International Journal of Food Science and Biotechnology
2025, Vol. 10, No. 4, pp. 93–97
https://doi.org/10.11648/j.ijfsb.20251004.12

Research Article

Review on the Effect of Aflatoxin on the Safety and Quality of Milk Production in Dairy Farms of Ethiopia

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Abstract

Aflatoxins are a group of highly toxic and carcinogenic secondary metabolites predominantly produced by the fungi *Aspergillus flavus*, *Aspergillus parasiticus*, and occasionally *Aspergillus nomius*. These fungi proliferate under warm, humid and tropical conditions, making certain regions, including Ethiopia, particularly susceptible to aflatoxin contamination. Factors such as fluctuating climatic conditions, traditional post-harvest handling and inadequate feed storage systems exacerbate the risk of contamination. When lactating cows consume aflatoxin-contaminated feed, primarily containing Aflatoxin B_1 (AFB_1), it is metabolized in the liver into Aflatoxin M_1 (AFM_1), which is subsequently excreted in milk. This metabolite is heat stable and can persist even after standard milk processing methods such as pasteurization or ultrahigh temperature (UHT) treatment, posing serious food safety concerns. AFM_1-contaminated milk is particularly hazardous to vulnerable populations, including infants, young children and pregnant women, as it can impair growth, compromise immunity and increases the risk of liver cancer over prolonged exposure. Effective mitigation strategies require a multifaceted approach. These include adopting proper feed management techniques, such as drying crops to safe moisture levels, using hygienic and elevated storage facilities, employing bio control methods to reduce fungal growth and routinely monitoring aflatoxin levels in both feed and milk. Awareness campaigns and farmer training programs are also critical to encourage compliance with best practices. In Ethiopia, strengthening regulatory frameworks and implementing systematic surveillance of aflatoxins in dairy production can significantly reduce public health risks, enhance milk safety and support the sustainable development of the dairy sector.

Keywords

Aflatoxin, Milk Safety, Dairy Feed Contamination, Ethiopia, Food Safety, Public Health, Storage Practice

1. Introduction

Aflatoxins are a group of structurally related, highly toxic, and carcinogenic secondary metabolites mainly produced by *Aspergillus flavus*, *Aspergillus parasiticus*, and occasionally *Aspergillus nomius* [13]. In Ethiopia particularly vulnerable due to its climatic variability, poor feed storage systems and traditional post-harvest handling practices [6].

Common feed ingredients used in Ethiopian dairy farms maize, groundnuts, noug cake (from *Guizotia abyssinica*), cottonseed cake, and brewery by-products—are highly susceptible to fungal growth and subsequent aflatoxin production, especially when stored under high humidity or in poorly ventilated facilities [15].

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Received: 12 November 2025; **Accepted:** 21 November 2025; **Published:** 26 December 2025

Among the aflatoxin group, Aflatoxin B_1 (AFB_1) is the most potent hepatotoxic and carcinogenic compound. When lactating dairy cows ingest feed contaminated with AFB_1, the toxin is absorbed through the gastrointestinal tract and metabolized in the liver by cytochrome P450 enzymes into a hydroxylated metabolite, Aflatoxin M_1 (AFM_1). AFM_1 is excreted primarily in milk and urine [14].

The transfer of AFB_1 to AFM_1 in milk is a critical food safety challenge in Ethiopia, where milk is an essential part of daily nutrition for urban and rural households, particularly for infants, children, and pregnant women. The stability of AFM_1 against common milk-processing methods such as pasteurization, boiling, or ultra-high temperature (UHT) treatment further compounds the problem [12].

2. Objective

1) To assess the occurrence, sources and public health implications of aflatoxin contamination in Ethiopian dairy production systems,
2) To highlight contributing factors such as climatic conditions, feed handling and storage practices.

3. Effect on Milk Safety

a) Presence of AFM_1 in Milk

Studies conducted in Ethiopia have consistently demonstrated that AFM_1 contamination in milk is widespread.

Surveys in Addis Ababa, Oromia, Amhara, and SNNPR regions revealed that between 60%–90% of raw milk samples and 50%–80% of processed milk products contained detectable AFM_1 residues [15].

The carry-over rate (the percentage of AFB_1 in feed that appears as AFM_1 in milk) typically ranges between 0.3% and 6.2%, depending on the feed quality, milk yield, and metabolic rate of the animal. In high-yielding cows under intensive feeding, the rate may approach 2–3% [9].

Because most Ethiopian dairy farms rely on agro-industrial by-products (like oilseed cakes and cereal residues) that are prone to mold growth, the feed-to-milk transfer pathway is a major route of contamination.

b) Heat Stability and Resistance to Processing

AFM_1 is thermally stable, and Ethiopian households often rely on boiling milk before consumption. However, boiling reduces AFM_1 by only 20–25%, and pasteurization or UHT treatment causes less than 10–20% reduction. Hence, milk contaminated at the production stage remains unsafe after processing; posing chronic exposure risks [7]. This emphasizes the need for preventive feed management rather than post-contamination treatment [12].

c) Toxicological Impact

AFM_1 has been classified by the International Agency for Research on Cancer (IARC) as a Group 1 carcinogen, meaning it is carcinogenic to humans. Chronic exposure to AFM_1 can cause:

1) Liver cancer (hepatocellular carcinoma), especially when combined with hepatitis B infection (common in parts of Africa).
2) Immune suppression, reducing resistance to infectious diseases.
3) Growth retardation and under nutrition in children.
4) DNA damage and mutagenesis, which may have long-term generational effects.

In Ethiopian contexts, children and pregnant women are most at risk. Studies indicate that daily milk intake among Ethiopian children (1–5 years old) ranges from 250–500 mL, leading to potentially high exposure relative to body weight. When combined with frequent consumption of contaminated maize or peanut-based foods, the risk of cumulative aflatoxin exposure increases substantially [15].

d) Public Health Concern

AFM_1 contamination in Ethiopian milk represents a major public health issue.

1) Ethiopia has one of the fastest-growing dairy sectors in Africa; yet feed safety regulation remains weak.
2) Milk and dairy products are often consumed without prior quality testing, especially in informal markets, which account for over 80% of national milk sales.

The risk is particularly severe for urban consumers, where intensive farms near cities (e.g., Addis Ababa and Adama) use compound feeds sourced from unregulated feed suppliers. These feeds often contain moldy maize, cottonseed, or brewery residues contaminated with AFB_1. Without regular monitoring, contaminated milk can enter the food chain unnoticed, posing long-term health risks including liver disease, malnutrition, and impaired child growth [15].

4. Effect on Milk Quality

a) Nutritional Quality

Aflatoxin exposure not only threatens safety but also impairs the nutritional quality of milk:

1) Cows exposed to AFB_1-contaminated feed exhibit reduced appetite, lower milk yield, and altered milk composition (lower fat and protein) [4].
2) Liver dysfunction caused by aflatoxins disrupts nutrient metabolism, affecting casein and lactose synthesis [1].
3) Chronic aflatoxin ingestion also reduces antioxidant vitamins (A, E) in milk and increases oxidative stress, lowering the nutritional value and shelf stability [8]. Studies in Ethiopian dairy herds have linked visible feed mold to lower daily yield (by 0.5–2 L/cow) and poorer milk solids content [9].

b) Technological and Processing Quality

AFM_1's chemical stability influences milk's technological behaviour during processing:

1) AFM_1 binds to casein micelles, so cheese, yogurt, and butter can retain or concentrate the toxin. Cheeses made from contaminated milk can contain 3–5 times higher

AFM_1 levels than the raw milk [15].

2) AFM_1 may affect starter culture activity in fermented milk, leading to poor curd formation and off-flavors.
3) Ethiopian small-scale processors, often using traditional fermentation ("Ergo"), may unknowingly concentrate AFM_1 in their products [1].

This contamination reduces the technological quality, affecting texture, flavor, and safety thereby limiting both domestic marketability and export potential.

c) Shelf-Life, Marketability and Regulatory Compliance

Contamination above Maximum Residue Limits (MRLs) reduces milk's commercial value and legal acceptability.

1) The EU limit for AFM_1 is 0.05 µg/kg, while Codex Alimentarius recommends the same for global trade. [2].
2) Ethiopia currently lacks a fully enforced national MRL for AFM_1, though the Ethiopian Food and Drug Authority (EFDA) and Ethiopian Standards Agency (ESA) are developing guidelines aligned with Codex standards [3].

Consequences of non-compliance include:

1) Rejection of milk and dairy products for local processing or export.
2) Economic loss to smallholder farmers and cooperatives.
3) Erosion of consumer confidence, particularly in urban centres like Addis Ababa where demand for safe milk is rising.

5. Economic and Regulatory Implications

A). Economic Impact

Aflatoxin contamination creates multi-level economic losses:

1) Reduced milk yield due to animal health impacts.
2) Higher veterinary and feed management costs.
3) Product rejections and downgrading to non-food uses.
4) Loss of export opportunities and trade competitiveness.

At the national scale, the Ethiopian dairy industry, which produces over 4 billion liters annually, faces significant productivity and quality challenges. Contamination undermines the goals of the Ten-Year Agricultural Development Plan and the Livestock Master Plan, which emphasize dairy as a key sector for income generation and nutrition improvement [10].

B). Regulatory Framework in Ethiopia

The Ethiopian Food and Drug Authority (EFDA), Ethiopian Agricultural Authority (EAA) and Ethiopian Standards Agency (ESA) share responsibility for food safety and feed regulation.

Effective implementation of these standards will require capacity building, farmer awareness and enforcement mechanisms throughout the dairy value chain.

6. Prevention and Control Strategies

A). Feed Management and Storage

1) Dry feed crops to ≤13% moisture before storage.
2) Use clean, elevated and ventilated storage facilities away from moisture.
3) Inspect feed regularly for mold and discard visibly infected batches.
4) Adopt biocontrol methods, such as *Aflasafe™*, which introduces non-toxigenic *Aspergillus flavus* strains to outcompete toxin producers a promising approach already piloted in parts of Ethiopia's maize sector.

B). Use of Mycotoxin Binders/Adsorbents

1) Incorporate bentonite clay, hydrated sodium calcium aluminosilicate (HSCAS), yeast cell walls, or activated charcoal into dairy rations to reduce aflatoxin absorption [11].
2) Several Ethiopian commercial feed manufacturers have begun adopting such additives, though quality assurance remains inconsistent.

C). Regular Monitoring and Testing

1) Implement routine surveillance of both feed and milk for aflatoxin contamination using ELISA or LC-MS/MS.
2) Establish regional laboratories (e.g., in Addis Ababa, Bishoftu, Hawassa, Bahir Dar) with standard testing protocols [3].
3) Encourage cooperative-based testing programs where farmers can check feed safety before use.

D). Good Agricultural and Manufacturing Practices (GAP & GMP)

1) Apply HACCP-based controls in feed mills, dairy collection centres and processing plants.
2) Strengthen extension services to promote awareness among smallholder dairy farmers.
3) Maintain sanitation, equipment calibration, and pest control to prevent fungal contamination [5].

E). Education and Policy Enforcement

1) Conduct farmer training programs on feed handling, drying, and mold prevention.
2) Disseminate information on aflatoxin risks via radio, cooperatives, and agricultural TV programs.
3) Enforce penalties for selling visibly moldy or unsafe feed ingredients (MoA, 2021).

F). Processing and Detoxification Technologies

1) Evaluate low-cost techniques such as ozonation, UV irradiation, or biological degradation using lactic acid bacteria to reduce AFM_1 in milk.
2) Research institutions such as ILRI and Addis Ababa University are exploring microbial detoxification methods applicable to small-scale processors [9].

7. Conclusion

Aflatoxin contamination remains a critical challenge to Ethiopia's dairy sector, threatening milk safety, nutritional quality and public health. The transformation of Aflatoxin B_1 (AFB_1) in contaminated feed into Aflatoxin M_1 (AFM_1) in milk illustrates a direct link between feed management and human exposure.

The persistence of AFM_1 through pasteurization and boiling underscores that prevention rather than post-contamination treatment is the most effective mitigation strategy. Chronic exposure, particularly among children and pregnant women, elevates the risk of liver cancer, stunting and immunosuppression.

The Ethiopian Food and Drug Authority (EFDA) and the Ethiopian Agricultural Authority (EAA) are strengthening regulatory frameworks while promoting farmer training, investing in laboratory capacity, enhancing feed quality monitoring and raising public health awareness.

8. Recommendations

1) Promote the formation of farmer cooperatives equipped with shared, well-ventilated feed storage facilities to ensure proper handling and effective moisture control.
2) Deliver continuous training and extension programs for farmers and processors on mold prevention, safe feed management and aflatoxin risk mitigation.
3) Support research and innovation in developing affordable, practical and scalable detoxification technologies tailored to smallholder dairy systems.
4) Strengthen multi-sectorial collaboration among the EAA, EFDA, MoA, ILRI, FAO and academic institutions to implement an integrated and sustainable national aflatoxin control strategy.

Abbreviations

Abbreviation	Meaning
AFB_1	Aflatoxin B_1
AFM_1	Aflatoxin M_1
UHT	Ultra-High Temperature
EU	European Union
FDA	Food and Drug Administration (United States)
IARC	International Agency for Research on Cancer
ILRI	International Livestock Research Institute
MRL(s)	Maximum Residue Limit(s)
EFDA	Ethiopian Food and Drug Authority
EAA	Ethiopian Agricultural Authority
ESA	Ethiopian Standards Agency
MoA	Ministry of Agriculture (Ethiopia)
FAO	Food and Agriculture Organization of the United Nations
HSCAS	Hydrated Sodium Calcium Aluminosilicate
ELISA	Enzyme-Linked Immunosorbent Assay
LC-MS/MS	Liquid Chromatography–Tandem Mass Spectrometry
GAP	Good Agricultural Practice
GMP	Good Manufacturing Practice
HACCP	Hazard Analysis and Critical Control Points

Author Contributions

Tegegn Teshome Woldamichael is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author affirms that there are no conflicts of interest related to this study. The work was carried out independently, and no financial, institutional, or personal interests influenced the review or conclusions presented in this paper.

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