



Aflatoxins and Effects in Ruminant Nutrition

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Abstract. Aflatoxins are mycotoxins produced by molds such as *Aspergillus flavus* and *Aspergillus parasiticus*, with potent toxic and carcinogenic properties. Aflatoxin B1 (AFB1), in particular, is the most frequently encountered and harmful form in ruminant nutrition. Although AFB1 ingested in feed is detoxified to a limited extent in the rumen, it is metabolized in the liver and can be transmitted to consumers through milk as Aflatoxin M1 (AFM1). Aflatoxin exposure in ruminants leads to adverse outcomes such as reduced feed intake, body weight loss, immune system suppression, impaired reproductive performance, and reduced milk yield. The legal limit for AFB1 in feed is 5 ppb ($\mu\text{g}/\text{kg}$) in Turkey and 20 ppb in European Union countries. Proper harvesting and storage conditions, biological and chemical detoxification methods, and the use of toxin-binding feed additives are key to reducing aflatoxin risk. Control of aflatoxins in ruminant feed is critical for both animal health and public health.

Keywords: *Aspergillus flavus*, *Aspergillus parasiticus*, Aflatoxins, Mycotoxins, Milk Yield

1 Introduction

Aflatoxins are a group of toxic secondary metabolites produced by fungi such as *Aspergillus flavus* and *Aspergillus parasiticus*. The most important aflatoxins include aflatoxins B1 (AFB1), B2 (AFB2), G1 (AFG1), G2 (AFG2), and M1 (AFM1). Aflatoxin B1, in particular, is known to be a significant carcinogen in humans and animals. Aflatoxins contaminate a variety of food products, including corn, peanuts, tree nuts, and spices, posing significant health risks in tropical and subtropical regions where conditions favor the growth of toxic fungal species [1,2]. Long-term exposure to aflatoxins can lead to serious health consequences. Long-term consumption of aflatoxin-containing foods has been associated with liver cancer, immune suppression, and other health problems [3,4].

The mechanisms behind the toxic effects of aflatoxins are multifaceted. It has been reported that they can cause oxidative stress, leading to cellular damage and mutations

that can lead to cancer [5; 6]. AFB1, in particular, can be metabolized in the liver and mutagenic by forming reactive intermediates that can bind to cellular macromolecules, including DNA [7]. Aflatoxin contamination also causes significant economic problems. Agricultural productivity and food security losses are experienced, particularly in low-income countries where regulatory frameworks are more flexible [8].

1.1 Aflatoxin Types

AFB1. Aflatoxin B1, the most potent and prevalent variant, is known for its potent carcinogenic properties, particularly those associated with liver cancer [9]. This toxin is primarily found in contaminated grains, nuts, and seeds, and its presence in animal feed can lead to significant health problems, such as reduced growth rate and impaired immune function [10]. AFB1 is broken down in the liver to aflatoxin M1, which is excreted in milk and poses a risk to humans who consume dairy products [11].

AFB2. Aflatoxin B2, while not as toxic as AFB1, is often produced by the same fungi and is found alongside AFB1 in contaminated food sources. It shares the same transmission routes and poses similar health risks [12]. Aflatoxins G1 and G2 are also produced by *Aspergillus* species and are primarily associated with grains and seeds. Although less researched than AFB1 and B2, they are recognized for their potential toxic effects [13].

AFM1. AFM1 is essential for milk production and is a hydroxylated metabolite of AFB1. It can be found in the milk of animals consuming feed contaminated with AFB1. The presence of AFM1 in milk poses a significant public health concern because it can cause chronic health problems in humans through the consumption of dairy products [14]. The detection of AFM1 in milk has raised regulatory concerns aimed at limiting its concentration to ensure food safety [15].

The aflatoxin types of primary concern are AFB1, AFB2, AFG1, AFG2, and AFM1, each with varying levels of toxicity and adverse effects on human and animal health. Managing aflatoxin exposure in animals is vital to ensuring the safety of animal food products and protecting public health.

1.2 Aflatoxin in Ruminant Nutrition

Aflatoxins, particularly AFB1, pose a significant health risk to ruminants when present in feed. Mycotoxins produced by *Aspergillus* species can lead to various health problems, including reduced milk production, impaired liver function, and increased susceptibility to disease [16]. Ruminants such as cattle and goats are more resistant to aflatoxins in their feed compared to non-ruminants due to the microorganism population in their rumens. These microorganisms can degrade or inactivate some toxins [17]. However, the degree of this protective effect may vary depending on the aflatoxin concentration in the feed and the overall health of the animal.

The transfer of AFB1 from contaminated feed into milk is a critical concern for milk production. When ruminants consume AFB1, it can be metabolized in the liver as AFM1 and passed into milk. Studies have shown that the rate of AFB1 transfer into

milk is affected by the amount of contaminant ingested in feed, with rates ranging from 0.01% to 0.02% [18]. This poses a risk not only to animal health but also to humans consuming dairy products. Although ruminant microorganisms have developed resistance to some aflatoxins, the risks associated with aflatoxin contamination in feed remain significant. To reduce the health risks posed by aflatoxins in ruminant feeds, effective control methods and precautions, ration changes, use of toxin binders and regular control of aflatoxin contamination levels are of great importance.

1.3 Effects of Aflatoxin on Ruminant Animals

Aflatoxins, particularly AFB1, have negative effects on the health, productivity, and general welfare of ruminants, although not as much as other farm animals. When ruminants consume feed contaminated with AFB1, the substance can be metabolized in the liver as AFM1 and passed into milk. This poses a risk not only to animal health but also to humans who consume milk and dairy products. The primary effects of aflatoxins on ruminants include hepatotoxicity, immune suppression, and decreased productivity. Chronic aflatoxicosis can negatively affect the animal's metabolism and general health by causing damage such as jaundice and impaired liver function. Studies have shown that AFB1 can significantly reduce feed efficiency, milk yield and quality due to the toxic effects [19; 16; 20]. Furthermore, aflatoxins can weaken the immune system, making ruminants more susceptible to infections and diseases. This can exacerbate potential health problems and lead to economic losses in livestock production [16]. Studies on aflatoxins in ruminant nutrition indicate that these toxins negatively affect protein and fat metabolism. Aflatoxin exposure causes growth retardation and poor overall health in animals. Its negative effects on protein synthesis ultimately lead to reduced meat quality. The presence of aflatoxins interferes with the regulation of fatty acids, which help ruminants meet their immediate energy needs, negatively impacting the flavor and nutritional value of meat [21]. Similar adverse effects on reproductive performance have been observed. Aflatoxin exposure causes hormone imbalance and disruptions in the reproductive cycle. It can reduce ovulation and pregnancy rates by inhibiting ovarian activity in female ruminants [22]. Some studies demonstrate the effects of aflatoxins on ovarian function. Aflatoxins can also negatively impact spermatogenesis and sperm quality, reducing the reproductive performance of male animals [23].

At the same time, the effects of aflatoxins on animals and animal products are not limited to health; they can also affect consumer satisfaction. While meat quality is evaluated in terms of both microbiological and nutritional value, the presence of aflatoxins can directly affect these parameters. Exposure to aflatoxin in ruminant animals increases the rate of meat spoilage, shortens its shelf life, and therefore leads to economic losses [24]. The presence of aflatoxins in ruminant feed can lead to reduced nutrient digestibility. Research shows that aflatoxin contamination can reduce the digestibility of ruminant feeds by up to 67%, negatively impacting nutrient absorption and overall animal performance. This reduced digestibility can also lead to poor growth rates and reduced reproductive performance in aflatoxin-affected animals [26].

Aflatoxins pose a serious threat to ruminant health and have significant economic impacts on the livestock sector. Effective methods, such as the use of adsorbents and regular aflatoxin level monitoring, are vital to mitigating the negative effects of aflatoxins in ruminant feeding systems.

1.4 Ruminant Aflatoxin Tolerance Level

Regulating aflatoxin levels in animal feed is critical for ensuring the health and productivity of ruminants in particular. Various international guidelines have established maximum aflatoxin levels in feed to reduce the health risks associated with aflatoxins. For example, the European Union has set a maximum limit of 20 µg/kg (20 ppb) for total aflatoxins in animal [26]. In Türkiye, aflatoxin limits in feed are generally based on international standards such as the European Union and the World Health Organization. According to the Turkish Food Codex Contaminants Regulation, the maximum acceptable standard for aflatoxin B1 in feed is set at 5 ppb [27]. This standard aims to minimize aflatoxin damage, which can lead to serious health problems such as liver damage and reduced productivity. To avoid the adverse effects of AFB1 levels in ruminant feeds, it is recommended that they not exceed 50-300 ppb. Adult ruminants, in particular, can acutely tolerate aflatoxin levels of up to 0.08 mg/kg body weight, corresponding to approximately 2500 µg/kg per feed. However, even chronic damage at lower levels can lead to harmful effects such as immune suppression and reduced milk production. Although the maximum levels recommended by regulatory agencies for aflatoxins in ruminant feeds are generally set at 20 ppb, findings from some studies suggest that aflatoxin tolerance may be as high as 300 ppb, depending on specific conditions and animal species.

1.5 Aflatoxin Prevention and Control Methods

Methods for preventing and combating aflatoxins in ruminant animals are crucial for animal health and nutrition. Aflatoxins are toxic compounds produced primarily by fungi of the *Aspergillus* species and can cause serious harm to animals. Several methods can be used to prevent such contamination:

Feed storage conditions are one of the key factors affecting aflatoxin formation. In particular, drying and storing forages in good conditions and regularly controlling moisture play a critical role in preventing aflatoxin contamination. Ogunade et al. [28] determined in their study that proper silage management is effective in reducing aflatoxin formation. Silage areas should be well ventilated to prevent fungal growth. Mycotoxin binders in ruminant rations are used as effective supplements to reduce the effects of aflatoxins. Natural binders such as bentonite have been shown to be effective in binding aflatoxins and removing them from feed [29]. Additionally, probiotics used in ruminant rations can reduce the effects of aflatoxin by improving digestive efficiency [30]. Natural compounds added to ruminant rations have also been shown to reduce the effects of aflatoxins. For example, the use of the plant *Hedyotis diffusa* has been found to reduce the liver-damaging effects of AFB1 [31]. Raising farmers' awareness of aflatox-

ins and reducing contamination is vital for both animal and human health. Raising farmers' awareness, particularly regarding feed management, silage storage conditions, and general hygiene standards, can reduce the risk of aflatoxins. Measures taken by informed farmers to improve feed quality can effectively reduce aflatoxin levels in animal products. Regular monitoring of aflatoxin levels is crucial for protecting animal health. Regularly monitoring aflatoxin levels in feed and dairy products is crucial for animal and human health. Sharafi et al. [32] emphasized the critical importance of regular control and monitoring practices for food safety. Physical and chemical methods are used to reduce the effects of aflatoxins. Proper storage conditions, along with temperature and humidity control, can prevent aflatoxin production [33]. Additionally, some chemicals can be added to rations to neutralize toxins in feed by binding them. Preventing and combating aflatoxins in ruminants is critical for animal health. Various methods, such as feed management, mycotoxin binders, ration supplements, and raising farmer awareness, can be used to reduce aflatoxin risk and protect animal health. Furthermore, regular aflatoxin level control and monitoring plays a crucial role in combating aflatoxins.

2 Conclusion

Aflatoxins, particularly AFB1, pose serious health risks to ruminants, negatively impacting both animal and human health. Regulating aflatoxin levels in feed is crucial for protecting animal health and preventing contamination in animal products such as milk and meat. It is recommended that aflatoxin levels be kept within the 50-300 ppb range to prevent ruminant health problems, particularly liver damage, immune suppression, and productivity loss. Effective management strategies, regular monitoring of aflatoxin levels in feed, and appropriate feeding practices can protect the health of both animals and humans.

3 References

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