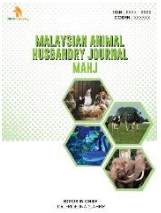
ZIBELINE INTERNATIONAL™ PUBLISHING

ISSN: 2805-5500 (Online)
CODEN: MAHJAQ

Malaysian Animal Husbandry Journal (MAHJ)

DOI: http://doi.org/10.26480/mahj.02.2024.83.89



RESEARCH ARTICLE

AN IN-DEPTH ANALYSIS OF THE IMPACT OF TOXINS AND TOXIN BINDERS IN POULTRY

Netra Prasad Ghimire, Bishnu Yadav*

G. P. Koirala College of Agriculture and Research Centre, Purbanchal University, Gothgaun, Morang, Nepal.
Corresponding Author Email: bishnuyadav2073@gmail.com

ARTICLE DETAILS

Article History:

Received 15 April 2024
Revised 23 May 2024
Accepted 10 June 2024
Available online 13 June 2024

ABSTRACT

Globally, Cereal grains are a major feed source for poultry, which are likely to be contaminated by different toxins. When provided to birds, those contaminated feeds can cause serious hazards and illness in poultry species. Thus, toxins in the feed must be detoxified to protect birds from major disorders. Recent trends directly focus on using substances that reduce toxin contamination. Regardless of chemical and natural origin, these substances are supplemented to poultry feed to counteract toxins, termed toxin binders. They act by reducing the adsorption of harmful substances from the alimentary canal, which is directly distributed to the bloodstream and target organs causing significant health hazards in poultry, such as mycotoxicosis. This investigation presents current relevancy and knowledge for utilising toxin binders in poultry feed. Recent information on the effects, efficiency, trends and performances associated with applications of toxin binders in the field are discussed in this paper.

KEYWORDS

Mycotoxin, Aflatoxin, Feed, Toxin binders, Poultry

1. INTRODUCTION

The new poultry industry means creating great items for minimal prices. As well as expanding interest in poultry meat, nonstop, successful, and designated medical services are needed to forestall the improvement of illnesses. The poultry sector is under more pressure to provide consumers with prime goods in bulk (Greco et al., 2014; Suleman et al., 2022). Antibacterial food-added substances have been utilized as anti-infection agents all through the world for quite a long time, as development advertiser upgrades to prevent and minimizes living microorganisms in the mucosa of intestines for the development of meat and eggs. Notwithstanding, the ill uses of anti-toxins in poultry enterprises have become bothersome because of their build-up on meat items (Soltani et al., 2019). Universally, most feeds are heavily polluted from mycotoxins, of which fumonisin, aflatoxin, ochratoxin, deoxynivalenol and zearalenone are the most normally found (Greco et al., 2014; Kemboi et al., 2020). Besides, these feeds are often sullied with mostly two mycotoxins, and the combination of those toxins might apply added substance or synergistic impacts (Kolosova and Stroka, 2011).

The utilization of mycotoxin-tainted food and feeds prompts decreased supplement retention, horrible showing, immunosuppression, build-ups in creature items, and expanded vulnerability to irresistible and parasitic sicknesses (Akinmusire et al., 2019; Nazarizadeh and Pourreza, 2019). Different blends or levels of natural concentrates have the key to harmony between collaboration and hostility, just as creature creation versus possible poisonousness of added substances that might be reflected in low or further developed creature development straightforwardly (Yadav and Paudel, 2022; Abd El-Hack et al., 2018). Probiotics can decrease the incidence of diseases in poultry and have serious effects from tainting poultry items. Creatures, like as poultry, are helpless against conceivably pathogenic microbes, for example, Salmonella spp., Campylobacter sputorum, Escherichia coli, and Clostridium perfringens (Agboola et al., 2015). There is an overall impact on the addition of dietary aflatoxins in lowering weight acquisition, admission of feed, and increment of feed change proportion.

An examination revealed the diminishing development execution of ovens by 5% for one ppm of aflatoxin B1 in poultry diet. The contentions in outcomes could be credited to the distinctions in incorporation paces of probiotics requiring explores that would characterize an optimal consideration level with ideal efficiency (Agboola et al., 2015). When devoured in the blend, these mycotoxins might show more prominent adverse consequences on the prosperity and usefulness of oven chickens than when burned alone (Manafi and Khosravinia, 2013). Nonetheless, regardless of its momentous reformist speed, challenges as far as illness episodes, shortage of feed, and defilement of meals with mycotoxins, likewise call for thought (Nabi et al., 2018). Thence, the proper assessment of toxin contamination in poultry feed and composition is imposed in applying proper legislation and standard for quality control in feed ingredients.

2. METHODOLOGY

This review was embarked upon with the primary objective of assessing the impact of toxins and the efficiency of toxin binders on poultry. By doing so, the aim was to compile and critically analyze the prevailing literature to provide a holistic understanding of the present knowledge base in this specialized domain. For the extraction of relevant data, we sourced peer-reviewed journal articles primarily from academic databases, namely Web of Science, Google Scholar, SpringerLink, and ScienceDirect. To ensure a comprehensive literature survey, we devised a structured search strategy. The search was framed using specific keywords and their combinations, such as 'Mycotoxin', 'Broilers', 'Toxins', 'Chicken', 'Toxin binders', and 'Aflatoxin'. To further narrow down the pool of articles and enhance their relevance, we set filters to only include English-language articles published within the last decade. The criteria for the inclusion of articles were rigorously defined to ensure the acquisition of quality and relevant data.

Quick Response Code	Access this article online	
	Website: www.mahj.org.my	DOI: 10.26480/mahj.02.2024.83.89

Cite The Article: Netra Prasad Ghimire, Bishnu Yadav (2024). An In-Depth Analysis of The Impact of Toxins and Toxin Binders in Poultry. *Malaysian Animal Husbandry Journal, 4(2): 83-89.*

Articles were deemed suitable for review if they were original research pieces assessing the effects of toxins or evaluating the efficiency of toxin binders on broilers, or if they were review articles that encapsulated the existing state of knowledge in this field. Only articles published in peer-reviewed journals were considered. On the other hand, any studies that deviated from the core theme of toxins and their impact on poultry, non-English articles, and those with incomplete data or methodologies were deliberately excluded from the review. Once the relevant articles were identified, a systematic approach was adopted for data extraction. Key data points, including the authorship, publication year, study design, type of toxin or toxin binder studied, primary outcomes, findings, and overarching conclusions, were extracted and tabulated for each article. Nevertheless, this structured methodology is designed to offer an encompassing overview of the current state of knowledge concerning the effects of toxins and toxin binders in poultry feeds and their performances.

3. Toxin Analysis in Poultry Feed

Poultry feeds are based on cereal grains thus, are very likely for contaminated by various mycotoxins, including aflatoxins and Fusarium toxins (Yadav et al., 2021; Mackay et al., 2022). Apart from cereals, other components are supplemented, ranging from various oilseed cakes to blood meals, bone meals, fish meals, etc., further enhancing the contamination of composite feeds from mycotoxins (Guerre, 2016; Shar et al., 2020). Due to the high rate of mortality and morbidity associated with aflatoxins in feed grains, they are widely understood and hence are high concerns for animal and human health (Bhat et al., 2010; Ghaemmaghami et al., 2020; Greco et al., 2014; Lahutiya and Yadav, 2023). Studies on aflatoxins concluded on having different hepatotoxigenic and carcinogenic impacts on poultry health and performance (Guerre, 2016; Kolosova and Stroka, 2011). Similarly, aflatoxins can pass through eggs and declined growth is noticed in young chicks (Naveed et al., 2022). In poultry, the toxin is mainly found to be causing aflatoxicosis resulting in total suppression of the body's defence system and a minimum production from poultry farms (Yang et al., 2020).

Aflatoxins (AF), zearalenone (ZEN), ochratoxin A (OTA), fumonisins (FUM), trichothecenes such as deoxynivalenol (DON), and T-2 toxin are some of the mycotoxins that can significantly impact the health and productivity of poultry species (Bingham et al., 2003; Greco et al., 2014; Murugesan et al., 2015; Suleman et al., 2022; Wongtangtintan et al., 2016). These are the mycotoxins of the most prominent agro-financial significance. Deoxynivalenol (DON) and Aflatoxin (AF) are two of the best-known and harmful substances for animal feed and other endeavours (İPÇAK et al., 2019; Istiqomah et al., 2017). Aflatoxin B1 (AFB1) is broadly known as the most liver poisonous among AF. To prevent the accessibility of the toxin absorbed by the wholesome lot, it is possible to deal with detoxifying AF by including an adsorbent in animal feed (Wongtangtintan et al., 2016). According to a study, results from the feed plant showed 0.1 ppb in maize and 1.8 ppb in soya bean cake, which was less than 20 ppb AFB1 reasonable level in feed fixings, and this manner ordered as low (Kehinde et al., 2018). In comparison, 736.5 ppb in groundnut cake, 129.3 ppb in Brewers dried grain (BDG), and 61.7 ppb in Maize offal were over 20 ppb and classified as high focus. This high frequency of AfB1 in groundnut cake is not simply dangerous to poultry alone as a result of direct openness but also proposes a high danger to human wellbeing with the chance of roundabout openness through polluted meat, eggs, and other poultry items and side effects.

Guerre found substantial levels of aflatoxins, more than µg/kg, in chicken diets comprised of maize and soybean meal with 50th percentile contamination across Asia and North America, in contrast to the most contaminated chicken diets in Latin America and Southern Europe. Aflatoxin levels in diets made from wheat and soybeans have never exceeded 20 µg/kg globally. However, in South America, diets made from maize had ochratoxin levels of above 100 g/kg at the 75th percentile of contamination in chicken (Guerre, 2016). Many of researchers reported occurrences of Aflatoxin at 64% in poultry feeds (Bindhu and Jin, 2010; Ghaemmaghami et al., 2020; Guerre, 2016; Manafi and Khosravinia, 2013). The standard limit of 20 µg/kg, as stated by the EU, has been found primarily in countries of the tropics, including Nigeria, Ghana, Kenya, and Uganda (Shar et al., 2020; Manafi and Khosravinia, 2013; Bindhu and Jin, 2010; Wongtangtintan et al., 2016). All samples of maize from Malawi, Uganda, and Ethiopia were sullied with aflatoxins at the highest levels of 150 µg/kg (Bhat et al., 2010; Mackay et al., 2022; Attia et al., 2016). Other Sub-Saharan African nations' maize samples showed lower frequencies of below 50% but with amounts as high as 567 µg/kg (Ochieng et al., 2021).

Researchers examined the prevalence of different mycotoxins in various feed samples, finding that the average amounts of Aflatoxin, fumonisin, ochratoxin A, and zearalenone varied from 0.21 to 0.48 ppb, 1.4 to 3.2 ppm, 4.6 to 9.6 ppb, and 46.4 to 67.6 ppb, respectively, and DON from 0.17 to 0.29 ppm were found (Beg et al., 2006). Likewise, the comparison of ERG concentrations in grain samples from maize in 2001 and 2002 revealed a massive difference in aflatoxin levels giving results of 0.2-72 mg/kg, with an average of 6.4 mg/kg in 2001, compared to 0.2-9.7 mg/kg, with an average of 2.1 mg/kg in 2002 (Cegielska-Radziejewska et al., 2013). Naveed et al. Studied the prevalence of Aflatoxin in three different poultry feeds that indicated 92.5% of contamination from collected samples, with grower feed having the highest frequency of aflatoxin levels of 56.34 ppb (Naveed et al., 2022).

3.1 Effects of toxins in poultry

Mycotoxin's effect slyly affects creatures and human wellbeing. This has accounted for more than 500 kinds of mycotoxins (Soltani et al., 2019). The issue of parasitic poisons and supplements debased with a mycotoxin, which has destructive impacts on poultry creation throughout the planet (Abd El-Hack et al., 2018). Mycotoxicosis addresses the third most significant well-being risk influencing the oven business in Pakistan. Mycotoxins, especially aflatoxins, have contaminated creature feedstuffs, inciting dismalness and mortality in business poultry (Nabi et al., 2018).

Many signs showed up because of burning-through high measures of contagious poisons, which led to mortality and were checked to diminish poultry efficiency and clear clinical signs in posthumous injuries. Notwithstanding, in most constant infectious, poisonous cases, low-level parasite digesting consumption results in immunosuppression, a stampeded fall in chicken performance, and subcutaneous drain. Mycotoxins' main negative effects on poultry include a decrease in food consumption, low supplement take-up and digestion, unsettling influence on endocrinology, and immunosuppression (Abd El-Hack et al., 2018). Likewise, Aflatoxin in the diet modifies the amount of the animals' serum biochemical boundaries, demonstrating that these boundaries may be a major factor in aflatoxicosis. According to a study, bacteria disrupt the normal microbiome and gastro epithelial layer, which not just aims to break down the capacity to process and retain supplements but also diminish the villus stature in the small digestive system. Fitting wholesome techniques could reduce the unfriendly impacts of mycotoxins on the presentation and resistance of birds (Soltani et al., 2019).

Aflatoxicosis addresses a form of genuine sickness of ducks that deferred the development of their flesh and skeletal muscles (Astoreca et al., 2011; Ghaemmaghami et al., 2020; Greco et al., 2014). The issue of parasitic poisons and supplements tainted with mycotoxin prompts unsafe consequences for poultry creation throughout the planet. It was affirmed that 25% of overall harvest creation might be sullied with parasitic poisons, and its misfortunes in the poultry businesses utilized came at least $100 million every year (Abd El-Hack et al., 2018). It incorporates the grimness and mortality of poultry, low creation effectiveness, and significant expenses of veterinary consideration (Akinmusire et al., 2019).

4. Different Toxin Binders in Poultry Feed and Their Efficiency

A novel and intriguing tactic to protect animals from such feed's harmful effects is using chemicals to reduce mycotoxin contamination of feed (Yadav et al., 2022). These components, known as mycotoxin binders (MB), are added to food to reduce the number of mycotoxins that reach the blood and target organs and prevent or diminish mycotoxicosis in animals (Kolosova and Stroka, 2011). Although the applications of mycotoxin binders have been a popular countermeasure, given the extreme diversity in the chemical composition of mycotoxins, it is obvious that no specific technique can be used to deactivate them in feed.

As a result, various tactics must be coupled to focus on specific mycotoxins without affecting feed quality (Abd El-Hack et al., 2018; Murugesan et al., 2015). Activated carbons, bentonites, zeolites, and hydrated sodium calcium aluminosilicate have all been investigated and employed as MB adsorbents (Patil et al., 2014). For detoxifying mycotoxins, organic binders such as elements of yeast cell walls, dietary fibres, synthetic polymers, and volatile compounds constitute an intriguing alternative (Kolosova and Stroka, 2011). As a result, it has become common practice to include non-nutritive clay minerals in animals' diets to lower the bioavailability of toxins and their exposure to tainted feeds (Murugesan et al., 2015).

The characteristics of the mycotoxin and the binder affect how well MB works. Depending on their mechanism of action, these feed additives may either bind mycotoxins to their surface (adsorption) or degrade or convert them into metabolites that are less hazardous (biotransformation) (Kolosova and Stroka, 2011). In ground-breaking research from the 1980s, calcium dioctahedral smectite clay (NovaSil, NS) greatly reduced

enterosorption in the GIT, which in turn reduced toxin bioavailability and significantly reduced the negative effects of AF in animals (Murugesan et al., 2015).

The findings showed that AFB1 significantly reduced feed intake, weight increase, feed efficiency, and haematological parameters compared to the control. The pattern of serum Ca and P concentrations and serum proteins (globulin, albumin, and total protein) was the same. AFB1 raised the relative weights of the heart, gizzard, and liver as well as the AST activity in serum in a dose-dependent manner but did not significantly change the ALT activity. TXB boosted weight gain, feed efficiency, haematological parameters, and serum proteins in the AFB1-contaminated diet. The commercial mycotoxin binders did not significantly impact the weight and serum Ca and P concentrations of the relevant organ, although they did reduce AST and ALT activity. This investigation found that total cholesterol, LDL, and HDL were unaffected by AFB1 or commercial toxin binders (Nazarizadeh and Pourreza, 2019).

The inclusion of a binder might greatly change the negative effects of AF. When chicks were fed binder alone without AF, they performed better than the control group. According to the study, AF and binders may have a cumulative effect that harms broiler chicken health (Hedayati et al., 2014). The inorganic TBs were found to have the highest binding capacity, at 98 and 93% at pH 3.0 and 6.8, respectively, whereas the organic TBs had the lowest binding capacity, at 40 and 45% at these same pHs. In vitro testing revealed that mixed TBs had 96 and 88% binding ability to AFB1 at pH 3.0 and 6.8, respectively. The inorganic and composite TBs might be used to lessen the negative effects of AFB1 in chicken feeds because they effectively bind AFB1 among the TBs.

It was discovered that the organic TBs could not bind AFB1 (Yalcin, 2018). Esterified glucomannan bound to AF significantly (p0.01) more (81.6%), whereas moderate binding was observed with T-2 (27.8%) and OA (25.6%). As the number of toxins in the feed increased, so did the binding of each toxin. No relationship was found between the medium's pH and E-capacity GMs to bind mycotoxin (Raju and Devegowda, 2002). A minimum 50% decrease in the levels of AFB1 in liver samples demonstrated the effectiveness of the MTB binder evaluated in the current trial in reducing AFB1 absorption in broilers. In birds fed ten g AFB1/kg feed (P 0.10) and 50 g AFB1/kg feed (P 0.05), the dietary addition of 5 g MTB/kg feed decreased the hepatic AFB1 content by 54.2% and 52.5%, respectively (Moran et al., 2013).

5. Performance of Commercial Broilers on The Inclusion of Toxin Binders in Poultry Feed

No critical mycotoxin × fastener collaboration was noticed for any of the attributes considered; consequently, just fundamental impacts are introduced. The ADG and ADFI were essentially lower ($P < 0.01$) in the ovens that took care of diets containing AFB1. The birds that took care of a diet containing four µg/g of AFB1 had the most elevated FCR though the least FCR is recorded in chicks getting ate less containing 0 and 2 µg/g of AFB1. Poison covers do not influence the ADFI, yet mycotoxin covers (TXB) further developed FCR. Furthermore, the chickens getting Mycosorb and Anzymit have essentially more prominent ADG ($P < 0.01$) than the benchmark group and those getting Formycin (Nazarizadeh and Pourreza, 2019). They have contrasted and the control birds, a more prominent relative load of the heart ($P < 0.05$), gizzard ($P < 0.01$), and liver ($P < 0.01$) is seen in the grills taken care of AFB1-containing consumes fewer calories. No huge impact of TXB was seen on any deliberate organ loads (Table 1) (Nazarizadeh and Pourreza, 2019).

Nonetheless, expanding Aflatoxin to the eating routine without poison fasteners could expand FCR and reduce BW and FI in examination with uncontaminated weight control plans with Aflatoxin in producer and finisher periods. Past reviews have shown a decrease in the execution of oven chicks getting the aflatoxin-defiled eating regimens. An investigation has announced that dietary consideration of 300 ng/kg of AFB1 diminished body weight by 21%. Another examination has shown a 10% reduction in weight gain of grill chicks that took care of the 0.8 mg/kg of AFB1 (Soltani et al., 2019). Taking care of Aflatoxin brought about a checked expansion in DNA fracture, micronucleated normochromic erythrocytes (Mn-NCE) in bone marrow, lipid peroxidation and FAS mRNA articulation, and a stamped decrease in PHGPx quality articulation, micronucleated polychromatic erythrocytes/miniature nucleated normochromic erythrocytes (PCE/NCE) proportion in bone marrow, and GSH in testis and liver (Table 1) (Abd El-Hack et al., 2018).

Table 1: Detailed information about the research on toxin and toxin binders in poultry.

Authors	Study	Toxin	Toxin binder	Dose	Findings	Conclusion	Location
Hasanpour et al., 2018	In-vivo Evaluation of Commercial Toxin Binder (Milbond-TX) as an Anti-Aflatoxin B1 Using Gamma Rays, Electron-beam Irradiation, and a Chicken Model	Aflatoxin B_1	Milbond-TX (Chemical)	0.3%	Milbond-TX toxin binders were added to the contaminated meals, and this had no changes from the control diet in terms of the inhibitory effects of dietary AFB1 on haematological parameters, immunological response, blood chemical variables, factors related to renal function, or lipid profile.	The inclusion of these toxin binders may lessen the negative effects caused by AFB1 in the diets of Japanese quails.	Tehran, Iran
Ahmed et al., 2009	Aflatoxicity's histopathological changes and reduction using a herbomineral toxin binder in broilers	Aflatoxin B_1	Toxiroak (Herbal)	0.125%	Compared to mycotoxicated untreated birds, group III birds that had been afflatoxicated and treated with Toxiroak had modest fatty alterations, an accumulation of lymphoid cells with few heterophils in the liver and kidney, and hemorrhagic patches on the muscle (Group II).	According to the current research, broilers' aflatoxicity may be reduced by supplementing with a herbomineral toxin binder product.	Bangalore, India
Mesgar et al., 2022	Effect of Dietary L-Threonine and Toxin Binder on Aflatoxin B1-Exposure-Related Performance, Blood Parameters, and Immune Response in Broilers	Aflatoxin B_1	Mycofix Plus (Chemical)	1 g/kg	Regardless of AFB1 concentration, Mycofix Plus enhanced several tibia features. In a two-way interaction with AFB1, the additional MP reduced the levels of serum cholesterol and LDH.	The compromised immunological response in broilers exposed to AFB1 was helped by L-Thr and MP.	Shabestar, Iran

Table 1(Cont.): Detailed information about the research on toxin and toxin binders in poultry.

Authors	Study	Toxin	Toxin binder	Dose	Findings	Conclusion	Location
Bedre et al., 2010	Effectiveness of the herbal remedy "Toxiroak" on gross and histological signs of mycotoxicosis in broilers	Aflatoxin B1 + Ochratoxin A	Toxiroak (Herbal)	1.25 g/Kg	When Toxiroak was added to the mycotoxin-containing feed of group IV, the liver and kidneys had minor modifications as opposed to group II, where mycotoxin-fed birds saw significant abnormalities.	The effectiveness of a herbal product in preventing liver and kidney damage brought on by mycotoxin was shown by histopathological criteria.	Maharastra, India
Rashidi et al., 2020a	Effects of licorice extract, probiotic, toxin binder, and biochar made from the chicken litter on the behaviour, immune system function, blood indices, and histology of the liver in broilers exposed to aflatoxin-B1	Aflatoxin B1	Agrabond (Herbal)	1 g/kg	Agrabond reduced the activities of alkaline phosphatase, aspartate aminotransferase, and alanine transaminase 73, the MDA content in breast meat, and the pathological damage to the liver ($P<0.05$).	The harmful effects of AFB1 on the blood indices, immunity, and performance of broiler 75 chickens may be lessened by the toxic binder.	Ilam, Iran
Mahmood et al., 2017	Using readily accessible toxin binders, experimental quails' AFB1 was chemically detoxified	Aflatoxin B1	MycoAD (Chemical)	2.5 g/kg	Treatment with MycoAD led to improvements in body weight increase, feed intake, and feed conversion ratio. Additionally, compared to the control therapy, the haemoglobin contents, leukocyte count, and erythrocyte sedimentation rate all improved.	Given that quails are a more competitive source of protein than broiler chicks in poor nations like Pakistan, this research supports the use of toxin binders in quail diets to reduce AFB1 toxicity in quails.	Lahore, Pakistan
Swathi et al., 2014	Effect of Natural Mycotoxin Binders on White Leghorn Laying Hens' Induced Mycotoxicosis	Aflatoxin & Ochratoxin A	Vilocym (Herbal)	1 kg/ton	In comparison to the mycotoxin-fed group II throughout the trial, improvements in haematological values were seen in treatment groups supplemented with Vilocym® in group III, and the results are similar to the control group I fed with a baseline diet.	The addition of herbal mycotoxin binders to a mycotoxin-contaminated diet resulted in improvements in all metrics, showing that these binders lessen the degree of poisoning.	Bangalore, India
Rajendran et al., 2020	Evaluation of H-zeolite as a poultry ochratoxin binder	Ochratoxin A	H-β zeolite (Natural chemical)	1 kg/ton	When compared to T2, control, and negative control, the broiler treated with HBZ showed enhanced performance in the areas of BW gain, FI, and FCR.	Studies conducted in vitro and in vivo have shown that HBZ is quite effective in adsorbing OTA. A further benefit of HBZ is that it interacts with vitamins less. Such OTA-HBZ interactions show the possible use of HBZ in chicken feed for OTA detoxification.	Chennai, India
Farooqui et al., 2019	In broilers fed aflatoxin and ochratoxin, aluminosilicates and yeast-based mycotoxin binders had ameliorated effects on growth, immunity, and serum chemistry	Aflatoxin & Ochratoxin A	Toxfin (Chemical)	1 g/kg	Chicken treated with Toxfin toxin binders has a better growth rate, FCR, and immunological indices.	1 g/kg of toxin binder is sufficient to reduce the negative effects of aflatoxin B1 and OTA at lower mycotoxin levels in the diet.	Lahore, Pakistan

Table 1(Cont.): Detailed information about the research on toxin and toxin binders in poultry.

Authors	Study	Toxin	Toxin binder	Dose	Findings	Conclusion	Location
Valchev et al., 2020	Aflatoxin B1's hepatotoxic effects are mitigated by the complex toxin binder mycotox® ng in experimentally treated goslings.	Aflatoxin B1	Mycotox NG (Chemical)	0.5 g/kg	The harmful effects of aflatoxin B1 on blood concentrations of examined biochemical blood parameters and the severity of histological liver alterations were somewhat mitigated by the addition of Mycotox NG to the diet of Group IV.	Mycotox NG can lessen the severity of histological lesions brought on by aflatoxicosis as well as the severity of alterations in the parameters that were being analyzed.	Zagora, Bulgaria
Singh, 2019	Effect of Toxin Binder (Mycodetox B2) Supplementation on Liveability, Immune Response, and Organ Pathology in Aflatoxicosis in Japanese Quails	Aflatoxin B1	Mycodetox B2 (Chemical)	1.32 g/kg	Dietary AFB1 at 400 or 600 ppb lowered liveability, suppressed immunity, decreased haemoglobin concentration, raised the H/L ratio, and caused severe histopathological changes in the organs of quail chicks. Toxic binders were added to alleviate these adverse effects.	Japanese quails' deleterious effects on liveability, immunity, haematological parameters, and the gross and histopathology of their internal organs were reduced by the addition of toxin binder (Mycodetox B2) to the AFB1-contaminated meal.	Izatnagar, India
Bibin Becha and Devi, 2015	Effect of Hydrated Sodium Calcium Aluminosilicate (HSCAS) Addition on the Levels of Total Aflatoxin in Poultry Feeds	Aflatoxin B1	Toximar (Chemical)	0.1%	Due to its powerful binding ability, the inclusion of HSCAS considerably reduced the toxicity of Aflatoxin B1 in layer chicken.	The amount of total aflatoxin was discovered to be over the permitted limits in quail layer diets after the addition of HSCAS at the approved dosage.	Kerala, India
Mekala et al., 2015	Enrofloxacin's kinetics of interaction with a toxin-binding substance found in broiler chickens, hydrated sodium calcium aluminosilicate	Enrofloxacin	Hydrated sodium calcium aluminosilicate (Chemical)	0.5%	The presence of HSCAS demonstrated that the volume of distribution was increased and the maximum plasma concentration was dramatically reduced owing to binding interaction with HSCAS introduced in the feed.	The research finds that HSCAS may lower myotoxicity, but that long-term enrofloxacin treatment of broilers combined with HSCAS would impair therapeutic effectiveness and hasten the development of antibiotic resistance.	Tamil Nadu, India

Besides, the beneficial outcome of probiotic and mycotoxin fasteners on grill execution is through the control of the gut microbiota. The significance of controlling the development of intestinal microflora as a method for further developing the prosperity of the host is very much reported. This is because great intestinal well-being will prompt a superior development rate and feed productivity (Agboola et al., 2015). It showed that incorporating one or the other probiotic or mycotoxin fastener in counts calories took care of to grill chickens further developed feed admission at the starter stage, albeit not as much as with the PC diet (Agboola et al., 2015). Mycotoxin Binder can balance with dietary AFB 1 and decay its reverse impact on egg creation and as feed admission. In this way, the cover utilized in the current investigation has an expansive range of action against Aflatoxin as it contains diatomaceous earth minerals and curcuminoids just as chemicals (Manafi and Khosravinia, 2013).

These outcomes showed that aflatoxins unfavourably influenced the invulnerable reaction of birds, stifling the immunizer titter against the ND antibody. Nonetheless, the simultaneous organization of mycotoxins and mycotoxin folios improved the immunosuppressive impact of AF (Nabi et al., 2018). The expansion of mycotoxin folios neutralized the development of the stifling effects of AF. The organization of MT lessened the impeding impacts of mycotoxins on weight gain and FCR of ovens, as recommended by past investigations (Table 1) (Nabi et al., 2018). Nonetheless, supplementation of herbal toxin binder items is effectual in further developing general meat quality credits, for example, corpse yield, dressing %, giblet yield, filet and delicate yield, tactile crude meat attributes, available qualities, organoleptic cooked meat boundaries, by and large attractiveness and adequacy of meat. The item does not have any lingering or antagonistic impact on the crude, eating, and cooking nature of meat and thus is all right for utilization (Waskar et al., 2009).

According to the findings, adding AF to the diet impacted cholesterol, HDL, and LDL levels as well as the weights of the spleen, liver, and pancreas while not affecting the weights of the thymus and kidney. Adding a binder to the impacted parameters might greatly reverse some of these negative impacts. The mortality rate for incorporating the single binder was 0% (Hedayati et al., 2014). The BW growth and FCR of broiler hens fed 0.5 mg of AFB1/kg were able to be restored numerically and significantly by the LE, protein, toxin binder, and PLB utilized in the current investigation. Results revealed that the study's serum biochemical markers and performance were both protected by additives (Rashidi et al., 2020). The ratio of body weight to bone weight, tibia fresh weight, and grower feed intake were improved with Mycofix Plus (p 0.05). The serum aspartate transaminase (AST), glutathione peroxidase (GPX), grower FI, and breast meat yield rose with L-threonine (p 0.05). Breast meat production, cholesterol, lactate dehydrogenase (LDH), and IBV titer all had favourable relationships (Mesgar et al., 2022).

6. Conclusion

Overall, the food and feeds contaminated with toxic substances greatly threaten poultry health. These toxin substances are to be lowered safely by including different toxin binders, which promote the health and

performance of poultry, especially those of commercial boilers. Toxin binders help in the detoxification of those substances. However, these toxic binders should have some positive effect through which diseases like aflatoxicosis and mycotoxicosis can be prevented and helps increase their activity. From this investigation, it can be concluded that different toxic binders are helpful in the performance of commercial boilers. Various materials can bind with toxic substances in feed and thus reduces toxic exposure in consuming poultry. These binding agents help increase body weight, improve the body's immune system, and promote the chicken's health. Hence, the harmful effect of toxic substances in feed should be made known to the farmers to improve commercial poultry production.

REFERENCES

Abd El-Hack, M.E., Samak, D.H., Noreldin, A.E., El-Naggar, K., and Abdo, M., 2018. Probiotics and plant-derived compounds as eco-friendly agents to inhibit microbial toxins in poultry feed: a comprehensive review. Environmental Science and Pollution Research, 25 (32), Pp. 31971–31986. https://doi.org/10.1007/s11356-018-3197-2

Agboola, A.F., Omidiwura, B.R.O., Odu, O., Odupitan, F.T., and Iyayi, E.A., 2015. Effect of Probiotic and Toxin Binder on Performance, Intestinal Microbiota and Gut Morphology in Broiler Chickens. Journal of Animal Science Advances, 5 (7), Pp. 1369. https://doi.org/10.5455/jasa.20150709085312

Ahmed, M.A.E., Ravikanth, K., Rekhe, D.S., and Maini, S., 2009. Histopathological alterations in aflatoxicity and its amelioration with herbomineral toxin binder in broilers. Veterinary World, 2 (10), Pp. 390–392.

Akinmusire, O.O., El-Yuguda, A.D., Musa, J.A., Oyedele, O.A., Sulyok, M., Somorin, Y.M., Ezekiel, C.N., and Krska, R., 2019. Mycotoxins in poultry feed and feed ingredients in Nigeria. Mycotoxin Research, 35 (2), Pp. 149–155. https://doi.org/10.1007/s12550-018-0337-y

Astoreca, A.L., Dalcero, A.M., Pinto, V.F., and Vaamonde, G., 2011. A survey on distribution and toxigenicity of Aspergillus section Flavi in poultry feeds. International Journal of Food Microbiology, 146 (1), Pp. 38–43. https://doi.org/10.1016/j.ijfoodmicro.2011.01.034

Attia, Y.A., Abd Al-Hamid, A.E., Allakany, H.F., Al-Harthi, M.A., and Mohamed, N.A., 2016. Necessity of continuing of supplementation of non-nutritive feed additive during days 21-42 of age following 3 weeks of feeding aflatoxin to broiler chickens. Journal of Applied Animal Research, 44 (1), Pp. 87–98. https://doi.org/10.1080/09712119.2015.1013964

Bedre, D.K., Kulkarni, G.B., Gangane, G.R., Mote, C.S., and Dhaygude, V.S., 2010. Efficacy of "Toxiroak" (herbal preparation) on gross and histopathological observations in mycotoxicosis in broilers. Indian Journal of Veterinary Pathology, 34 (2), Pp. 141–144.

Beg, M.U., Al-Mutairi, M., Beg, K.R., Al-Mazeedi, H.M., Ali, L.N., and Saeed, T., 2006. Mycotoxins in poultry feed in Kuwait. Archives of Environmental Contamination and Toxicology, 50 (4), Pp. 594–602. https://doi.org/10.1007/s00244-005-2094-0

Bhat, R., Rai, R.V., and Karim, A.A., 2010. Mycotoxins in Food and Feed: Present Status and Future Concerns. Comprehensive Reviews in Food Science and Food Safety, 9 (1), Pp. 57–81. https://doi.org/10.1111/j.1541-4337.2009.00094.x

Bibin, B.B., and Devi, S.S., 2015. Effect of addition of hydrated sodium calcium aluminosilicate (HSCAS) on the total aflatoxin levels in poultry feeds. Indian Veterinary Journal, 92 (5), Pp. 41–43.

Bindhu, L.V., and Jin, K.T., 2010. Mycotoxin binders-evaluation of efficiency by the in vitro method. J International Poultry Production, 18 (1), Pp. 1–2.

Bingham, A.K., Phillips, T.D., and Bauer, J.E., 2003. Potential for dietary protection against the effects of aflatoxins in animals. Journal of the American Veterinary Medical Association, 222 (5), Pp. 591–596. https://doi.org/10.2460/javma.2003.222.591

Cegielska-Radziejewska, R., Stuper, K., and Szablewski, T., 2013. Microflora and mycotoxin contamination in poultry feed mixtures from western Poland. Annals of Agricultural and Environmental Medicine, 20 (1), Pp. 30–35.

Farooqui, M.Y., Khalique, A., Rashid, M.A., Mehmood, S., and Malik, M.I., 2019. Aluminosilicates and yeast-based mycotoxin binders: Their ameliorated effects on growth, immunity and serum chemistry in broilers fed aflatoxin and ochratoxin. South African Journal of Animal Sciences, 49 (4), Pp. 619–627. https://doi.org/10.4314/sajas.v49i4.3

Ghaemmaghami, S.S., Pashootan, N., and Razzaghi-Abyaneh, M., 2020. Toxigenicity and phylogeny of Aspergillus section Flavi in poultry feed in Iran. Current Medical Mycology, 6 (1), Pp. 22–29. https://doi.org/10.18502/CMM.6.1.2504

Greco, M.V., Franchi, M.L., Rico Golba, S.L., Pardo, A.G., and Pose, G.N., 2014. Mycotoxins and mycotoxigenic fungi in poultry feed for food-producing animals. Scientific World Journal, Pp. 1–10. https://doi.org/10.1155/2014/968215

Guerre, P., 2016. Worldwide mycotoxins exposure in pig and poultry feed formulations. Toxins, 8 (12). https://doi.org/10.3390/toxins8120350

Hasanpour, S., Rahimi, S., Fani Makki, O., Shahhosseini, G., and Khosravi, A., 2018. In Vivo Assessment of Gamma Rays, Electron-beam Irradiation plus a Commercial Toxin Binder (Milbond-TX) As an Anti-Aflatoxin B1 in a Chicken Model. Iranian Jornal of Toxicology, 12 (2), Pp. 15–20. https://doi.org/10.29252/arakmu.12.2.15

Hedayati, M., Manafi, M., and Yari, M., 2014. Aflatoxicosis in Broilers: Efficacy of a Commercial Mycotoxin Binder on Performance and Immunity Parameters. International Journal of Ecosystem, 4 (4), Pp. 176–183. https://doi.org/10.5923/j.ije.20140404.03

Hedayati, M., Manafi, M., Yari, M., and Mousavipour, S.V., 2014. Commercial Broilers Exposed to Aflatoxin B 1 : Efficacy of a Commercial Mycotoxin Binder on Internal Organ Weights, Biochemical Traits and Mortality. International Journal of Agriculture and Forestry, 4 (5), Pp. 351–358. https://doi.org/10.5923/j.ijaf.20140405.02

İpçak, H.H., Alçiçek, A., and Özüretmen, S., 2019. Evaluation of the effects of mycotoxin binders in animal nutrition. Black Sea Journal of Agriculture, 2 (4), Pp. 218–223.

Istiqomah, L., Damayanti, E., Julendra, H., Suryani, A.E., Sakti, A.A., and Anggraeni, A.S., 2017. Effect of methionine and lactic acid bacteria as aflatoxin binder on broiler performance. AIP Conference Proceedings, 1854(June 2017). https://doi.org/10.1063/1.4985408

Kehinde, H.W., Sekoni, A.A., Olugbemi, T.S., and Onimisi, P.A., 2018. Prevalence of aflatoxin b1 in some common poultry feed ingredients and optimum inclusion levels ofmycofix binder as feed additive on performance of broiler chickens. Nig. J. Anim. Prod., 45 (2), Pp. 137–149.

Kemboi, D.C., Ochieng, P.E., Antonissen, G., Croubels, S., Scippo, M.L., Okoth, S., Kangethe, E.K., Faas, J., Doupovec, B., Lindahl, J.F., and Gathumbi, J.K., 2020. Multi-Mycotoxin Occurrence in Dairy Cattle and Poultry Feeds and Feed Ingredients from Machakos Town, Kenya. Toxins, 12 (12), Pp. 1–16. https://doi.org/10.3390/toxins12120762

Kolosova, A., and Stroka, J., 2011. Substances for reduction of the contamination of feed by mycotoxins: A review. World Mycotoxin Journal, 4 (3), Pp. 225–256. https://doi.org/10.3920/WMJ2011.1288

Mackay, N., Marley, E., Leeman, D., Poplawski, C., and Donnelly, C., 2022. Analysis of Aflatoxins, Fumonisins, Deoxynivalenol, Ochratoxin A, Zearalenone, HT-2, and T-2 Toxins in Animal Feed by LC-MS/MS Using Cleanup with a Multi-Antibody Immunoaffinity Column. Journal of AOAC International, 105 (5), Pp. 1330–1340. https://doi.org/10.1093/jaoacint/qsac035

Mahmood, S., Younus, M., Aslam, A., Anjum, A.A., and Sohail, M.L., 2017. Chemical detoxification of AFB1 in experimental quails using commercially available toxin binders. Journal of Animal and Plant Sciences, 27 (4), Pp. 1133–1141.

Manafi, M., and Khosravinia, H., 2013. Effects of Aflatoxin on the Performance of Broiler Breeders and Its Alleviation through Herbal Mycotoxin Binder. Journal of Agriculture Science and Technology, 15, Pp. 55–63.

Mekala, P., Jagadeeswaran, A., Arivuchelvan, A., Kumar, P.S., Nanjappan, K., and Murthy, T.R.G.K., 2015. Interaction kinetics of enrofloxacin with hydrated sodium calcium aluminosilicate - a toxin binder in broiler chicken authors. World Journal of Pharmaceutical Research, 4 (5), Pp. 1867–1882. http://www.wjpr.net/download/article/1430455217.pdf

Mesgar, A., Shahryar, H.A., Bailey, C.A., Ebrahimnezhad, Y., and Mohan, A., 2022. Effect of Dietary L-Threonine and Toxin Binder on Performance, Blood Parameters, and Immune Response of Broilers Exposed to Aflatoxin B1. Toxins, 14 (3), Pp. 1–23. https://doi.org/10.3390/toxins14030192

Moran, C.A., Apajalahti, J., Yiannikouris, A., Ojanperä, S., and Kettunen, H., 2013. Effects of low dietary aflatoxin B1 on broiler liver concentration without and with Mycosorb ® toxin binder. Journal of Applied Animal Nutrition, 2(Ross 308), Pp. 4–6. https://doi.org/10.1017/jan.2013.11

Murugesan, G.R., Ledoux, D.R., Naehrer, K., Berthiller, F., Applegate, T.J., Grenier, B., Phillips, T.D., and Schatzmayr, G., 2015. Prevalence and effects of mycotoxins on poultry health and performance, and recent development in mycotoxin counteracting strategies. Poultry Science, 94 (6), Pp. 1298–1315. https://doi.org/10.3382/ps/pev075

Nabi, H., Hussain, I., Adil, M., Nasir, A., Sikandar, A., Khan, S., and Khan, N., 2018. Impact of Mycotoxin Binders on Humoral Immunity, Lymphoid Organs and Growth Performance of Broilers. Pakistan Journal of Zoology, 50 (5), Pp. 1611–1618. https://doi.org/10.17582/journal.pjz/2018.50.5.1611.1618

Naveed, M., Haleem, K.S., Ghazanfar, S., Tauseef, I., Bano, N., Adetunji, C.O., Saleem, M. H., Alshaya, H., and Paray, B.A., 2022a. Quantitative Estimation of Aflatoxin Level in Poultry Feed in Selected Poultry Farms. BioMed Research International, Pp. 1–40. https://doi.org/10.1155/2022/5397561

Naveed, M., Haleem, K.S., Ghazanfar, S., Tauseef, I., Bano, N., Adetunji, C.O., Saleem, M.H., Alshaya, H., and Paray, B.A., 2022b. Quantitative Estimation of Aflatoxin Level in Poultry Feed in Selected Poultry Farms. BioMed Research International, 2022. https://doi.org/10.1155/2022/5397561

Nazarizadeh, H., and Pourreza, J., 2019. Evaluation of three mycotoxin binders to prevent the adverse effects of aflatoxin B 1 in growing broilers. Journal of Applied Animal Research, 47 (1), Pp. 135–139. https://doi.org/10.1080/09712119.2019.1584106

Ochieng, P.E., Scippo, M.L., Kemboi, D.C., Croubels, S., Okoth, S., Kang'ethe, E.K., Doupovec, B., Gathumbi, J.K., Lindahl, J.F., and Antonissen, G., 2021. Mycotoxins in poultry feed and feed ingredients from sub-saharan africa and their impact on the production of broiler and layer chickens: A review. Toxins, 13 (9). https://doi.org/10.3390/toxins13090633

Patil, R.D., Sharma, R., and Station, R., 2014. Mycotoxicosis and its control in poultry: A review. Journal of Poultry Science and Technology, 2 (1), Pp. 1–10.

Rajendran, R.M., Umesh, B., and Chirakkal, H., 2020. Assessment of H-β zeolite as an ochratoxin binder for poultry. Poultry Science, 99 (1), Pp. 76–88. https://doi.org/10.3382/ps/pez535

Raju, M.V.L.N., and Devegowda, G., 2002. Esterified-glucomannan in broiler chicken diets-contaminated with aflatoxin, ochratoxin and T-2 toxin: Evaluation of its binding ability (in vitro) and efficacy as immunomodulator. Asian-Australasian Journal of Animal Sciences, 15 (7), Pp. 1051–1056. https://doi.org/10.5713/ajas.2002.1051

Rashidi, N., Khatibjoo, A., Taherpour, K., Akbari-Gharaei, M., and Shirzadi, H., 2020a. Effects of licorice extract, probiotic, toxin binder and poultry litter biochar on performance, immune function, blood indices and liver histopathology of broilers exposed to aflatoxin-B1. In Poultry Science (Vol. 99, Issue 11). Poultry Science Association Inc. https://doi.org/10.1016/j.psj.2020.08.034

Rashidi, N., Khatibjoo, A., Taherpour, K., Akbari-Gharaei, M., and Shirzadi, H., 2020b. Effects of licorice extract, probiotic, toxin binder and poultry litter biochar on performance, immune function, blood indices and liver histopathology of broilers exposed to aflatoxin-B1. Poultry Science, 99 (11), Pp. 5896–5906. https://doi.org/10.1016/j.psj.2020.08.034

Shar, Z.H., Shar, H.H., Jatoi, A., Sherazi, S.T.H., Mahesar, S.A., Khan, E., and Phanwar, Q.K., 2020. Natural co-occurrence of Fusarium toxins in poultry feed and its ingredients. Journal of Consumer Protection and Food Safety, 15 (4), Pp. 341–350. https://doi.org/10.1007/s00003-020-01292-z

Singh, R., 2019. Effect of Supplementation of Toxin Binder (Mycodetox B 2) on Liveability, Immune Response and Pathology of Organs During Aflatoxicosis in Japanese Quails. 07 (01), Pp. 1–7.

Soltani, D.M., Shahryar, H.A., Hosseini, S.A., Ebrahimnezhad, Y., and Aghashahi, A., 2019. Effects of dietary inclusion of commercial toxin binders and prebiotics on performance and immune responses of broiler chicks fed aflatoxin-contaminated diets. South African Journal of Animal Sciences, 49 (2), Pp. 323–331. https://doi.org/10.4314/sajas.v49i2.12

Suleman, S., Qureshi, J.A., and Rasheed, M., 2022. Poultry feed contamination and its potential hazards on human health. Biomedical Letters, 8 (1), Pp. 70–81. https://doi.org/10.47262/bl/8.1.20210901

Swathi, A., Sanganal, J., Shridhar, N., Rashmi, R., Prem Kumar, G., and Suhasini, K., 2014. Effect of Herbal Mycotoxin Binders in Amelioration of Induced Mycotoxicosis in White Leghorn Laying Hens. Science, Technology and Arts Research Journal, 3 (3), Pp. 63. https://doi.org/10.4314/star.v3i3.11

Valchev, I., Stojanchev, K., Nicolov, N., and Binev, R., 2020. Complex toxin binder mycotox® ng influence on the hepatotoxic effect of aflatoxin B1 in experimental treated goslings. Agricultural Science and Technology, 12 (3), Pp. 234–240. https://doi.org/10.15547/ast.2020.03.037

Waskar, V.S., Devangare, A.A., Gosavi, P.P., Ravikanth, K., Maini, S., and Rekhe, D.S., 2009. Meat quality attributes of broilers supplemented with herbal toxin binder product. Veterinary World, 2 (7), Pp. 274–277. https://doi.org/10.5455/vetworld.2009.274-277

Wongtangtintan, S., Neeratanaphan, L., Ruchuwararak, P., Suksangawong, S., Tengjaroenkul, U., Sukon, P., and Tengjaroenkul, B., 2016. Comparative study of aflatoxin B1 adsorption by Thai bentonite and commercial toxin binders at different temperatures in vitro. Livestock Research for Rural Development, 28 (4).

Yalcin, N.F., 2018. In Vitro Activity of Toxin Binders on Aflatoxin B1 in Poultry Gastrointestinal Medium. Pakistan Veterinary Journal, 38 (01), Pp. 61–65. https://doi.org/10.29261/pakvetj/2018.012

Yang, C., Song, G., and Lim, W., 2020. Effects of mycotoxin-contaminated feed on farm animals. In Journal of Hazardous Materials (Vol. 389). Elsevier B.V. https://doi.org/10.1016/j.jhazmat.2020.122087

Yadav, S.P.S., and Paudel, P., 2022. The process standarzizing of mango (Mangifera indica) seed kernel for its value addition: A review. Reviews In Food And Agriculture, 3 (1), Pp. 6-12.

Yadav, S.P.S., Ghimire, N.P., and Yadav, B., 2021. Assessment of nano-derived particles, devices, and systems in animal science: a review. Nanotechnology in Agriculture, 2 (1).

Lahutiya, V., and Yadav, S.P.S., 2023. Systematic analysis of nutritional contents in mango seed kernel (msk) after application of different processing techniques. Malaysian Journal of Halal Research (MJHR), 6 (1), Pp. 09-12.

Yadav, S.P.S., Ghimire, N.P., Yadav, B., and Paudel, P., 2022. Key requirements, status, possibilities, consumer perceptions, and barriers of organic poultry farming: A review. Fundamental and Applied Agriculture, 7 (2), Pp. 150-167.