed type were obtained, representing batches manufactured in May, June, and July 2025. Approximately 500 g of each sample was collected using multiple sub-sampling points within sacks to form composite samples. Each sample was labeled systematically, and metadata including store ID, feed type, batch number, month of manufacture, and date were recorded. Samples were transported under cool, dry conditions to the laboratory for analysis, with duplicate aliquots retained for re-testing when necessary. This approach provided representative, traceable, and reliable data for evaluating aflatoxin contamination across the city for feed batches produced in May, June, and July 2025. Lists of eligible stores were compiled for each division, and random selection was conducted using Excel to ensure unbiased sampling, with pre-identified replacement stores in case selected stores could not provide samples.

3.5. Procedure of extracting aflatoxins

Twenty-five grams (25g) of each feed sample was added into a conical flask followed by 75ml of 70% methanol (extraction solvent). The conical flask was then covered with aluminum foil and vortexed at 1500 rpm for 10 minutes. The mixture was then filtered with cotton into another labelled clean conical flask. To the filtrate was added 10 ml of distilled water followed by 10 ml of chloroform and then vortexed at 1500 rpm for 5 minutes. The mixture was then transferred immediately into a separating funnel to allow separation of organic-aqueous layers, after 10 minutes the lower organic layer was obtained in a bijou bottle and stored until analysis

3.6. TLC detection of aflatoxins

The TLC plate was activated by heating at 90°C for 1 hour in an oven. The loading plan was then drawn in a record book containing the sample ID and this plan was transferred on

the TLC plate. 10ul of the sample was spotted on the plate and allowed to air dry. The plate was then developed in a developing solution (acetone: chloroform in a ratio of 1:9) until the mobile phase was three quarter way the stationary phase then it was removed from the developing solution, allowing it to air dry. The plate was viewed under a UV lamp at a wavelength of 366 nm for the bands.

3.7. Data analysis

Data were entered into Microsoft Excel for analysis. Descriptive statistics (frequencies and percentages) were used to determine contamination prevalence across feed types and manufacturing months. Results were presented in graphs to illustrate the various aflatoxin levels in the samples relative to the research questions. While inferential statistics were not applied due to resource limitations, future studies are encouraged to employ chi-square or regression models to statistically test associations between feed type, manufacturing period, and aflatoxin contamination.

3.8. Ethical considerations

Verbal permission was sought from feed store owners before sampling. Store and brand identities were kept confidential. Laboratory safety protocols for handling aflatoxins, which are carcinogenic, were strictly observed (FAO, 2020). No human or animal subjects were directly involved.

CHAPTER FOUR

RESULTS

4.1. Prevalence of aflatoxin contamination in selected commercial animal feeds.

Findings from this study showed that the prevalence of aflatoxin contamination was 48.3%, indicating that nearly half of the feed samples analyzed contained detectable levels of aflatoxins. This prevalence rate suggests that a substantial proportion of commercial feeds could potentially exceed the UNBS safety limit of 10 µg/kg if quantified. The results indicated that of the contaminated samples, 69% were aflatoxin G and the remaining 31% were aflatoxin B. These results demonstrated that contamination was not incidental but rather widespread across feed stores in Kampala. The prevalence observed in this study provided evidence of the scale of the problem and reinforced concerns that animal feeds constitute a significant source of aflatoxin exposure within livestock production systems.

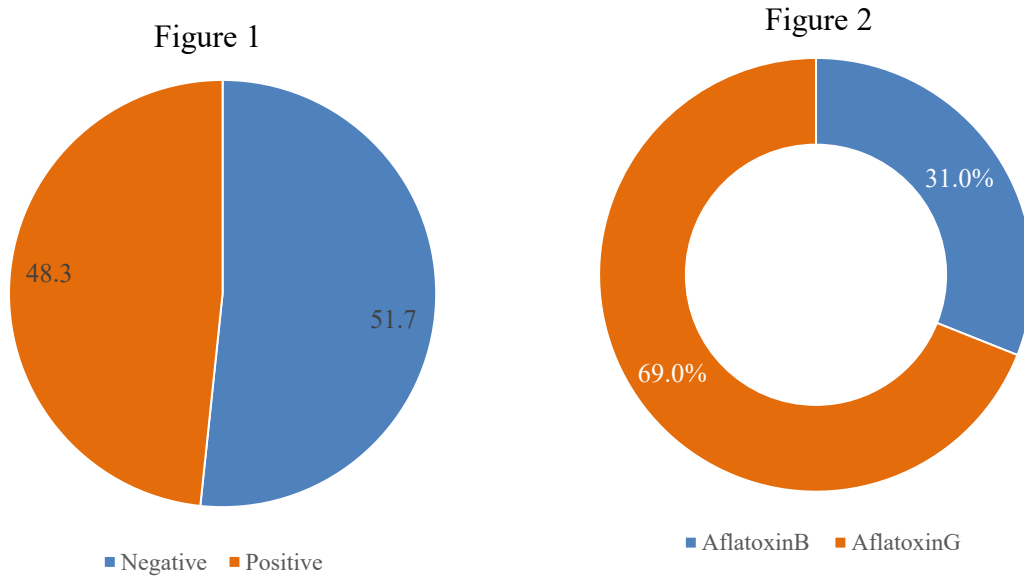


Figure 1: Overall contamination status. **Figure 2:** Contamination by aflatoxin type

4.2. Aflatoxin contamination status by feed type

Findings from this study showed that aflatoxin contamination varied across feed categories. Layers mash recorded the highest contamination at 66.7%, followed by dairy meal at 53.3%, fish feeds at 46.7%, and pig concentrate at 33.3%. The elevated contamination in layers mash likely reflects the high reliance on maize bran and oilseed cakes in poultry feed formulations, which are more susceptible to mold growth. These results demonstrated that contamination was not uniform across feed types, providing critical insight into which value chains face the highest risk and highlighting the need for targeted monitoring and intervention strategies.

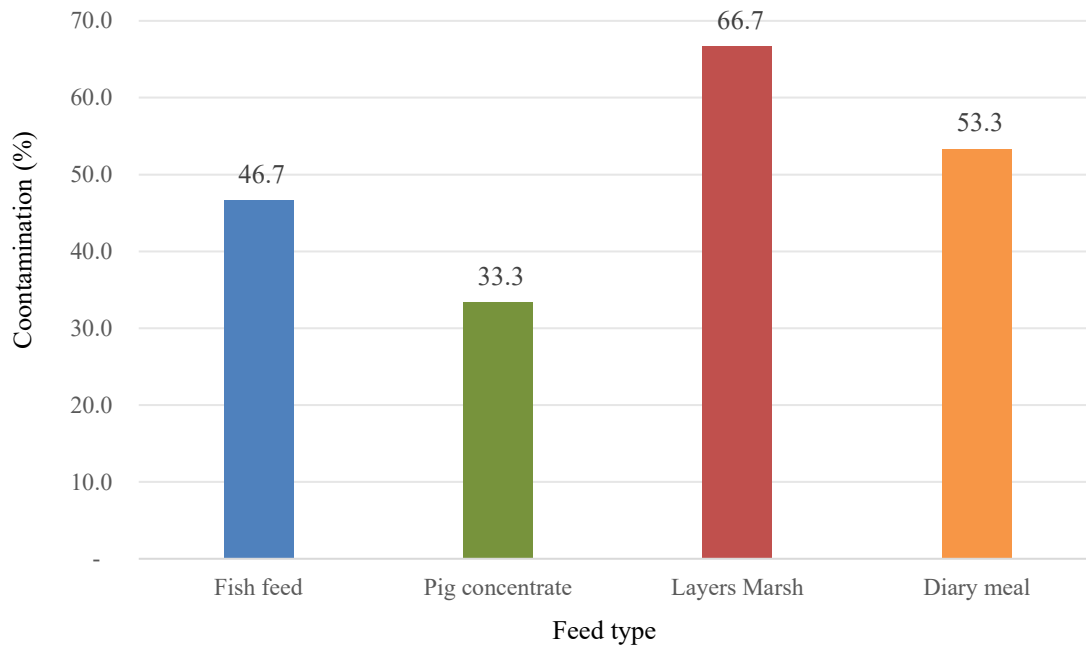


Figure 3: Contamination by feed type

4.3. Aflatoxin contamination status across different manufacturing periods

Findings from this study showed that aflatoxin contamination varied according to the month of feed manufacture. Samples produced in May had a contamination rate of 35%, those manufactured in June had 45%, while samples from July recorded the highest contamination at 80%. The higher contamination levels observed in June and July likely reflected seasonal factors such as increased rainfall, as well as suboptimal harvesting or processing practices, rather than storage conditions alone. These results demonstrated that contamination is influenced by production timing, highlighting the importance of considering manufacturing periods in aflatoxin risk management.

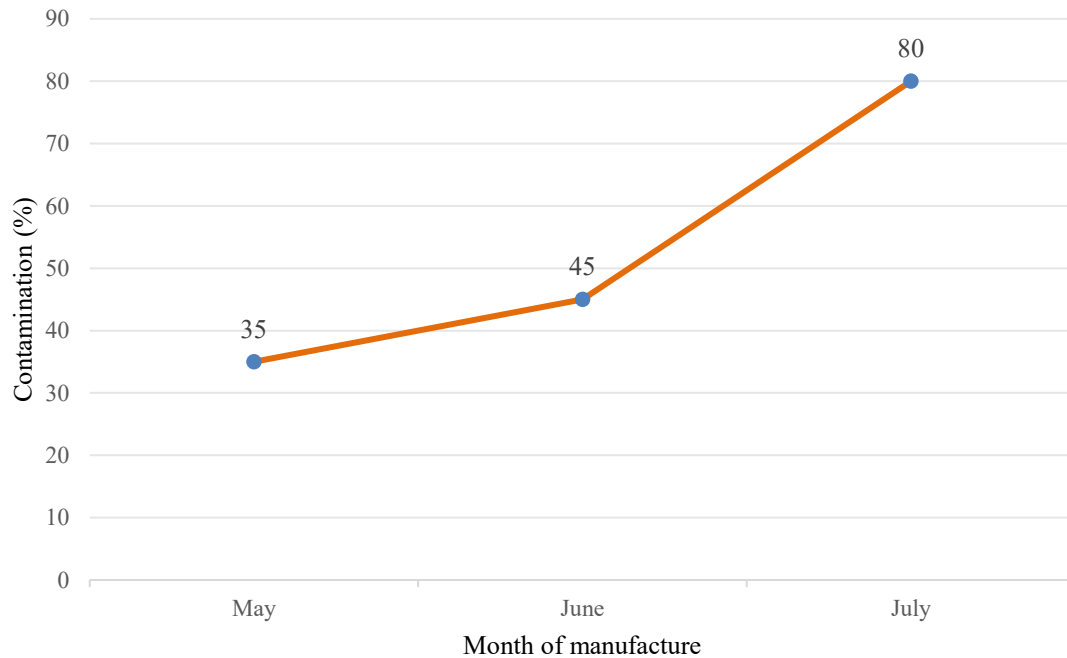


Figure 4: Contamination by month of manufacture

CHAPTER FIVE

DISCUSSION

Findings from this study showed that the overall prevalence of aflatoxin contamination was 48.3%, indicating that nearly half of the sampled feeds in Kampala contained detectable aflatoxins. This prevalence is broadly consistent with previously reported high contamination levels in Uganda (Kemboi et al., 2020; Nakavuma et al., 2021; Nakavuma et al., 2020; Matumba et al., 2021), which together indicate that aflatoxin contamination is a persistent problem in the region. When compared with reports from Ethiopia and Kenya that documented contamination rates exceeding 50%, the present overall rate was slightly lower, suggesting a marginal decrease relative to those higher regional figures but still showing a substantial contamination burden. In other words, contamination in Kampala remains high and lies close to the upper range reported regionally, rather than representing a marked improvement.

Moreover, this study found that 69% of contaminated samples contained aflatoxin G, and 31% contained aflatoxin B. This predominance of aflatoxin G is consistent with many regional reports that identify G-type aflatoxins as the dominant form in contaminated feeds and grains; thus, the distribution observed here supports existing evidence that the greater share of aflatoxin risk in feeds is attributable to G-type toxins.

Furthermore, the study found that layer's mash had the highest contamination (66.7%), followed by dairy meal (53.3%), fish feed (46.7%), and pig concentrate (33.3%). The elevated level in layers mash agreed with Kaaya et al. (2020) and with studies from Tanzania and other East African contexts (Ochieng et al., 2021; Kebede et al., 2020) that identified maize-based poultry rations as most affected. Relative to these cited studies, the high level in layers mash in this study represents either a similar magnitude or, in some comparisons, an increase in contamination of poultry feeds, consistent with the expectation that maize and oilseed heavy formulations remain particularly vulnerable. The lower contamination in pig concentrates (33.3%) indicates a relative decrease in contamination risk compared with poultry and dairy value chains; this pattern mirrors the ingredient

driven trends noted in the literature where non maize dominant feeds tend to register lower aflatoxin burdens.

Additionally, when samples were examined by month of manufacture, contamination rose markedly from May (35%) to June (45%), and peaked in July (80%). This temporal pattern a strong increase in contamination in later (wetter) months reinforces studies that link seasonal conditions to higher aflatoxin formation (Wacoo et al., 2019; Neogi et al., 2024), and matches observations from Uganda and Kenya where wet seasons correspond with contamination peaks. Compared with those studies, our results showed an accentuated seasonal effect (particularly the very high July rate), implying that contamination increased substantially during the wet period sampled in this study. The sharp rise to 80% in July suggests that production and post-harvest related factors (poor drying, delayed processing) during the rainy season contributed more to contamination than storage duration per se, aligning with the literature that identifies harvest and processing stage vulnerabilities.

The results of this study therefore suggest widespread contamination in Kampala feed stores. Given that the UNBS maximum allowable level for aflatoxins in animal feeds is 10 µg/kg, it is likely that a considerable fraction of the positive samples would exceed this threshold if quantitatively analyzed. Similar concerns were raised in previous compliance assessments by UNBS (2019–2023) and Nakavuma et al. (2020), which reported non-compliance among commercial feed producers

CHAPTER SIX:

CONCLUSION AND RECOMMENDATIONS

6.1. Limitations of the study

This study was limited by several factors that should be considered when interpreting the findings.

1. The analysis was qualitative, focusing on the presence or absence of aflatoxins using Thin Layer Chromatography (TLC). As a result, actual concentration levels of aflatoxins were not determined, which limited the ability to compare the results against regulatory thresholds.
2. The sample size was relatively small (60 samples) and limited to five divisions in Kampala, which, although representative of the city, may not fully reflect contamination trends in other parts of Uganda. While the purpose of the study was explained to store owners, some high-potential stores could not be sampled due to concerns that unfavorable results might harm their reputations.
3. The study covered only three months of manufacture (May, June, and July), which may not reflect contamination patterns across the entire year. Finally, due to resource and time constraints, advanced statistical analyses were not applied to test associations between variables such as feed type, manufacturing period, and contamination status.

Despite these limitations, the study provides valuable insights into the prevalence and distribution of aflatoxin contamination in Kampala feed stores and establishes a strong basis for future, more comprehensive investigations.

6.2. Conclusion

This study demonstrated that aflatoxin contamination in commercial animal feeds sold in Kampala is both widespread and variable, with an overall prevalence of 48.3%. The findings showed that poultry and dairy feeds were more prone to contamination than pig and fish feeds, reflecting the high reliance on maize and oilseed based formulations, which

are susceptible to fungal infestation. Contamination also varied by manufacturing period, with July samples recording the highest prevalence (80%), followed by June (45%) and May (35%). This seasonal trend indicates that contamination is influenced not only by storage but also by environmental and post-harvest handling factors during wetter months. Furthermore, the predominance of aflatoxin G (70%) over aflatoxin B (30%) underscores its significance as the main toxin of concern in Kampala's feed system. Collectively, these results confirm that aflatoxin remains a serious challenge to feed safety, livestock productivity, and ultimately public health in Uganda. Further study is therefore required to assess the extent of contamination in comparison to the current established limits.

Overall, the presence of aflatoxins in 48.3% of the analyzed feeds indicates probable non-compliance with the national safety limit of 10 µg/kg established by UNBS, thereby emphasizing the need for quantitative surveillance and enforcement of feed quality standards in Uganda

6.3. Recommendations

- i. A countrywide study on aflatoxin contamination in animal feeds should be conducted to establish national prevalence, regional variations, and value-chain vulnerabilities. This would provide a stronger evidence base for policy and regulation.
- ii. Future studies should employ quantitative methods such as High-Performance Liquid Chromatography (HPLC) or ELISA to determine actual aflatoxin concentration levels in feeds. This would allow comparison with national and international safety limits and provide clearer insight into the risks to livestock and human health.
- iii. Longitudinal studies should assess how rainfall patterns, harvest practices, and feed processing methods influence contamination over time. Such studies would help identify critical periods for intervention and inform strategies for managing aflatoxin risks during wet seasons.
- iv. Studies assessing compliance with UNBS standards and evaluating enforcement mechanisms are necessary to bridge the gap between regulations and practice. Policy-

focused research could also explore cost-effective interventions for smallholder feed processors.

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Appendices

Appendix 1: Photos of the researcher and sample handling during the study



Sample collection in the field



Sample recording in the laboratory



Sample weighing in the laboratory

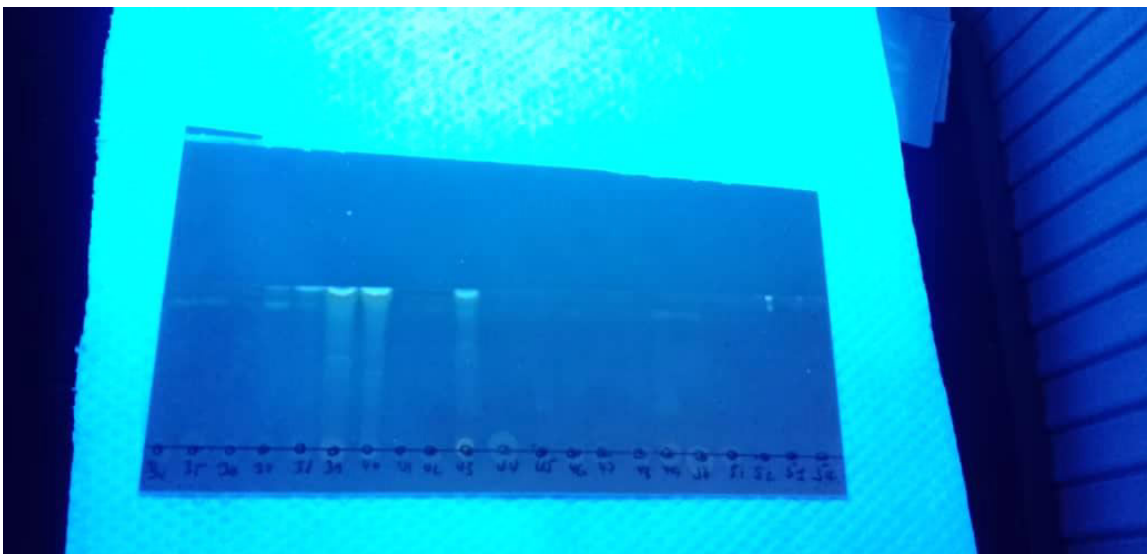


Photo of the TLC plate under UV light illuminator