International Journal of Applied Home Science
(An International Double Blind Peer Reviewed / Refereed Research Journal of Home Science)
Volume 12 (5 & 6), May & June (2025) : 296-302
Received : 24.04.2025; Revised : 08.05.2025; Accepted : 24.05.2025

REVIEW PAPER
ISSN : 2394-1413 (Print)
DOI: https://doi-ds.org/doilink/07.2025-95663341/IJASS/12.5&6/296-302

A Review of Micronutrient Deficiency and Exposure to Aflatoxin in Maize Contribute to Physical Development in Women and Child in Africa

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ABSTRACT

The review study explores the continuous consumption of maize leads to micronutrient deficiency and aflatoxin exposure leads to physical growth in child and women, Africa. The study analyzes various research articles published between 2004 and 2022 investigating themicronutrient deficiency and exposure to Aflatoxin in maize contribute to physical development in women and child in Africa. The review highlights that exposure to aflatoxins and micronutrient deficiency due to continuous consumption of maizeis linked to increased risks ofmalnutrition, stunted growth, weakened immunity, and developmental delays. The timing of Aflatoxin exposure during early stages of life plays a crucial role, with various physical developmental delays andits effects. Aflatoxins exposure and micronutrientdeficiency also influence the severity of these impacts. The review emphasizes the need for targeted interventions and adaptation strategies to protect women and young child from the health effects of high consumption of maize, particularly in vulnerable regions and populations.

Keywords: Aflatoxin, Malnutrition, Micronutrient deficiency, Physical development

INTRODUCTION

Micronutrient deficiencies, often referred to as "hidden hunger," continue to pose a significant public health challenge in Eastern and Southern Africa, particularly among women of reproductive age and young children. These deficiencies, including inadequate intake of vitamin A, iron, and zinc, contribute to impaired immune function, poor growth, reduced cognitive development, and increased morbidity and mortality. In this region, maize is a major staple food and serves as the primary source of daily energy for much of the population. However, its nutritional profile is limited, particularly in terms of essential vitamins and minerals. Understanding the extent to which maize contributes to micronutrient intake is critical for informing food and nutrition policies and developing sustainable strategies to combat malnutrition.

Maize and Aflatoxins:

Maize, while being a staple food for millions in Eastern and Southern Africa, is also highly susceptible to contamination by aflatoxins—naturally occurring mycotoxins produced by fungi, primarily *Aspergillus flavus* and *Aspergillus parasiticus*. Aflatoxin contamination typically occurs during pre-harvest and post-harvest stages under conditions of high humidity, temperature, and poor storage practices, all of which are common in tropical and subtropical regions. This contamination poses aserious food safety and public health risk, especially for populations that rely heavily on maize as a dietary staple.

Aflatoxins, particularly aflatoxin B1, are potent carcinogens and have been linked to liver cancer, immune suppression, and stunted growth in children. Chronic exposure to aflatoxins can lead to aflatoxicosis, with

How to cite this Article: Hanna, Sunkara and Kammar, Mouneshwari R. (2025). A Review of Micronutrient Deficiency and Exposure to Aflatoxin in Maize Contribute to Physical Development in Women and Child in Africa. *Internat. J. Appl. Home Sci.*, **12** (5 & 6) : 296-302.

symptoms ranging from gastrointestinal distress to acute liver damage and death in severe cases. Young children are particularly vulnerable due to their developing immune systems and higher food consumption relative to body weight.

In many countries in Eastern and Southern Africa, studies have reported frequent aflatoxin contamination in maize, leading to widespread exposure among both rural and urban populations. This is of particular concern in areas where dietary diversity is low and maize accounts for a large proportion of daily intake, increasing the risk of prolonged aflatoxin exposure. Additionally, socio-economic factors, limited public awareness, and inadequate food safety regulations exacerbate the problem.

Addressing the issue of aflatoxin contamination in maize requires a multi-pronged approach, including the promotion of good agricultural practices, improved post-harvest handling and storage, regular monitoring and testing, public education, and the development and adoption of resistant maize varieties. Reducing aflatoxin exposure is critical not only for improving food safety but also for enhancing nutrition outcomes and protecting public health in the region.

Maize is the staple food for many populations in Africa, especially in Eastern and Southern Africa. However, maize's nutritional profile is often poor in critical micronutrients such as iron, zinc, vitamin A, calcium, and folate, essential for healthy physical growth and development. This micronutrient deficiency in diets reliant on maize contributes significantly to malnutrition, stunted growth, weakened immunity, and developmental delays, particularly in pregnant women and young children.Improving maize nutritional quality through biofortification and fortification programs. Reducing aflatoxin contamination by improving post-harvest handling, storage, and regular monitoring. Promoting dietary diversity to include other nutrient-rich foods. Public health education on safe food storage and consumption.In the light of above discussion, the present review aims to focus on the impact of continuous consumption of maize affecting the physical development in women and child in Africa.

Objective:

This study aims to review the literature on the "A review of micronutrient deficiency and exposure to Aflatoxin in maizecontribute to physical development in women and child in Africa.

METHODOLOGY

Information sources and search strategy:\

A literature review, with the support of Google Scholar, Science Direct, SpringerLink and Research Gate was conducted with keywords Aflatoxin, malnutrition, micronutrient deficiency, physical development.

Eligibility criteria:

Qualitative articles published in English between 2004 and 2022 that analyzed and evaluated the micronutrient deficiency and exposure to Aflatoxin in maize contribute to physical development in women and child in Africa**.** Thus, 10 articles were found relevant to this topic, but only 6 were suitable according to the eligibility criteria.

RESULTS AND DISCUSSION

Studied showed maize is the staple food in Eastern and Southern Africa, where micronutrient deficiencies (MNDs) such as iron, vitamin A, iodine, zinc, calcium, and selenium are highly prevalent, especially among women and children. Despite high maize consumption, its nutritional contribution is limited, providing some energy, protein, and B vitamins but very low levels of fats, calcium, selenium, and vitamins A, C, and E. MNDs are worsened by nutrient loss during processing, low dietary diversity, and poor nutrient bioavailability. Strategies like maize fortification, dietary diversification, and biofortification have shown success in improving nutritional status, with biofortification notably reducing vitamin A and zinc deficiencies in rural populations.

A synthesis of agronomic data and literature across sub-Saharan Africa (SSA) revealed widespread micronutrient deficiencies in arable soils, especially zinc (Zn), boron (B), iron (Fe), molybdenum (Mo), and copper (Cu). These deficiencies often co-occur and impact the nutritional quality of staple crops like maize, beans, wheat, and rice.

A study conducted on 374 Gambian infants from the Early Nutrition and Immune Development (ENID) trial investigated the effects of aflatoxin exposure on child growth from birth to two years of age, as well as its potential impact on insulin-like growth factor (IGF)-axis proteins. Aflatoxin exposure was measured through

Table 1 : Overview of studies included in the current review

Sr. No	Title of the study	Author and year	Aim of the study	Methodology	Findings/outcomes
1.	A review of micronutrient deficiencies and analysis of maize contribution to nutrient requirements of women and children in Eastern and Southern Africa	Klemm *et al.* (2010).	The study aimed to assess the prevalence of key micronutrient deficiencies in Eastern and Southern Africa and to analyze how maize and the staple food in this region contributes to the dietary micronutrient requirements of women and children.	The researchers conducted a literature review and data analysis on micronutrient deficiencies (particularly vitamin A, iron, and zinc) and evaluated dietary intake data. They also assessed maize consumption patterns and its nutrient composition to estimate the extent to which maize contributes to the recommended daily nutrient intake for target populations.	▪ Micronutrient deficiencies, especially of vitamin A, iron, and zinc, are highly prevalent among women and children in Eastern and Southern Africa. ▪ Maize, although widely consumed, provides limited amounts of these essential nutrients. ▪ The high dependence on maize contributes to the risk of deficiencies unless complemented with other nutrient-rich foods or fortified/biofortified maize varieties. ▪ The study emphasizes the need for nutrition interventions, including food fortification, biofortification, and dietary diversification, to address these deficiencies effectively.
2	Micronutrient deficiencies in African soils and the human nutritional nexus: opportunities with staple crops	Joy Smith *et al.* (2020)	To examine the relationship between micronutrient deficiencies in African soils and their impact on human nutritional status, and to evaluate opportunities to improve micronutrient intake through staple crop biofortification and soil management.	Review and analysis of existing literature on soil micronutrient status across African regions. Assessment of the nutritional composition of staple crops grown on deficient soils. Evaluation of biofortification strategies, including agronomic and genetic approaches. Discussion of integrated interventions combining soil health and crop nutrition.	Significant deficiencies of zinc, selenium, iron, and iodine in African soils lead to reduced micronutrient content in staple crops. This deficiency in crops contributes to widespread human micronutrient malnutrition, especially in women and children.
3.	Impaired growth in rural Gambian infants exposed to aflatoxin: a prospective cohort study	Watson *et al.* (2018)	To investigate the association between dietary aflatoxin exposure and growth impairment in infants living in rural Gambia.	It is a Prospective cohort study with 374 Gambian children followed from birth to 12 months of age.Aflatoxin-albumin (AF-alb) adducts measured in infant serum at 6-, 12-, and 18-months using ELISA. Anthropometric measurements (length and weight) taken regularly to assess growth indicators such as length-for-age (LAZ) and weight-for-age (WAZ) z-scores	A significant inverse relationship was observed between aflatoxin exposure and infant growth.Higher AF-alb levels were associated with lower LAZ and WAZ scores. The study concluded that dietary exposure to aflatoxin in infancy is linked to impaired growth in rural Gambian children, highlighting aflatoxin as a potential public health concern affecting early childhood development in sub-Saharan Africa.
4.	Aflatoxin Exposure Among Young Children in Urban Low-Income Areas of Nairobi and Association with Child Growth	Kiarie *et al.* (2018)	To assess the levels of aflatoxin exposure in children aged 12–36 months in two urban low-income areas of Nairobi, Kenya (Korogocho and Dagoretti), and investigate the association between aflatoxin intake and child growth indicators (stunting, underweight, wasting).	Its Cross-sectional studywith a Sample size of 204 low-income households with children aged 1–3 years. **Data Collection:** ○ **Anthropometry**: Height and weight measurements to calculate HAZ (Height-for-Age Z-score), WAZ, and WHZ ○ **Dietary Intake**: 24-hour recall ○ **Aflatoxin Measurement:** ELISA tests on samples of maizecollected from households or retailers • **Data Analysis:** Mixed-effects regression models to assess associations between aflatoxin exposure (AFM1, AFB, AFG) and growth metrics	**Aflatoxin Presence:** • 98% of food samples tested positive for aflatoxins • 95% of maize samples were contaminated **Child Growth:** • 41% of children were stunted, 17% underweight, and 4% wasted • Stunting was significantly associated with: ○ Higher exposure to AFM1 ○ Being male ○ Living in Korogocho, the poorer of the two areas • A significant association was found between total aflatoxins (AFB + AFG) and child growth outcomes

Table 1 contd.

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5.	Postweaning Exposure to Aflatoxin Results in Impaired Child Growth: A Longitudinal Study in Benin, West Africa	Gong *et al.* (2004)	To examine the association between postweaning aflatoxin exposure and growth impairment in children over time in Benin, West Africa.	▪ **Study Design**: Longitudinal cohort study ▪ **Participants**: 200 children aged 16–37 months at baseline ▪ **Duration:** 8 months of follow-up **Measurements:** ▪ Blood samples were collected at recruitment and follow-up to measure aflatoxin–albumin (AF-alb) adduct levels as a biomarker of exposure ▪ Anthropometric data (height and weight) were collected to assess child growth using Height-for-Age Z-scores (HAZ) ▪ **Analysis:** Children were grouped into low, medium, and high exposure categories based on AF-alb levels; growth changes were compared across groups	▪ Aflatoxin–albumin adducts were detectable in 98% of children ▪ Children in the high aflatoxin exposure group had significantly lower HAZ over the follow-up period compared to those in the low exposure group ▪ The study demonstrated a negative association between aflatoxin exposure and child linear growth, suggesting a causal link between dietary aflatoxin intake and stunting ▪ These findings provide strong evidence that postweaning exposure to aflatoxins can impair growth in young children
6.	Aflatoxin exposure among children of age 12–59 Months in Butajira District, South-Central Ethiopia: a community based cross-sectional study"	Ayele *et al.* (2022)	The study was to assess the prevalence of aflatoxin exposure among children aged 12–59 months in the Butajira District of South-Central Ethiopia.	**Study Design**: A community-based cross-sectional study stratified by agro-ecological zones. **Study Area:** Health and Demographic Surveillance Site (HDSS) of Butajira. Participants: 332 children aged 12–59 months, selected through simple random sampling using HDSS registration numbers. **Data Collection:** • Structured questionnaires were administered to gather information on socio-demographic characteristics and dietary practices. • A Food Frequency Questionnaire (FFQ) assessed the types of foods consumed by the children in the three days preceding the survey. • Urine samples were collected to measure Aflatoxin M1 (AFM1) concentrations using the Enzyme-Linked Immunosorbent Assay (ELISA) method.	**Prevalence of Aflatoxin Exposure:** • Detectable levels of urinary AFM1 were found in 62.4% of the children (95% Confidence Interval: 56.9%–67.5%). • AFM1 concentrations ranged from 0.15 to 0.4 ng/ml. **Associated Factors:** • Agro-Ecological Zone: Children residing in lowland areas had more than twice the odds of aflatoxin exposure compared to those in highland areas (Adjusted Odds Ratio [AOR] = 2.11; 95% CI: 1.15–3.88). • Socio-Economic Status (SES): ○ Children from lower SES households had significantly lower odds of aflatoxin exposure compared to those from higher SES households (AOR = 0.27; 95% CI: 0.14–0.50). ○ Children from medium SES households also had reduced odds (AOR = 0.47; 95% CI: 0.25–0.87). **Dietary Practices:** • Maize was the most commonly consumed and stored crop among the households, with 85.5% reporting its storage. • Children in lowland areas consumed more maize-based products, which are susceptible to aflatoxin contamination.

aflatoxin-albumin adducts (AF-alb) in blood samples collected at 6, 12, and 18 months. The study found significant inverse relationships between aflatoxin levels and key growth indicators—length-for-age (LAZ), weight-for-age (WAZ), and weight-for-length (WLZ)—from 6 to 18 months, indicating that higher aflatoxin exposure was associated with impaired growth. Specifically, aflatoxin exposure at 6 months predicted reduced WLZ between 6 and 12 months, while exposure at 12 months was linked to reduced LAZ and length growth from 12 to 18 months. Additionally, a weak negative correlation was found between AF-alb at 6 months and IGFBP-3 at 12 months, though no strong association was observed with IGF-1 levels. These findings suggest that aflatoxin exposure has a small but significant negative effect on early child growth in this population, though the IGF-axis does not appear to be the primary pathway mediating this impact.

This cross-sectional study investigated the relationship between aflatoxin exposure and child growth among low-income households in two urban areas of Nairobi, Kenya—Korogocho (high population density) and Dagoretti (low population density). A total of 204 households were randomly selected, and data were collected on household demographics, child dietary intake (via 24-hour recall), and anthropometric measurements of children aged 1–3 years. Height-for-age (HAZ), weight-for-age (WAZ), and weight-for-height (WHZ) z-scores were calculated using WHO growth standards. Food samples from households and retailers were tested for aflatoxins using ELISA, and daily aflatoxin intake was estimated based on dietary assessments.

A longitudinal study conducted in Benin followed 200 children aged 16–37 months over eight months to assess the effects of aflatoxin exposure on growth. Children from four villages (two with high aflatoxin exposure and two with low exposure) were monitored, with measurements taken for serum aflatoxin-albumin (AF-alb) levels, height, dietary intake, and micronutrient status. Results showed that AF-alb levels increased significantly over time, especially in fully weaned children consuming maize-based porridge. There was no association between aflatoxin levels and vitamin A or zinc, indicating that the effect was not due to general malnutrition. However, higher aflatoxin exposure was strongly linked to reduced height gain—children in the highest exposure group grew 1.7 cm less over the study period than those in the lowest group. The study concludes that aflatoxin exposure during the weaning period contributes to stunted growth in children and highlights the need for interventions to reduce exposure.

Community-based cross-sectional study in Butajira district, South-Central Ethiopia, assessed aflatoxin exposure among 332 children aged 12–59 months using urinary Aflatoxin M1 measured by ELISA. Results showed that 62.4% of children had detectable aflatoxin levels, with exposure significantly higher in children living in lowland agro-ecological zones and those from higher socio-economic status households. The findings highlight a substantial risk of aflatoxin exposure among young children in the area, underscoring the urgent need for community awareness programs and mitigation strategies. Further research is also recommended to evaluate the long-term effects of aflatoxin on child growth and development.

Maize is a staple food across much of sub-Saharan Africa, but its dominance in diets, especially when consumed without adequate dietary diversity—has been linked to stunting in children, particularly through nutrient deficiencies and aflatoxin contamination.Klemm *et al.* (2010) found that although maize is a major staple in Eastern and Southern Africa, it contributes poorly to the intake of essential micronutrients like vitamin A, iron, and zinc. This dependence, especially among women and children, increases the risk of micronutrient deficiencies, which are strongly associated with growth retardation and stunting."Maize provides a large proportion of daily energy but insufficient amounts of essential micronutrients" – Klemm *et al.* (2010)

Kamala et al. (2018) reported widespread aflatoxin contamination in maize and groundnuts in Tanzanian households. High exposure to aflatoxins, particularly from maize, posed a significant risk to child health, including growth impairment and immune suppression. "Children in communities where maize is heavily contaminated with aflatoxins are at high risk of stunting" – Kamala *et al.* (2018)

Kiarie *et al.* (2018) studied aflatoxin exposure in urban low-income areas in Nairobi and found:95% of maize samples were aflatoxin positive.Stunting was significantly associated with aflatoxin M1 exposure. Korogocho, the poorer area with higher maize consumption and contamination, had 49% stunted children.Most exposure was from maize (average 59.5%), and AFM1 intake was negatively associated with height-for-age z-scores" – Kiarie *et al.* (2018)

Conclusion:

This review highlights the significant impact ofcontinuous consumption of maize in African child and women effecting on their physical development.Despite high consumption levels, maize provides insufficient amounts of essential nutrients like vitamin A, zinc, calcium, and selenium, and nutrient losses during processing, along with poor dietary diversity, exacerbate these deficiencies.chronic exposure to aflatoxins—common contaminants of maize in sub-Saharan Africa—poses a serious threat to child growth and development. Multiple studies across different African settings consistently show that higher aflatoxin exposure correlates with impaired growth indicators such as stunting and reduced weight gain in young children. These negative effects appear independent of general micronutrient deficiencies, underscoring aflatoxins as a direct contributor to growth impairment.

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