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**PREVALENCE AND PREDISPOSING FACTORS OF AFLATOXIN
CONTAMINATION IN EXOTIC AND LOCAL EGGS SOLD IN
SHOPS ACROSS KAWEMPE DIVISION KAMPALA UGANDA**

BY

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DECLARATION AND APPROVAL

I, **Birungi Musa**, declare that this research report is mine and has never been presented to any academic institution of higher learning for the award of any academic qualification

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DEDICATION

I dedicate this research report to my loving family who supported me through my entire education period, the financial support, my Loving friends who have encouraged me, helped me and advised me throughout the entire process. I also dedicate it to my supervisor who has been my potential aid in all that I was able to do and write.

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TABLE OF CONTENTS

DECLARATION AND APPROVAL.....	i
DEDICATION	ii
ACKNOWLEDGEMENTS.....	iii
TABLE OF CONTENTS	iv
LIST OF TABLES	vii
LIST OF FIGURES	viii
LIST OF ABBREVIATIONS	ix
ABSTRACT.....	x
CHAPTER ONE	1
INTRODUCTION	1
1.1 Background	1
1.3 Research objectives.....	2
1.3.1 General objective	2
1.3.2 Specific objectives	2
1.4 Research questions.....	3
1.5 Justification	3
1.6 Significance	4
CHAPTER TWO	5
LITERATURE REVIEW	5
2.1 Aflatoxins and Their Classification	5
2.2 Mechanism of Action of Aflatoxin Toxicity	5
2.3 Factors Influencing Aflatoxin Production.....	6
2.3.1 Moisture	6
2.3.2 Storage Conditions.....	6
2.3.3 Contaminated Surfaces	7
2.4 Methods for Aflatoxin Analysis	7

2.4.1 Thin Layer Chromatography (TLC)	7
2.4.2 Radioimmunoassay	7
2.4.3 High-Performance Liquid Chromatography (HPLC)	8
2.4.4 Liquid Chromatography - Mass Spectrometry (LC–MS).....	8
CHAPTER THREE	9
MATERIALS AND METHODS	9
3.1 Study Design.....	9
3.2 Study Area.....	9
3.3 Sample size	9
3.4 Data collection	9
3.4.1 Questionnaire Administration	9
3.5 Sampling strategy and sample collection.....	10
3.6 Assessment of Aflatoxin Contamination.....	10
3.6.1 Aflatoxin extraction	10
3.6.2 TLC detection of Aflatoxins	10
3.7 Data and statistical analysis	11
3.8 Ethical considerations	11
3.9 Quality control	11
CHAPTER FOUR.....	12
RESULTS.....	12
4.1 Prevalence of aflatoxin contamination in local and exotic eggs.....	12
4.2 Distribution of aflatoxin-positive and negative samples	12
4.3 Socio-demographic characteristics of respondents.....	13
4.4 Association between selected factors and aflatoxin contamination.....	13
CHAPTER FIVE	15
DISCUSSION	15
CHAPTER SIX.....	18

CONCLUSIONS AND RECOMMENDATIONS	18
REFERENCES	20
APPENDICES	25
Appendix 1: Questionnaire	25
Section 4: Risk Reduction Practices	29
Appendix 1: Consent form.....	31

LIST OF TABLES

Table 1: Prevalence of aflatoxin contamination according to egg type	12
Table 2: Socio-demographic characteristics of respondents	13
Table 3: Association between selected predisposing factors and aflatoxin contamination in eggs	14

LIST OF FIGURES

Figure 1: Distribution of aflatoxin-positive and negative samples.....	12
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LIST OF ABBREVIATIONS

AFB1	Aflatoxin B1
AFB2	Aflatoxin B2
AFM1	Aflatoxin M1
AFM2	Aflatoxin M2
DNA	Deoxyribonucleic acid
FDA	Food and Drug Administration
SPSS	Statistical Package for the Social Sciences
TLC	Thin Layer Chromatography
UNBS	Uganda National Bureau of Statistics
WHO	World Health Organization

ABSTRACT

Aflatoxins are toxic mycotoxins produced mainly by *Aspergillus* species and are important food-safety hazards because of their carcinogenic and other adverse health effects. Eggs are widely consumed as an affordable source of animal protein, yet limited information exists on aflatoxin contamination of eggs sold in urban retail markets in Uganda. This study determined the prevalence of aflatoxin contamination and assessed selected predisposing factors associated with contamination of local and exotic eggs sold in shops across Kawempe Division, Kampala, Uganda.

A cross-sectional study was conducted using 60 egg samples, comprising 30 local and 30 exotic eggs, collected from shops in Bwaise, Kikoni and Kalerwe markets. Thirty egg retailers were also interviewed using structured questionnaires to obtain information on socio-demographic characteristics, sourcing, storage and handling practices. Aflatoxins were extracted using 70% methanol and detected by thin-layer chromatography under ultraviolet light at 366 nm. Data were analysed using SPSS, and chi-square tests were used to determine associations between selected predisposing factors and aflatoxin contamination at a significance level of $p < 0.05$.

Aflatoxin contamination was detected in 11 (18.3%) of the 60 samples. Local eggs had a higher prevalence of contamination (7/30, 23.3%) than exotic eggs (4/30, 13.3%), although egg type was not significantly associated with contamination ($\chi^2 = 1.176$, $p = 0.278$). Most assessed factors, including egg source, storage duration, storage method, inspection for spoilage, storage-area hygiene, reuse of trays, separation of damaged eggs, stock rotation and procurement records, were not significantly associated with contamination. However, mould or dampness in the storage area was significantly associated with aflatoxin contamination ($\chi^2 = 4.516$, $p = 0.034$), while exposure to heat or direct sunlight showed a relatively stronger but non-significant association ($X^2 = 2.986$, $p = 0.084$).

The study concludes that aflatoxin contamination occurs in both local and exotic eggs sold in Kawempe Division, with mould or dampness in storage areas representing an important associated factor. The findings support strengthened food-safety surveillance, improved storage conditions and retailer education, alongside further studies using larger samples, quantitative aflatoxin analysis and assessment of contamination in poultry feeds to clarify contamination pathways and potential consumer exposure.

CHAPTER ONE

INTRODUCTION

1.1 Background

Aflatoxins are naturally occurring mycotoxins produced primarily by *Aspergillus flavus* and *Aspergillus parasiticus*, commonly found in improperly stored grains and feed ingredients (Schrenk et al., 2020). Among the various aflatoxins, aflatoxin B1 (AFB1) is the most potent and frequently detected in poultry feeds (Sarker *et al.*, 2023). The main subtypes of aflatoxins include B (1 and 2), G (1 and 2) which can synthesize aflatoxin M1 and M2 respectively, however Aflatoxin B1 remains the most prevalent in foods posing significant health risks to consumers (Schrenk *et al.*, 2020). Following ingestion by poultry, AFB1 undergoes hepatic biotransformation to aflatoxin M1 (AFM1), which can be transferred to animal-derived products including milk and eggs. Although extensive research has focused on aflatoxin contamination in feed and tissues such as liver and kidneys, evidence on contamination in eggs remains inconsistent (Herzallah, 2009). Existing variability is largely attributed to differences in feed quality, on-farm storage practices, environmental fungal burden, and production systems (Fakhri *et al.*, 2025).

There is an increasing concern about food safety and human exposure to aflatoxins through animal products across the globe, especially in regions where regulation of feed quality and storage conditions is weak resulting in to an increasing incidence of non-communicable diseases (Ladeira et al., 2017). Studies have attributed this to a number of factors including but not limited to increased drug use, lifestyles and consumption of various foodstuffs contaminated with hazardous chemicals. Poor Agricultural practices like poor food storage contributes a lot to the above which greatly favor the growth of molds in the foods. Eggs are widely consumed, affordable, and nutritionally important, making contamination a significant public health risk (Pal & Molnár, 2021). Commercial poultry systems (exotic breeds) and traditional backyard systems (local breeds) differ substantially in feeding practices, storage facilities, husbandry, and supply chain characteristics, potentially influencing aflatoxin contamination levels (Kipng' & Tarus, 2019). However, a systematic comparison of aflatoxin prevalence in eggs sourced from exotic versus local production systems remains scarce (Fakhri et al., 2021).

In Uganda, aflatoxin contamination levels seem to vary according to the food stuff for example groundnuts -2000ppb, cassava -30ppb, silverfish -32ppb, maize -701ppb (Gaizi & Muzoora, 2023). The recommended limit of aflatoxins in food in Uganda is 10 ppb set by Uganda National Bureau of Statistics (UNBS). Due to high prevalence of aflatoxin in agricultural feeds and feed ingredients such as milk in Uganda, a high-risk carryover of the toxins into animal products such as milk for human consumption exists. This comparative study is meant to assess the prevalence and predisposing factors of Aflatoxin contamination in local and exotic eggs sold in shops around Kawempe Division in Kampala District, Central Uganda.

1.2. Problem statement

Aflatoxins are associated with major health effects especially Aflatoxin B1 which has been identified as a carcinogen (Li et al., 2022). There has been an increase in the cases of liver disease, stunted growth experienced in children in Uganda, immunosuppression and possible cases of cancer over the past decades and majority of them have been linked to Aflatoxin contamination of foods grown locally and those processed from food processing plants (Chibuike Ogo & Chinyere Ugbogu, 2016). Uganda experiences many new cases of Aflatoxin related cancer and Aflatoxicosis every year due to inadequate understanding of Aflatoxin contamination levels, limited knowledge of climate and agricultural factors influencing aflatoxin production, ineffective detection and monitoring methods and insufficient evidence-based mitigation strategies (Meijer et al., 2021). Despite increased awareness of mycotoxin contamination in the food chain, limited systematic evidence exists on the burden of aflatoxin contamination specifically in both local and exotic eggs sold across different shops in Kawempe division Kampala

1.3 Research objectives

1.3.1 General objective

To determine the prevalence and predisposing factors of aflatoxin contamination in eggs sold in shops across Kawempe division Kampala Uganda.

1.3.2 Specific objectives

- i. To determine the prevalence of aflatoxin contamination of local and exotic eggs in shops across Kawempe Division Kampala, Uganda.

- ii. To assess the predisposing factors to aflatoxin contamination and their association with the occurrence of aflatoxins in local and exotic eggs sold in shops across Kawempe Division, Kampala Uganda.

1.4 Research questions

1. What is the prevalence of aflatoxin contamination of local and exotic eggs in shops across Kawempe Division Kampala, Uganda?
2. What predisposing factors and socio-demographics are associated with aflatoxin contamination of local and exotic eggs sold in retail shops across Kawempe Division?

1.5 Justification

Aflatoxin contamination remains a persistent public health and food-safety concern in Uganda, particularly within urban and peri-urban food systems where regulatory oversight is often limited. Eggs, a widely consumed source of affordable animal protein, may serve as a potential vehicle for aflatoxin exposure when poultry birds ingest contaminated feed. While several studies within the country have focused on aflatoxin levels in grains and animal feed, there is limited empirical evidence regarding contamination in eggs, especially comparing exotic and local varieties sold in informal and semi-formal markets (Abdulhakfm, 2014). Kawempe Division characterized by dense population, high poultry product demand, and diverse retail outlets presents a strategic setting for investigating this public health risk (Abdulhakfm, 2014).

This study is justified by the growing concern over dietary exposure to aflatoxins and the possible implications for human health, including immunosuppression, carcinogenicity, and impaired child growth. Urban consumers often assume eggs to be inherently safe, yet the contamination risk remains unknown given the documented presence of aflatoxins in poultry feeds and resulting carry-over into eggs (Kipng' & Tarus, 2019). Understanding the prevalence of aflatoxin contamination in both exotic and local eggs provides evidence needed to inform food safety policies, consumer protection strategies, and targeted interventions in the poultry value chain.

1.6 Significance

The findings from this study were of substantial value to multiple stakeholders across Uganda's food system. First, the study provided baseline data on the prevalence of aflatoxins in exotic and local eggs sold in Kawempe Division, an area with high egg consumption and rapid market turnover. Such data are currently scarce, despite growing concern about the safety of poultry products.

Second, by identifying the predisposing factors associated with contamination such as feed quality, storage conditions, environmental factors, and handling practices, the study helped stakeholders identify critical control points where interventions can be most effective. Poultry farmers, feed producers, traders, and retailers benefited from these insights, enabling them to adopt improved practices that reduce contamination risks.

Third, the work supported public health authorities in developing evidence-based guidelines and risk-communication strategies to protect consumers from chronic aflatoxin exposure. The Ministry of Health, KCCA, and the Uganda National Bureau of Standards (UNBS) may utilize the findings to strengthen monitoring systems and enforce food-safety standards (Kankya et al., 2020.).

CHAPTER TWO

LITERATURE REVIEW

2.1 Aflatoxins and Their Classification

Aflatoxins are toxic secondary metabolites produced predominantly by specific *Aspergillus* species, most notably *Aspergillus flavus* and *Aspergillus parasiticus* (Benkerroum, 2020). These naturally occurring mycotoxins frequently contaminate a variety of food crops such as cereals, nuts, and spices, particularly in hot and humid regions. Among all identified aflatoxins, aflatoxin B1 is recognized as the most widespread and the most harmful. Due to their high toxicity and carcinogenic potential, aflatoxins pose serious threats to public health and agricultural productivity. Research has demonstrated that long-term exposure even at low levels commonly found in contaminated staple foods heightens the likelihood of liver cancer, immunosuppression (Chibuike Ogo & Chinyere Ugbogu, 2016) and impaired growth in children. A historical example includes the Turkey-X disease outbreak in England, which was linked to Brazilian peanut meal and ultimately led to the discovery of aflatoxins, marking a major advancement in modern mycology approximately twenty-six years ago.

Aflatoxins are grouped into various categories based on their structural characteristics and fluorescence under ultraviolet light. The principal types include: Aflatoxin B1 and B2, the most toxic variants strongly associated with liver carcinogenesis, commonly found in grains and known for intense fluorescence B1 being the most predominant in food products. Aflatoxin M1 and M2 are metabolic derivatives that appear in the milk of animals exposed to contaminated feed, posing considerable risks to infants and young children (Theses & Spencer Smith, 2017).

2.2 Mechanism of Action of Aflatoxin Toxicity

Most aflatoxins exert toxic effects through similar biochemical mechanisms, with aflatoxin B1 (AFB1) recognized as the most potent hepatocarcinogen. The toxic action of AFB1 is largely dependent on its metabolic activation and its subsequent interaction with DNA, which alters the DNA structure and triggers mutagenic processes. Once ingested, aflatoxins are metabolized in the liver by cytochrome P450 enzymes into reactive intermediates such as AF-8,9-epoxide, which binds to DNA and serum albumin, causing molecular damage (Mart *et al.*, 2023). Specifically, the metabolism of AFB1 produces the highly

reactive AFB1-8,9-epoxide, which forms covalent bonds with the N-7 position of guanine bases in DNA. This leads to depurination, DNA strand instability, and ultimately carcinogenesis (Wang & Groopman, 2019) . The attachment of this epoxide results in mutagenic DNA adducts such as AFB–E–deoxyguanosine and AFB–formamidopyrimidine (AFB–FaPy–dG).

Exposure to elevated levels of aflatoxins during pregnancy in humans or animals can disrupt fetal development, causing adverse outcomes such as weight loss and miscarriages (Smith *et al.*, 2017). Aflatoxins are further linked to impaired immune function, increasing vulnerability to infections and diminishing the effectiveness of vaccinations (Saha Turna *et al.*, 2024). AFB1 mainly suppresses cell-mediated immunity more than humoral responses by reducing lymphoid cell populations and hindering lymphoblast formation. The immunosuppressive effects of AFB1 and other mycotoxins generally arise from oxidative stress, apoptosis, and autophagy of immune cells, as well as interference with immune-related signaling pathways (Ren *et al.*, 2020.).

2.3 Factors Influencing Aflatoxin Production

Aflatoxin production is shaped by numerous environmental, climatic, and agricultural factors that determine fungal growth and the extent of contamination.

2.3.1 Moisture

In many tropical and subtropical regions eggs and other foodstuffs are often stored under damp conditions. This is a major contributor to aflatoxin development, especially where farmers lack sufficient knowledge, tools, and facilities for proper drying. High humidity and moisture content above 13-14% create favorable conditions for fungal proliferation and toxin formation (Mannaa & Kim, 2017). Proper storage of eggs in moisture-free environment immediately after collection is critical in reducing moisture levels and preventing aflatoxin buildup.

2.3.2 Storage Conditions

Aflatoxins can develop not only in improperly stored eggs and other foodstuffs but also in in proper storage under unsuitable conditions. Poor storage environments characterized by warm temperatures and high humidity encourage fungal growth and toxin production. Maintaining cool, dry, and well-ventilated storage facilities is essential (Kobia, 2022).

Techniques such as vacuum sealing or controlled-atmosphere storage can further limit contamination by reducing oxygen availability, which is necessary for fungal metabolism

2.3.3 Contaminated Surfaces

Contaminated tools, surfaces, or storage containers can act as sources of aflatoxin-producing fungi, facilitating cross-contamination of fresh produce. Once contaminated eggs enter the food chain, aflatoxins may appear in food products consumed by humans and animals. Livestock fed contaminated feed may transfer aflatoxin metabolites into eggs, milk, and meat (Peles *et al.*, 2019). In poultry, contamination can be particularly high in edible products. For this reason, strict sanitation and hygiene practices in handling equipment and storage areas are crucial preventive measures.

2.4 Methods for Aflatoxin Analysis

Reliable detection of aflatoxins is essential to ensure food and feed safety. Various analytical technologies are used to measure aflatoxin levels, generally categorized into chromatographic, immunological, and spectrophotometric techniques. Commonly applied methods include high-performance liquid chromatography, thin-layer chromatography, and radioimmunoassay.

2.4.1 Thin Layer Chromatography (TLC)

Thin-layer chromatography (TLC) is a cost-effective, sensitive, and relatively simple analytical tool widely used for aflatoxin detection, especially in low-resource laboratories. The technique employs a silica-coated plate as the stationary phase and a solvent mixture as the mobile phase, enabling the separation of aflatoxins, which are later visualized under UV light (Bele *et al.*, 2011). This separation is governed by the chemical interactions between the stationary phase and the solvent system. Although less sensitive than more advanced technologies, TLC remains a common technique for preliminary screenings and routine quality control analyses (Coman & Herghelegiu, 2025).

2.4.2 Radioimmunoassay

Radioimmunoassay relies on radioactively labeled molecules to detect aflatoxins with high levels of specificity and sensitivity. Despite their accuracy, the requirement for specialized laboratory infrastructure and trained personnel restricts their use in many regions (Chu, 2004).

2.4.3 High-Performance Liquid Chromatography (HPLC)

HPLC is a highly precise and widely adopted method for the quantitative analysis of aflatoxins (Karabat *et al.*, 2023). It separates compounds in a chromatographic column and uses ultraviolet or fluorescence detectors to identify and quantify aflatoxins with high accuracy. However, this method is more costly and resource-intensive compared to TLC.

2.4.4 Liquid Chromatography - Mass Spectrometry (LC-MS)

LC-MS integrates the separation capability of liquid chromatography with the high sensitivity of mass spectrometry, making it one of the most advanced techniques for aflatoxin detection (Donato *et al.*, 2012). It allows detailed quantification and identification of different aflatoxin types, though its complexity and high operational cost mean it is typically limited.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Design

A cross-sectional study design was used to assess the prevalence of aflatoxin contamination in eggs samples collected from various vendors in Kawempe division. Aflatoxin occurrence in eggs was assessed. Predisposing factors for aflatoxin occurrence was also assessed by collecting sociodemographic data and storage conditions information using questionnaires.

3.2 Study Area

The study was conducted in Kawempe division, of Kampala District in the Central region of Uganda. Respondents were selected from Bwaise, Kikoni and Kalerwe markets all found within the same division. These areas were selected because they are the major markets attended by the general population in and around Kawempe Division. Both local and exotic eggs will be collected from the shops in these markets.

3.3 Sample size

The sample size was estimated using the central limit theorem, which states that the sampling distribution of the mean will always be normally distributed, as long as the sample size is large enough regardless of whether the population is distributed in any way.

The central limiting there holds when $n \geq 30$

Therefore, sixty (60) egg samples 30 local eggs and 30 exotic eggs were collected from the shops in Bwaise, Kikoni and Kalerwe and also 30 questionnaires were distributed and filled.

3.4 Data collection

3.4.1 Questionnaire Administration

Thirty structured questionnaires were administered to each of the thirty (30) market vendors to gather respondents' sociodemographic data, sourcing, storage and handling practices of eggs.

3.5 Sampling strategy and sample collection

The respondents who sell both exotic and local eggs in the markets were randomly selected from the study area. Samples of both exotic and local eggs were collected in clean well aerated containers, from different retail shops, labelled with a laboratory number, sample identification number. The samples were brought to the Analytical Biosciences Laboratory in the College of Veterinary Medicine Animal Resources and Biosecurity of Makerere University, and stored in a refrigerator at 4°C before analysis.

3.6 Assessment of Aflatoxin Contamination

3.6.1 Aflatoxin extraction

Twenty-five milliliters (25ml) of egg suspension 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 filtered with cotton into another labelled clean conical flask. To the filtrate was added 5 ml of distilled water followed by 10 ml of chloroform in the ratio of 1:2 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 bijoux bottle and stored in at a temperature of -20°C until analysis.

3.6.2 TLC detection of Aflatoxins

The samples were screened using TLC (Thin Layer Chromatography) to screen for aflatoxins presence in the egg samples. 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 translated onto the TLC plate. 10ul of the sample was spotted on the plate and allowed to air dry. The plate was 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. The results were recorded as positive or negative with a plus (+) to indicate presence of aflatoxins with high number of plus indicating high intensity in contamination levels, while a minus (-) indicated absence of aflatoxins. A blue band indicated presence of Aflatoxin B while a green band indicated the presence of Aflatoxin G.

3.7 Data and statistical analysis

This involved three critical steps that included summarizing data, editing the data and finally data and statistical analysis. The aflatoxin occurrence data was transferred into an MS Excel sheet and graphs will be plotted to represent the different levels of aflatoxins in the samples. The data was then analyzed using Chi-squared test in SPSS to evaluate the association between predisposing factors and presence of aflatoxins. All associations with $p < 0.05$ was considered significant.

3.8 Ethical considerations

Informed consent and confidentiality of information were the priority in the research following submission of consent forms and introductory letters to the authorities in Kawempe division local council offices before collection of samples. Health and Safety, accuracy and transparency of the study will be stated clearly before conducting it to prevent environmental impact thus minimizing environmental contamination. The names of the specific traders and sample sources were replaced with new laboratory identification numbers; the same were applied during publication of results to protect the manufacturer and the consumers.

3.9 Quality control

Random selection of samples from different batches were carried out to ensure consistency in quality and aflatoxin levels. Use of aflatoxin standards and certified methods such as standard operating procedures will be followed during each process from sample collection to data analysis for accurate detection. Sterile collection containers were used to avoid contamination of samples, calibration and validation, record keeping and documentation were carried out to ensure reliable results.

CHAPTER FOUR

RESULTS

4.1 Prevalence of aflatoxin contamination in local and exotic eggs

The results indicate that 11 (18.3%) of the 60 egg samples tested positive for aflatoxin contamination, while 49 (81.7%) tested negative. The proportion of positive samples was higher among local eggs, where 7 (23.3%) were positive, compared with 4 (13.3%) among exotic eggs. Thus, local eggs demonstrated a comparatively higher occurrence of aflatoxin contamination than exotic eggs

Table 1: Prevalence of aflatoxin contamination according to egg type

Egg type	Positive, n (%)	Negative, n (%)	Total, n (%)
Local eggs	7 (23.3)	23 (76.7)	30 (50.0)
Exotic eggs	4 (13.3)	26 (86.7)	30 (50.0)
Total	11 (18.3)	49 (81.7)	60 (100.0)

4.2 Distribution of aflatoxin-positive and negative samples

The results indicate that 23.33% of the local egg samples and 13.33% of the exotic egg samples were positive for aflatoxin contamination, while 76.66% local and 86.67% of the exotic egg samples were negative. Thus, positive samples constituted a smaller proportion of the total samples in both egg categories. However, the greater number of positive local samples suggests a comparatively higher occurrence of contamination among local eggs.

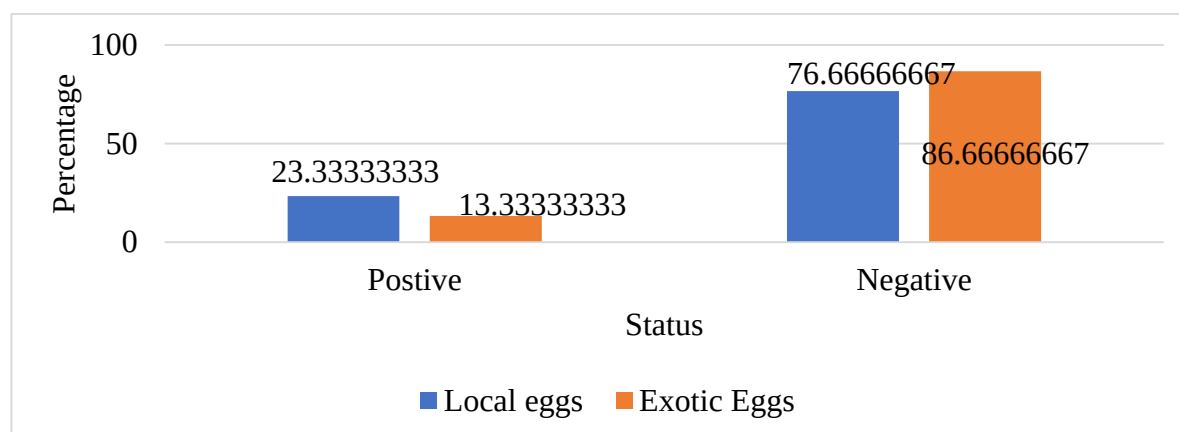


Figure 1: Distribution of aflatoxin-positive and negative samples

4.3 Socio-demographic characteristics of respondents

A total of 30 respondents participated in the questionnaire component of the study. The respondents were predominantly male (60.0%), while females accounted for 40.0%. The largest proportion of respondents was aged 26-35 years (40.0%). Regarding education, secondary education was the most frequently reported level (43.3%), followed by tertiary education (26.7%). Most respondents had operated their shops for between one and three years (33.3%). This indicates that the egg retailing respondents were largely young-to-middle-aged adults with at least some formal education and moderate experience in retail operations.

Table 2: Socio-demographic characteristics of respondents

Variable	Category	Frequency (n)	Percentage (%)
Sex	Male	18	60.0
	Female	12	40.0
Age	18-25 years	5	16.7
	26-35 years	12	40.0
	36-45 years	8	26.7
	46 years and above	5	16.7
	No formal education	2	6.7
Education	Primary	7	23.3
	Secondary	13	43.3
	Tertiary	8	26.7
Duration of shop operation	Less than 1 year	4	13.3
	1-3 years	10	33.3
	3-5 years	8	26.7
	Above 5 years	8	26.7

4.4 Association between selected factors and aflatoxin contamination

The table shows that most of the assessed predisposing factors were not significantly associated with aflatoxin contamination ($p > 0.05$). Local eggs had a higher proportion of positive samples (23.3%) than exotic eggs (13.3%), while contamination varied across the different sources and storage practices. Exposure to heat or direct sunlight showed a relatively stronger association with contamination ($\chi^2 = 2.986$, $p = 0.084$), although this

was not statistically significant. However, the presence of mould or dampness in the storage area was significantly associated with aflatoxin contamination ($\chi^2 = 4.516$, $p = 0.034$), suggesting that poor storage conditions may increase the likelihood of contamination.

Table 3: Association between selected predisposing factors and aflatoxin contamination in eggs

Independent variable	Category	Positive, n (%)	Negative, n (%)	Chi-square (χ^2)	p-value
Egg type	Local eggs	7 (23.3)	23 (76.7)	1.176	0.278
	Exotic eggs	4 (13.3)	26 (86.7)		
Source of eggs	Bwaise	5 (25.0)	15 (75.0)	3.421	0.319
	Kalerwe	4 (20.0)	16 (80.0)		
	Kikoni	2 (10.0)	18 (90.0)		
Storage duration	Less than 3 days	2 (10.0)	18 (90.0)	2.947	0.400
	3–7 days	5 (25.0)	15 (75.0)		
	More than 7 days	4 (20.0)	16 (80.0)		
Storage method	Open shelf	4 (20.0)	16 (80.0)	4.126	0.248
	Covered container/shelf	3 (15.0)	17 (85.0)		
	Refrigerator	1 (10.0)	9 (90.0)		
	Other method	3 (30.0)	7 (70.0)		
Exposure to heat/direct sunlight	Yes	7 (28.0)	18 (72.0)	2.986	0.084
	No	4 (11.4)	31 (88.6)		
Inspection for spoilage	Yes	3 (13.6)	19 (86.4)	1.835	0.175
	No	8 (21.1)	30 (78.9)		
Storage-area hygiene	Very good	1 (10.0)	9 (90.0)	3.274	0.352
	Good	3 (15.0)	17 (85.0)		
	Fair	5 (25.0)	15 (75.0)		
	Poor	2 (20.0)	8 (80.0)		
Mould/dampness in storage area	Yes	7 (35.0)	13 (65.0)	4.516	0.034
	No	4 (10.0)	36 (90.0)		
Reuse of egg trays	Yes	7 (21.2)	26 (78.8)	2.618	0.106
	No	4 (14.8)	23 (85.2)		
Separation of damaged eggs	Yes	3 (13.0)	20 (87.0)	1.927	0.165
	No	8 (21.6)	29 (78.4)		
Stock rotation	Yes	2 (28.6)	5 (71.4)	1.762	0.184
	No	9 (17.0)	44 (83.0)		
Supplier/procurement records	Yes	4 (26.7)	11 (73.3)	0.946	0.622
	No	7 (15.6)	38 (84.4)		

CHAPTER FIVE

DISCUSSION

The study found that 11 (18.3%) of the 60 egg samples tested positive for aflatoxin contamination, while 49 (81.7%) were negative. Local eggs had a higher proportion of contamination, with 7 (23.3%) positive samples, compared with 4 (13.3%) among exotic eggs. This finding is comparable to evidence from a global systematic review and meta-analysis, which reported an overall aflatoxin prevalence of 20.15% in birds' eggs, suggesting that the 18.3% prevalence observed in the present study is within the range reported internationally (Fakhri *et al.*, 2021). A more recent global meta-analysis similarly estimated pooled aflatoxin prevalence in domestic bird eggs at 17.56%, which is remarkably close to the prevalence observed in this study. The presence of aflatoxin in nearly one-fifth of the sampled eggs may reflect carry-over of aflatoxin or its metabolites from contaminated poultry feed into edible animal products, particularly where feed quality control and storage are inadequate. (Peles *et al.*, 2019) explained that livestock and poultry consuming contaminated feed may channel aflatoxins into food products, including eggs. The observed prevalence therefore indicates that eggs sold in Kawempe Division cannot be assumed to be free from aflatoxin contamination and highlights the importance of monitoring both poultry feed and animal-derived foods within the food chain.

The higher contamination observed in local eggs (23.3%) than in exotic eggs (13.3%) suggests that the production system may influence exposure to aflatoxin, although the difference was not statistically significant ($X^2 = 1.176$, $p = 0.278$). Similar concerns have been reported in studies of indigenous poultry production in Western Kenya, where aflatoxin contamination has been investigated in eggs and other tissues from indigenous chickens (Tarus *et al.*, 2019). However, the absence of a statistically significant association in the present study indicates that egg type alone may not adequately explain contamination. Differences between local and exotic eggs may instead arise from variation in feed sources, feed storage, husbandry systems, environmental exposure and supply chains. (Kipng' and Tarus 2019) similarly highlighted differences in production systems, feeding practices and management conditions as potential determinants of aflatoxin exposure in poultry products. The slightly higher contamination among local eggs therefore warrants attention but should not be interpreted as evidence that local eggs are inherently more susceptible to aflatoxin contamination. The implication is that interventions should

focus on the production and supply-chain conditions affecting both egg categories rather than targeting one egg type exclusively.

The study also found that most of the assessed handling, storage and procurement factors were not statistically associated with aflatoxin contamination. Egg source, storage duration, storage method, inspection for spoilage, storage-area hygiene, reuse of egg trays, separation of damaged eggs, stock rotation and supplier or procurement records all had p-values greater than 0.05. This pattern differs from evidence showing that environmental and storage conditions are important determinants of fungal growth and mycotoxin production. (Mannaa and Kim 2017) reported that temperature and water activity strongly influence fungal proliferation and mycotoxin production, while (Meijer *et al.*, 2021) emphasized the importance of environmental and agricultural conditions in determining aflatoxin contamination across Africa. The lack of significant associations in this study may partly be explained by the relatively small sample size of 60 eggs and the cross-sectional nature of the investigation, which may have limited the statistical power to detect modest associations. In addition, questionnaire-derived information on handling and storage practices may not fully capture actual environmental exposure over the entire period preceding sample collection. The implication is that non-significant statistical findings should not necessarily be interpreted as evidence that these practices have no biological relevance; rather, larger studies incorporating direct measurements of temperature, humidity, feed contamination and storage conditions would provide stronger evidence.

Exposure of eggs to heat or direct sunlight showed a relatively stronger relationship with aflatoxin contamination than several of the other assessed factors, although the association did not reach statistical significance ($X^2 = 2.986$, $p = 0.084$). This finding is biologically plausible because environmental conditions involving elevated temperature and moisture can influence fungal growth and subsequent mycotoxin production. (Mannaa and Kim 2017) demonstrated that temperature and water activity are important determinants of fungal development and mycotoxin production. Similarly, (Kobia 2022) reported that unsuitable storage environments characterized by unfavorable temperature and humidity conditions can promote mould development and aflatoxin contamination. The relatively low p-value observed for direct heat or sunlight exposure may therefore indicate a potential relationship that could become statistically evident in a larger sample. However, direct sunlight exposure should be interpreted cautiously because the present study did not

quantify temperature, humidity or duration of exposure. The implication is that retail egg storage should nevertheless minimize prolonged exposure to adverse environmental conditions, while future investigations should incorporate objective measurements of storage temperature and humidity.

A statistically significant association was observed between the presence of mould or dampness in the storage area and aflatoxin contamination ($X^2 = 4.516$, $p = 0.034$). This was the only assessed predisposing factor that demonstrated statistical significance at the 5% level. The finding is consistent with established evidence that moisture and environmental conditions conducive to fungal growth are important determinants of aflatoxin occurrence. (Mannaa and Kim 2017) reported that increased water activity and favorable environmental conditions promote the growth of toxigenic fungi and mycotoxin production, while (Kobia 2022) similarly identified poor storage environments and mould contamination as important food-safety concerns. The association observed in the present study may be explained by the fact that damp environments provide favorable conditions for fungal persistence and proliferation, increasing the probability of contamination of food-contact surfaces and products. (Peles *et al.*, 2019) further noted that contaminated surfaces and storage materials can facilitate the movement of aflatoxin-producing fungi within the food chain. The implication is that controlling dampness and mould in egg-storage premises represents a practical critical control point for reducing aflatoxin exposure and should be emphasized in food-safety inspections and retailer education.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The study established that aflatoxin contamination occurred in 18.3% of the 60 egg samples examined in Kawempe Division. Local eggs had a higher contamination prevalence (23.3%) than exotic eggs (13.3%), although the difference was not statistically significant. Most assessed handling, storage and procurement factors were not significantly associated with contamination. However, mould or dampness in storage areas was significantly associated with aflatoxin contamination ($X^2 = 4.516$, $p = 0.034$). The findings demonstrate that environmental conditions within egg-storage facilities may contribute to contamination. The occurrence of aflatoxins in both local and exotic eggs indicates a potential food-safety concern for consumers. Since aflatoxins are important foodborne hazards with established toxic and carcinogenic effects, their presence in commonly consumed foods warrants appropriate control measures. Overall, the study provides evidence supporting improved monitoring of eggs and conditions along the poultry food chain in Kawempe Division

6.2 Recommendations

- i. Kampala Capital City Authority, Uganda National Bureau of Standards and other relevant food-safety authorities should strengthen routine surveillance of aflatoxin contamination in eggs and poultry products sold within urban markets. Particular attention should be given to retail premises with visible mould or dampness because this factor showed a statistically significant association with contamination in the present study. Regular inspection and enforcement of appropriate storage conditions should therefore be incorporated into food-safety monitoring programmes.
- ii. Egg retailers should maintain clean, dry and well-ventilated storage areas and promptly address sources of dampness or mould. Retailers should also receive practical training on appropriate egg handling, storage and stock management to minimize conditions that may facilitate contamination. Such measures are consistent with established food-safety guidance emphasizing dry and appropriate

storage as an important measure for reducing mould growth and mycotoxin production.

- iii. Further studies should be conducted using larger sample sizes and more sensitive quantitative analytical methods to determine the concentration and specific types of aflatoxins present in eggs. Future investigations should also assess aflatoxin levels in poultry feeds from the same supply chains and directly measure storage temperature and humidity. This would provide stronger evidence on the pathways contributing to contamination and enable more precise assessment of potential consumer exposure.

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APPENDICES

Appendix 1: Questionnaire

Questionnaire on Predisposing Factors and Socio-Demographics Associated with Aflatoxin Contamination of Local and Exotic Eggs Sold in Retail Shops Across Kawempe Division

This questionnaire is designed to support field data collection using face-to-face interviews. Participants should be informed about the purpose of the study, confidentiality of responses, and the need to answer all questions to the best of their ability.

Section A: Demographic Information

1. What is your sex?

☐

Male

☐

Female

2. What is your age range?

☐

18–25

☐

26–35

☐

36–45

☐

46 and above

3. What is your highest level of education

☐

No formal education

☐

Primary

☐

Secondary

☐

Tertiary

4. How long have you been operating this retail shop

☐ Less than 1 year

☐ 1–3 years

☐ 3–5 years

☐ Above 5 years

Section 2: Egg Handling and Storage Practices

1. What type of eggs do you commonly sell?

☐ Local eggs

☐ Exotic eggs

☐ Both

2. Where do you commonly purchase your eggs?

☐ Wholesalers

☐ Farmers

☐ Markets

☐ Other (specify).....

3. On average, how many trays of eggs do you procure per batch?

☐ 1–5 trays

☐ 6–10 trays

☐ 11–20 trays

☐ More than 20 trays

4. How long do eggs typically stay in your shop before being sold?

☐ Less than 3 days

☐ 3–7 days

☐ 1–2 weeks

☐ More than 2 weeks

5. How do you store eggs in your shop?

☐ Open shelf

☐ Covered shelf

☐ Refrigerated storage

☐ Other (specify):

6. Are eggs exposed to heat or direct sunlight in your shop?

☐ Yes

☐ No

7. Do you inspect eggs for spoilage before display?

☐ Yes

☐ No

Section 3: Predisposing Environmental and Handling Factors

1. What are the general hygiene conditions of your storage area?

☐ Very good

☐ Good

☐ Fair

☐ Poor

2. Do you clean the egg storage area regularly?

☐ Daily

☐ Weekly

☐ Occasionally

☐ Never

3. Have you noticed mold or dampness in the storage area?

☐ Yes

☐ No

4. Do you reuse egg trays?

☐ Yes

☐ No

5. If yes, how often do you clean or disinfect them?

☐ Never

☐ Occasionally

☐ Regularly

6. Do you separate damaged/cracked eggs from the rest?

☐ Yes

☐ No

Section 4: Risk Reduction Practices

1. Do you monitor the quality of eggs when receiving them from suppliers?

☐ Always

☐ Sometimes

☐ Rarely

☐ Never

2. Do you reject trays with visibly poor-quality or cracked eggs?

☐ Yes

☐ No

3. Do you rotate egg stock (first-in, first-out)?

☐ Yes

☐ No

4. Do you keep records of egg suppliers or procurement batches?

☐

Yes

☐

No

END

Appendix 1: Consent form

I..... voluntarily agree to participate in this research study. I understand that my response will be kept confidential and anonymous.

Participants name.....

Participants signature.....

Date.....

Researchers name.....

Researchers signature.....

