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(Review Article)

Impact of Aflatoxin on food security, health, and economics in Kenyan Peanuts: A Systematic Review

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Abstract

Aflatoxin contamination presents a significant threat to food security and public health in Kenya, particularly in relation to Arachis hypogaea (peanuts), a staple source of protein and income for many households. This systematic review examines the multifaceted issues associated with aflatoxins in peanuts, encompassing their nutritional benefits, health risks, and economic ramifications. Aflatoxins, toxic metabolites produced by fungi such as Aspergillus flavus, jeopardize human health, contributing to conditions like aflatoxicosis and liver cancer, particularly affecting vulnerable populations. In Kenya, the prevalence of aflatoxin contamination in peanuts is exacerbated by high humidity and inadequate post-harvest practices, leading to diminished product quality and significant health hazards. Despite regulatory measures, such as the maximum allowable aflatoxin levels established by the Kenya Bureau of Standards, many contaminated products continue to enter the market, highlighting gaps in enforcement. The economic burden of aflatoxin contamination is profound, with losses attributed to health care costs, decreased productivity, and rejected crop sales, particularly impacting smallholder farmers. It is estimated that the agricultural sector incurs billions in losses, emphasizing the urgent need for effective educational initiatives and improved agricultural practices. Through a comprehensive analysis of existing literature, this review emphasizes the importance of enhancing public awareness and implementing robust food safety measures to mitigate aflatoxin risks. Ultimately, addressing these challenges is critical to improving nutritional outcomes, safeguarding health, and promoting economic stability in Kenya's agricultural landscape.

Keywords: Arachis hypogaea; Aflatoxins; Food security; Economic burden; Health risks

1 Introduction

The right to safe food is essential for sustaining life, enhancing health, and preventing food insecurity and malnutrition. One of the largest global threats to food safety and public health arises from the contamination of staple crops by mycotoxins. Research reveals that a substantial number of crops from tropical regions face risks of aflatoxin contamination—harmful metabolites produced by toxic fungi like Aspergillus flavus. An estimated five billion individuals, particularly in developing nations, are at risk of chronic exposure to aflatoxins via contaminated food consumption (Strosnider et al., 2006). Ingesting foods tainted with aflatoxins can lead to severe health issues, including aflatoxicosis, cancer, stunted growth in children, and immunosuppression (Shephard, 2008; Wu, 2010). Recent estimates indicate that aflatoxin exposure accounts for approximately 25,200 to 155,000 hepatocellular carcinoma cases annually worldwide (Liu and Wu, 2010).

Aspergillus flavus, the key aflatoxin producer, thrives in peanuts when moisture levels exceed 9%, particularly under temperatures ranging between 25–30 °C and with a specific water activity threshold (Ribeiro et al., 2006). The

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conducive warm and humid conditions prevalent in Africa significantly contribute to the widespread contamination of food items, including groundnuts, with aflatoxins (Ndung'u et al., 2013).

In Africa, aflatoxins considerably jeopardize human and animal health, nutritional outcomes, and both local and international trade. An estimated four billion people in developing countries are frequently exposed to aflatoxins, undermining economic growth through stringent food safety standards (7–9). In Kenya, aflatoxin issues persist within food supplies, highlighted by established maximum permissible levels of aflatoxins set at 10 parts per billion (ppb) for maize and 15 ppb for peanut butter. Peanuts, regarded as an essential staple crop in Kenya after maize due to their resilience during dry spells, are still significantly affected by aflatoxin contamination despite rigorous food safety laws and regulations (Food, Drugs and Chemical Substances Act, 2012).

Despite the presence of laws and guidelines intended to curb aflatoxin contamination, many contaminated products remain accessible to consumers, resulting in notable health issues and fatalities in both humans and animals. Compounding matters, anecdotal sources indicated the existence of deceptive sales practices surrounding food safety regulations. Key regulations governing food safety in Kenya encompass the Food, Drugs and Chemical Substances Act (FDSCA) and the Standards Act (SA) alongside standards set by the Kenya Bureau of Standards (KEBS) for permissible aflatoxin levels.

Aside from influencing public health, aflatoxins impose a considerable economic burden. The Food and Agriculture Organization (FAO) estimates that approximately 25% of the world's food supply is lost due to contamination while an estimated loss of US$ 750 billion occurs globally at various stages of the food supply chain (FAO). Aflatoxin poses substantial challenges to the agricultural sector in Africa, contributing to significant economic losses. The World Bank (2011) suggested that a 1% decrease in post-harvest losses within sub-Saharan Africa could yield economic benefits nearing US$ 40 million each year, predominantly aiding smallholder farmers. Therefore, empowering both farmers and consumers through education about aflatoxin risks is crucial for mitigating economic impairments, particularly affecting vulnerable populations located in rural regions. An analysis of studies focusing on the prevalence of aflatoxins in peanuts within Kenya forms the basis for this research and addresses the economic ramifications associated therein.

2 Nutritional Value of Peanuts

The groundnut (Arachis hypogaea L.) stands as a crucial and cost-effective protein source worldwide, rapidly gaining recognition as one of the primary oil-bearing seeds. This valuable cash crop is extensively cultivated in tropical and subtropical regions, serving multiple roles as food, oil, fodder, and an organic soil conditioner. Peanuts are not only rich in protein and edible oils, but they also enhance soil nitrogen levels, allowing them to flourish even in impoverished soils. Their relatively fast growth lifecycle aligns with substantial market demands in Kenya. The presence of monounsaturated and polyunsaturated fats in peanuts advocates for heart health benefits. The high protein content is particularly essential for children, vegetarians, and individuals suffering from protein deficiency. Moreover, peanuts are abundant in antioxidants, specifically polyphenols, that combat free radicals and help mitigate infections.

Previous reports indicate that peanuts contain protein concentrations ranging from 20.7% to 25.3%, with crude fat ranging from 31% to 46% and carbohydrate content between 21% and 37%. Further, peanuts are recognized for their significant fiber, mineral (including calcium, phosphorus, magnesium, zinc, and iron), and vitamin (notably vitamins E, K, and the B complex) content (Alhassan, 2018). The shells of peanuts are repurposed as animal feed, fuel, litter, and fillers across various industries. Undoubtedly, peanuts are categorized as leguminous plants, meaning they contribute vital nitrogen and organic matter to soil health, making them integral to sustainable agricultural practices. Africa and Asia currently account for about 91% of global groundnut production (Wagacha et al., 2013).

Given the exemplary nutritional profile, peanuts serve as a dietary staple, with their basic composition per 100g of nuts encompassing water (1.55g), carbohydrates (21.51g), fiber (8.0g), lipids (fats) (49.66g), proteins (23.68g), energy (total calories: 244kJ or 585 kcal), vitamins (0.77g), and minerals (0.018g) (Settaluri et al., 2012). A majority of domestically utilized peanuts available in retail markets are typically raw. Nutritionally, raw peanuts are stable, with inherent high oleic/linoleic acid content. High linoleic acid levels present substantial health benefits, as linoleic acid is categorized as an essential fatty acid known to lower cholesterol levels. Consequently, peanut oil comprises around 10% palmitic acid alongside approximately 80% oleic and linoleic acids, which collectively account for roughly 90% of the total fatty acid content in peanut oil. The fat and protein content in groundnuts facilitates the production of protein-rich cookies, which are highly valued for their nutrient availability, palatability, compactness, and convenience.

3 Aflatoxin Contamination of Peanuts in Kenya

Aflatoxin contamination in groundnuts significantly contributes to pre- and post-harvest challenges that impair kernel quality. Empirical data on validated aflatoxin biomarkers from sub-Saharan Africa indicate substantial variability in exposure levels, influenced by geographical regions, close-knit villages, agro-ecological zones, and seasonal fluctuations (Turner et al., 2012; Turner, 2013). Numerous studies have highlighted that inadequate post-harvest management practices concerning handling, storage, and processing are pivotal contributors to aflatoxin accumulation in food crops within developing countries (Wu and Khlangwiset, 2010; Wu et al., 2013). Aflatoxin production is contingent upon prevailing environmental conditions, specifically temperature and moisture levels (Magan et al., 2011); however, other factors—such as the concentration of fungal inoculum, microbe interactions, insect infestations, crop damage, nutrient availability, and carbon dioxide levels—could promote infection and subsequent contamination (CAST, 2003). Findings by Mutegi (2013) corroborated that moisture content, physical damage, and rancidity correlate with varying aflatoxin levels in peanuts. They remarked that while physical damage ranged significantly from 0.1% to 9.8%, factors including storage temperature and relative humidity notably influenced these levels along with the type of storage container used.

Historical accounts of aflatoxicosis in Kenya trace back to 1961, leading to widespread deaths of turkeys (estimated at 16,000). Subsequent incidents, such as human aflatoxicosis outbreaks in Machakos, Makueni, and Kitui counties in 1981 (Marechera and Ndwiga, 2015), as well as significant fatalities recorded in 2004 (totaling 127 deaths) (Nkonge, 2016) and in 2016 (recording 72 deaths in the Eastern region of Meru County) (Ministry of Agriculture, 2016), underline the alarming incidences tied to aflatoxin contamination. High incidences of aflatoxigenic fungi (specifically A. flavus, A. parasiticus, and A. niger) have been identified in peanuts within the region, with contributions from other species such as A. caelatus, A. alliaceus, and A. tamarii being lower (Mutegi et al., 2012). In 2010, an alarming statistic reported that 10% of the maize crop was rendered unsuitable for consumption, equating to an economic loss of approximately $1.15 billion, with negative repercussions transversing the supply chain affecting farmers, traders, millers, and consumers alike (Nkonge, 2016).

Aft to the Hola Agriculture Scheme, Kenya experienced the loss of 60,000 maize bags, with an estimated economic toll amounting to nearly $50 million in 2013 (Omondi, 2019). Numerous studies conducted throughout the 21st century consistently reveal the prevalence of aflatoxins across various food items and geographical regions in Kenya (Daniel et al., 2011; Gachomo et al., 2004; Keter et al., 2017; Lewis et al., 2005; Menza et al., 2015; Mutegi et al., 2009, 2010, 2013; Mutiga et al., 2014, 2015; Mwihia et al., 2008; Sirma et al., 2016). Yard et al. (2013) reported aflatoxin exposure concerning geographical location, indicating that the Eastern province displayed the highest exposure levels (7.87 pg/mg albumin), compared to Coast (3.70 pg/mg albumin; $p < 0.01$), Nairobi (2.44 pg/mg albumin), Central (2.33 pg/mg albumin), North-Eastern (1.40 pg/mg albumin), Western (1.28 pg/mg albumin), Rift Valley (0.70 pg/mg albumin), and Nyanza (< LOD). Alarmingly, food products across diverse commodities continue to exceed the Kenyan aflatoxin regulatory thresholds of 10 µg/kg and 5 µg/kg for total aflatoxins and aflatoxin B1 content, respectively (KEBS, 2018a). Maize, peanuts, and animal feeds are among the top items significantly impacted by aflatoxin contamination within the Kenyan context. Geographical variances in ecological zones result in disparities in temperature and humidity levels contributing to fungal growth. Existing studies have examined the prevalence and levels of aflatoxin across various localities in Kenya, revealing divergent statistics and contamination trends.

3.1 Homabay

In Homa Bay County, research conducted by Ndisio Boaz et al. (2017) evaluated the susceptibility of locally-produced groundnut varieties to Aspergillus flavus. Among the eight varieties identified, Red Valencia was the most predominantly cultivated. A significant portion of farmers (66%) sourced their seeds from local markets, with a marked majority (92%) failing to utilize fertilizers, and a staggering 94% lacking knowledge about aflatoxins. Despite the poor agronomic practices, aflatoxin levels were notably low—highlighting that agro-ecological zoning and storage conditions are likely influencing contamination rates. Only 6.7% of the sampled kernels met the European Commission aflatoxin limit (≤4 ppb) and 4% failed to comply with the KEBS limit (≤10 ppb). A significant correlation ($t = 2.652$; $P = 0.010$) existed between groundnuts' storage conditions and aflatoxin levels, with 94% of unshelled samples exhibiting aflatoxin levels below 10 ppb.

A complementary study by Osao (2014) focused on peanut production and trade across Baringo, Elgeyo-Marakwet, and Meru Counties. The research monitored the prevalence of Aspergillus species and aflatoxin contamination at both pre- and post-harvest stages. It was noted that A. flavus S-strain, A. flavus L-strain, A. parasiticus, and A. niger were prevalent in soil, crop debris, and peanuts during various sampling intervals. Notably, high aflatoxin levels were observed in peanuts from Meru County—implying an elevated health risk. Results also revealed high populations of A. flavus S-strain—characterized by its ability to produce considerable aflatoxin levels—confirming the prudent need for heightened detection and management of aflatoxins in local peanut production.

3.2 Busia and Kisii

High incidences of stunting among children in Busia and Kisii Central districts have been positively associated with long-term exposure to sub-lethal doses of aflatoxins. Major groundnut-producing districts in Busia include Butula, Matayos, Funyula, and Budalangi, while Kisii features divisions such as Keumbu, Masimba, Suneka, and Mosocho. A report by Menza et al. (2015) indicated that 100% of peanuts in Kisii Central and 97.06% in Busia were tainted with aflatoxins, with concentrations of total aflatoxin ranging from 0.1 to 268 μg/kg and 1.63 to 591.1 μg/kg in Busia and Kisii Central, respectively. While the data revealed some samples within acceptable limits set by KEBS, the overall findings call for urgent interventions to combat burgeoning aflatoxin levels.

3.3 Kericho and Eldoret Towns

Nyirahakizimana et al. (2013) explored the variety and diversity of fungal species, alongside aflatoxin levels, in marketed peanuts across Kericho and Eldoret towns. The research concluded that informal market samples exhibited markedly higher total aflatoxin levels (mean = 97.1 μg/kg) compared to formal market samples (mean = 55.5 μg/kg). Communities exhibited discernible differences in fungal populations, including measurements indoors that vastly outnumbered other encountered fungi. The aflatoxin levels for both raw peanuts and processed varieties reflected the necessity of proper handling and processing protocols for peanuts along the supply chain to reduce contamination risks.

3.4 Nairobi, Nyanza and Western Provinces

A further investigation by Wagacha et al. (2013) encompassed raw peanuts and peanut products obtained from pivotal markets within Nairobi and Nyanza provinces. The research detected eight fungal species, noticing a significant prevalence of A. flavus (S-strain) among sampled products. Approximately 73% of A. flavus and A. parasiticus isolates tested produced at least one type of aflatoxin, with total aflatoxin levels among products ranging dramatically. The results underscored the pressing need for heightened efforts in the implementation of rigorous food safety measures across peanut supply chains.

4 Economic Burden

The economic strain attributable to peanut aflatoxin contamination resonates broadly within multiple interconnected sectors: escalating farming costs, health-related expenses leading to productivity loss, condemned produce resulting in farmer and trader losses, declines in animal production, and prohibitively high costs associated with decontamination processes (Grace et al., 2016; Guardian, 2004; Wagacha and Muthomi, 2008).

4.1 Aflatoxins, Trade, and Economic Burden

As noted by N'dede et al. (2012), aflatoxins present formidable economic challenges, costing the African continent millions in financial losses. High incidences of aflatoxin-producing fungi in peanuts headed for Kenyan markets heighten contamination risks, warranting robust stakeholder engagement to bolster compliance within the peanut value chain. Products exceeding aflatoxin standards risk market rejection, leading to diminished prices for farmers and producers (PACA, 2013). Consequently, findings from Mutegi et al. (2018) reported that 85% of households producing peanuts faced rejection due to contamination, and 82% acknowledged their vulnerability to market exclusion.

Aside from economic losses experienced by farmers in Kenya, significant price drops in maize attributed to aflatoxin alerts exemplify this burden, with prices dropping from Ksh 900 to 1800 in 2009 (Marechera and Ndwiga, 2015). Between 2004 and 2006, the maize sector saw the prohibition of 2.3 million maize bags from consumption, driven primarily by aflatoxin concerns (Marechera and Ndwiga, 2015). Economic losses witnessed throughout the African region, as informed by PACA reports, underscore the need for substantial interventions to address these challenges.

Inadequate disposal practices for aflatoxin-contaminated crops compound health dilemmas as contaminated crop residues are redirected to livestock. This pattern fosters a bioaccumulation risk for consumers as livestock products like meat, milk, and eggs become tainted (Mutegi et al., 2018). Consequently, the economic repercussions manifest as reduced livestock productivity and increased veterinary interventions required to address infertility and overall health concerns (Agriculture Trade, 2016).

4.2 Aflatoxins, Food, and Nutritional Security Burden in Kenya

Aflatoxins are toxic compounds produced by certain molds found in crops, particularly in warm and humid environments. In Kenya, aflatoxin contamination has become a critical issue affecting food security and nutritional health. As the global food security landscape becomes increasingly complex, with rising food prices, food waste, undernourishment, and climate change (PACA, 2013), the impact of aflatoxins on food quality and safety cannot be overstated. This paper examines the implications of aflatoxins on food security and nutritional security in Kenya, highlighting the challenges while identifying gaps in research and policy.

Aflatoxins are known to contaminate various staple crops in Kenya, including maize and groundnuts, with maize being the predominant staple food. The toxic nature of aflatoxins poses significant health risks, including liver cancer, immune suppression, and stunted growth in children (Jolly et al., 2006). Moreover, the economic impact is profound, as the presence of aflatoxins leads to increased food safety regulatory costs, loss of market access, and reduced agricultural productivity (Mutiga et al., 2018). In essence, aflatoxin contamination disrupts the three pillars of food security: accessibility, utilization, and stability.

In Western Kenya, peanuts have become a vital component of food security due to their adaptability to drought conditions. Groundnuts, frequently consumed as a part of traditional dishes, are an essential source of protein and fat for many households (Menza et al., 2015). However, the risk of aflatoxin contamination in peanuts poses a troubling dilemma. With rising yields potentially improving access to protein, the threat of aflatoxins undermines these gains, complicating the efforts to improve nutritional outcomes for local populations (Gong et al., 2016).

The cycle of undernourishment tied to aflatoxin exposure is particularly concerning. Continuous contamination leads to dietary inadequacies, with families unable to secure a balanced diet, thus exacerbating malnutrition rates. Studies have indicated that children exposed to aflatoxins through contaminated food are more likely to suffer from growth stunting and other developmental issues, translating into detrimental consequences for public health (Wagacha & Muthomi, 2008). This situation places additional economic burdens on families, making it difficult for them to prioritize nutrition, health, and education.

Despite the significant strides made in understanding aflatoxins and their impact, there remains a lack of comprehensive data on the actual prevalence and effects of aflatoxin contamination in various regions of Kenya. Most studies focus on individual crops or localized areas without establishing broader patterns of contamination across the food supply continuum. This leaves gaps in data needed for effective policy-making. Moreover, public awareness concerning aflatoxins remains low, creating obstacles for food safety practices at both household and community levels (Bandyopadhyay et al., 2018).

Furthermore, while various interventions have been implemented, such as improving agricultural practices, developing resistant crop varieties, and creating regulations for screening food products, challenges persist in effectively addressing the aflatoxin problem. Local farmers often lack access to technological advancements or training on best agricultural and storage practices to mitigate contamination (Kumar et al., 2017). Moreover, insufficient government funding and support for aflatoxin testing and regulation compromise food safety measures.

Research avenues currently flourishing, such as identifying aflatoxin-resistant crop varieties and developing interventions that target the post-harvest management stages alongside education initiatives for farmers, need to be expanded. Collaborative efforts among stakeholders—including governmental agencies, agricultural producers, health organizations, and researchers—are crucial for creating holistic strategies that can tackle the multifaceted aspects of aflatoxin contamination.

In conclusion, aflatoxins remain a significant burden on food security and nutritional health in Kenya. Addressing this issue requires a multi-pronged approach that involves enhanced research, awareness raising, and effective policy implementation. Understanding and combating aflatoxin contamination is not merely about improving food quality; it is deeply integrated into the broader narrative of strengthening national food security, improving public health outcomes, and ensuring sustainable community development.

4.3 Aflatoxins and Health Burden

4.3.1 Aflatoxins and Health Burden in Kenya

Aflatoxins, secondary metabolites produced by certain molds, represent a pervasive public health threat, especially in low and middle-income countries such as Kenya. The World Health Organization (2023) has recognized aflatoxins as potent toxins that can cause a spectrum of negative health outcomes ranging from acute effects to long-lasting chronic implications. In regions where regulations for permissible levels in food products are inadequate, the burden of aflatoxins on public health is particularly pronounced (Modupeade, 2021).

4.3.2 Health Risks Associated with Aflatoxins

The spectrum of health risks attributed to aflatoxin exposure is extensive. Aflatoxins are known to exhibit mutagenic and carcinogenic properties, primarily affecting the liver but also impacting the immune system and functioning of the kidneys (Gong et al., 2016; Akinola, 2020). Unfortunately, in many developing regions, including Kenya, aflatoxicosis contributes to over 40% of health issues linked to food consumption (Völkel et al., 2011). The economic burdens associated with these health issues are significant, straining local health systems that are often already under-resourced.

One of the most alarming instances of acute aflatoxicosis in Kenya occurred in Eastern Kenya when 317 individuals presented with acute hepatic failure, resulting in 125 fatalities directly attributable to aflatoxin exposure (Gong et al., 2016). Such incidents spotlight the severe consequences of aflatoxin contamination, particularly when food safety regulations are not strictly enforced.

4.3.3 Vulnerability of Specific Populations

The impact of aflatoxins is not uniformly distributed across the population. Infants and children are particularly susceptible, given their developing immune systems. Maternal consumption of contaminated foods can lead to the presence of aflatoxins in breast milk, exposing infants to these harmful toxins (Magoha et al., 2014). Detectable levels of aflatoxin M1 in breast milk samples highlight the transplacental risks associated with maternal diets (Kiomars et al., 2022).

This exposure adds to the existing burden of malnutrition in Kenya. Rather than simply being a dietary concern, aflatoxin exposure correlates with broader health issues, including learning disabilities and elevated neonatal mortality rates (World Hunger Services, 2013). These connections underscore the complexity of health outcomes related to aflatoxin exposure, extending beyond immediate toxic effects to influence developmental trajectories.

4.3.4 Socioeconomic Factors and Aflatoxin Exposure

Cultural and socioeconomic dynamics compound the risks associated with aflatoxin exposure. Many rural communities in Kenya face significant dietary deficiencies, often reliant on crops such as maize and peanuts that are particularly susceptible to aflatoxin contamination. The lack of access to affordable, safe food products further entrenches these communities in cycles of poverty and poor health (Akinola, 2020). Additionally, poor agricultural practices and storage conditions exacerbate the risk of aflatoxin development, thus perpetuating the cycle of contamination.

Despite existing literature outlining the health impacts of aflatoxins, several gaps remain. For instance, while significant acute cases have been documented, more research is needed to understand the long-term chronic effects of aflatoxin exposure across various demographic groups in Kenya. Furthermore, existing studies primarily focus on the agricultural and health dimensions, often overlooking the socio-economic and cultural aspects that facilitate aflatoxin exposure and its impacts.

Addressing the health burden of aflatoxins in Kenya requires a multifaceted approach. Prioritizing food safety regulations, improving agricultural practices, and enhancing public awareness on the risks of aflatoxin exposure are essential steps. Educational initiatives targeting vulnerable communities can play a vital role in mitigating the health impacts of these toxins. Ultimately, rigorous research is needed to better understand the long-term effects of aflatoxins, particularly within vulnerable populations. Collaborative efforts among governmental, non-governmental, and international organizations can help close these gaps and protect affected populations from the severe consequences of aflatoxin contamination.

4.4 Aflatoxins and the Burden of Management/Mitigation Practices

Given the complexities surrounding aflatoxin issues, the burden of management and mitigation occupies central concern, particularly as farmers incur additional costs across the spectrum—from soil treatments to intensifying post-harvest practices aimed at safeguarding crops from contamination.

Aflatoxin prevalence requires that farmers adopt comprehensive pre- and post-harvest intervention measures to mitigate risks (Mutegi, 2011; Wagacha and Muthomi, 2008). Implementation of effective management strategies can result in efficient reductions of aflatoxin occurrence in agricultural commodities—achieved through timely harvests, use of non-aflatoxigenic fungal strains for biocontrol, insect pest management, and rigorous soil treatments (Cotty and Mellon, 2006; Dorner, 2004). Moreover, incidences of mold infestation and subsequent fungal spore infections have reached concerning levels due to inadequate grain storage practices, often exacerbated by poverty compounding challenges within the agricultural landscape (Timothy Omara et al., 2021). Key avenues for reducing aflatoxin contamination in peanuts encompass the following dimensions:

4.4.1 Agronomic Practices

Farmers can significantly reduce aflatoxin contamination through early harvests, improving pest control measures, and optimizing storage conditions. Surveys in lower Eastern Kenya reveal that certain practices, like crop rotation, actively mitigate the risks posed by aflatoxins during production (Marechera and Ndwiga, 2014).

4.4.2 Postharvest Measures - Handling, Storage, and Packaging

Emphasizing crop protection strategies—predominantly drying, sorting, and inspection—extends the life cycle of peanuts and reduces the likelihood of aflatoxin formation. Studies highlight optimal conditions for peanut storage, showcasing effective techniques geared toward minimizing contamination risks, particularly through innovative approaches such as hermetic storage options and enhanced environmental controls to stave off mold growth and minimize moisture accumulation.

4.4.3 Food Processing

Peanuts undergo various transformations in processing—consumed raw, roasted, blanched, or utilized in peanut butter preparation. Implementing processing techniques such as heating and fermentation can diminish aflatoxin levels; however, traditional cooking methods are not sufficient to eradicate them completely (Kabak, 2009). Proper protocols need to be instituted during processing to avoid cross-contamination with unsuitable materials. Improving food safety protocols among producers, processors, and regulatory agencies remains critical for improving the overall public health implications tied to aflatoxins.

5 Current Strategies to Reduce Consumer Exposure to Aflatoxins

Present methodologies advocating for the reduction of aflatoxin exposure pivot between pre-harvest prevention of fungal growth and post-harvest elimination strategies. Practices such as utilizing genetically modified, aflatoxin-resistant crop varieties remain paramount alongside integrated methods fostering crop resilience via improved irrigation, fertilization, and biological control measures (Peles et al., 2021).

Post-harvest strategies incorporate effective drying methods, sorting practices targeting visibly contaminated peanuts, and establishing storage protocols resistant to insect damage. Educating farmers on good agricultural practices (GAPs), including harvest techniques and storage protocols, could catalyze significant decreases in aflatoxin prevalence. Furthermore, post-harvest interventions are fundamental to promoting food safety and eradicating existing contamination (Karlovsky et al., 2016).

6 Conclusion

The pervasive threat of aflatoxin contamination remains a pressing public health concern with wide-ranging implications for food security, nutrition, and economic productivity within Kenya. It is evident that unyielding diligence is required across every facets of peanut cultivation—from farmer education and public awareness initiatives to enhanced policymaking strategies—ultimately aiming to enact systemic changes to mitigate and manage aflatoxin levels within the agricultural ecosystems.

Recommendations

To combat aflatoxin issues, establishing a robust regional or national surveillance framework inclusive of reference laboratory capabilities is essential. Heightened public awareness and education surrounding aflatoxins, focusing on health risks and prevention strategies, should be prioritized in rural areas. Continued investments in innovative research and viable applications of contaminated agricultural products are critical for safeguarding vulnerable communities from aflatoxin exposure and its consequential health effects

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

Ethical Approval and Informed Consent

Ethical approval and informed consent were unnecessary for this review, as it analyzes existing literature on aflatoxin's effects on food security, health, and economics in Kenyan peanuts.

Authors' contributions

All authors contributed equally to this work.

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