Iraqi Journal of Veterinary Sciences

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Evaluating zeolite stability as a mycotoxin binder in broiler chickens' growth performance: A meta-analysis

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Article information

Article history:
Received 24 February, 2025
Accepted 28 April, 2025
Published 30 May, 2025

Keywords:
Aflatoxin
Average daily gain
Clinoptilolite
Mycotoxin
Zeolite

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Abstract

Mycotoxin contamination in broiler chicken feed negatively impacts health, growth, and feed efficiency. This study aimed to assess the efficacy of zeolite additives in enhancing growth performance and reducing mortality in broiler chickens exposed to mycotoxins. A systematic review was conducted, analysing relevant studies published between 1970 and 2025, sourced from databases such as BASE, JSTOR, PubMed, ScienceDirect, and Scopus. Of the 169 identified articles, 13 met the inclusion criteria, covering 70 experiments. Publication bias was evaluated using Egger's test, and a random-effects model Hedges (g') was applied to calculate effect sizes. Zeolite supplementation significantly improved average daily gain (ADG), daily feed intake (DFI), and feed conversion ratio (FCR) in mycotoxin-exposed broiler chickens, with effect sizes consistently exceeding $g' > 0.8$ ($P<0.01$). Aflatoxin, aflatoxin B1, and ochratoxin A exhibited the highest responsiveness to zeolite. Improvements were observed across all rearing phases, particularly during the starter and finisher stages. Clinoptilolite-based zeolite significantly reduced FCR and mortality rates ($g' > |0.8|$, $P<0.05$); however, overall mortality rates remained largely unchanged. These findings indicate that zeolite supplementation, particularly clinoptilolite, represents a viable dietary strategy for mitigating mycotoxin exposure in poultry production systems by enhancing growth performance and alleviating mycotoxin-related adverse effects.

DOI: 10.33899/ijvs.2025.157757.4148, ©Authors, 2025, College of Veterinary Medicine, University of Mosul.

Introduction

Mycotoxins are detrimental pollutants frequently present in broiler chicken feed and in the majority of animal feeds. Exposure to mycotoxins, including aflatoxin B_1, ochratoxin A, and fumonisin B_1, adversely affects the health, growth, and feed efficiency of broiler chickens (1,2). The negative consequences encompass diminished weight gain and feed efficiency and increased mortality rates, all of which collectively undermine productivity and profitability in broiler chicken production systems (3-5). Aflatoxin B_1 and ochratoxin A can induce liver and kidney damage, impair immunological function (as seen by reduced antibody titters), and provoke oxidative stress via the production of reactive oxygen species (6). The regulatory limits of contamination levels are also an important consideration, such as the maximum allowable concentration of aflatoxin B_1, ranging from 10-50 ppb in grain-based feeds (7).

Therefore, mitigation strategies are mainly needed as a way of reducing the harmful effects of mycotoxins, mainly residues, which may pose risks to consumers. Zeolites have been extensively investigated for their potential as nutritional additives to mitigate the harmful effects of mycotoxins in broiler chickens. The mechanism of action whereby they exert their effect is through the adsorption and detoxification of a wide range of mycotoxins in the gut, where any adverse effect on performance and health is avoided (8,9). Clinoptilolite (an aluminosilicate mineral classified as a zeolite), possessing a microporous structure, presents a high surface area for adsorption according to pore size and surface characteristics (10). These properties are needed for the trapping of mycotoxins in the zeolite structure (11). Additionally, van der Waals forces, also known as weak forces, enable physical adsorption of the mycotoxins at the surface of clinoptilolite (12,13). Additional studies indicate various chemical interactions that are significant, e.g., mycotoxin adsorption owing to clinoptilolite's large cation exchange capacity, hydrophobic interactions enhanced by organic modifications, and hydrogen bonding with functional groups existing on its surface (13,14). It is worth noting that pH considerably influences mycotoxin adsorption. Ochratoxin A and zearalenone adsorption capacities are pH-dependent and show different adsorption values in different ranges of pH (14,15). Furthermore, organic and acid clinoptilolite treatments have shown enhanced capacities for mycotoxin binding (15,16). Zeolite supplementation in broiler chickens has been noted to have significant benefits on nutrient utilization and overall health. It improves digestion and nutrient retention, leading to better absorption of dry matter, organic matter, crude protein, and gross energy (17,18). It also enhances pancreatic enzyme activity, for example, lipase and amylase, and enhances intestinal health through improved villus height and villus height-to-crypt depth ratio, which enhances better nutrient absorption (19,20). Clinoptilolite evokes immune reactions by elevating percentages of T lymphocytes, i.e., cluster of differentiation 4^+ or 25^+, and B lymphocytes, as well as enhancing blood interleukin concentrations (21). Clinoptilolite enhances intestinal mucosa and serum antioxidant capacity as well and reduces oxidative stress caused by mycotoxins and mortality in infected chickens (19,22). The mechanisms mentioned suggest that incorporating zeolite can enhance both the productivity and health of broiler chickens while concurrently reducing mortality rates (23,24). However, further studies involving the use of zeolite have produced outcomes of lower importance (25,26). Such differences are likely due to extraneous factors that vary across studies, including contrasts in zeolite types, broiler growth stages, and mycotoxin types applied in the experiment. There is a necessity for further scrutiny of these three variables using statistical random-effects models, including the determination of effect size using Hedges' g values (27,28). Variations in mycotoxin type, rearing stage, and zeolite type are likely to have a significant impact on the effectiveness of zeolite in mitigating mycotoxin impact. However, zeolite supplementation minimizes the adverse effects on broiler performance.

This meta-analysis reviews the effects of zeolite supplementation on weight gain, feed intake, feed efficiency, and mortality rate in broiler chickens exposed to mycotoxins. It also examines how different zeolite types, rearing phases, and mycotoxin types influence the growth performance of broiler chickens.

Materials and methods

Data sources and inclusion criteria

Relevant studies were obtained from the BASE, JSTOR, PubMed, ScienceDirect, and Scopus databases, spanning the years 1970 to 2025. The search query employed was: ALL (dietary OR supplementation OR addition) AND ALL (zeolite*) AND ALL (broiler OR broiler chicken) AND ALL (mycotoxin OR aflatoxin OR ochratoxin OR fumonisin OR vomitoxin OR zearalenone). The inquiry, using the PICO approach, encompassed Population (broiler chickens), Intervention (zeolite therapy), Comparison (broiler chickens with and without zeolite supplementation to mitigate mycotoxins), and Outcome (growth performance of broiler chickens) trials. A total of 169 original research publications were identified (Figure 1). Following a filtering procedure conducted by Mendeley, the initial selection comprised 93 articles. Seventy-six papers were analyzed. Forty-three publications were removed as they did not add to the meta-analysis. Ultimately, 28 publications fulfilled the criteria and were subsequently downloaded for further study.

The inclusion criteria for the study were randomized study designs using the Dersimon-Liard method, study populations of fast-growing commercial broiler chickens aged 1-56 days (encompassing the starter to finisher phases of rearing), and interventions that evaluated groups exposed to mycotoxins without zeolite treatment and those exposed with zeolite. Several indicators of broiler chicken growth performance, including average daily weight gain (ADG), total daily feed intake (DFI), feed conversion ratio (FCR), and mortality rate (%), were used as outcome measurements. Only studies that were based on research and provided sufficient data to evaluate heterogeneity (such as variation, standard deviation, or standard error) were considered.

Out of the 32 eligible articles, ten were excluded: two did not report parameters related to broiler chicken growth, three lacked standard deviation measures, and six failed to include relevant treatments. The selection criteria did not impose any restrictions regarding the year of publication. A total of 13 articles were included and categorized into starter, grower, and finisher phases, resulting in 70 input data points (k).

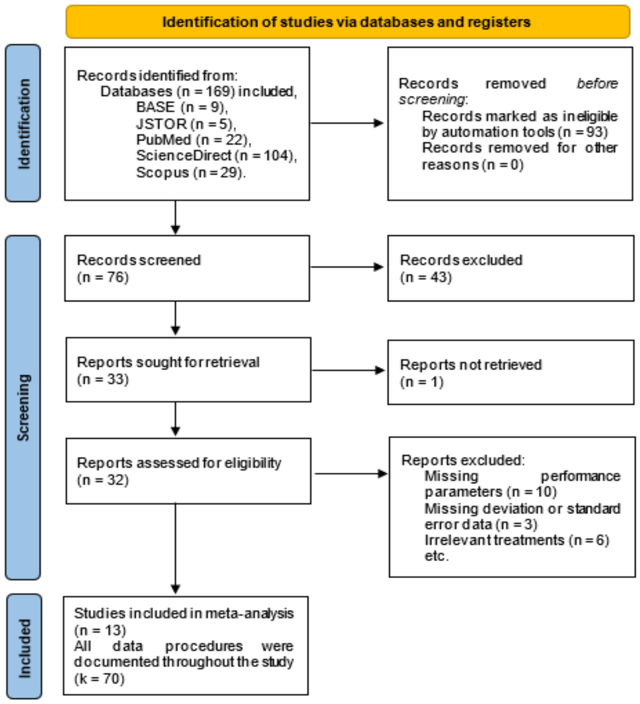

Figure 1. The compilation of studies assessing broiler chicken growth performance under mycotoxin exposure and zeolite application.

Data extraction

Initial information related to the data was tabulated in table 1. The table included details regarding the type and level of zeolite additive (% as fed), type and exposure of mycotoxin (mg/kg), duration of treatment (days of age), and the total number of birds subjected to the tests. The types of zeolites, based on the dominant minerals recorded, included clinoptilolite, hydrated sodium calcium aluminosilicate (HSCA), and an unspecified zeolite (dominant mineral not detailed). The levels of zeolite administered ranged from 0.5% to 2.5% as fed. The types of mycotoxins examined included aflatoxin, aflatoxin B_1, ochratoxin A, and an unspecified mycotoxin (type of mycotoxin unknown). The exposure to mycotoxins varied from 0.05 to 7.5 mg/kg of feed. The duration of treatment ranged from 1 to 56 days of age for the broiler chickens. Additionally, the number of broiler chickens subjected to the treatment varied from 160 to 600.

Analysis of data, software, and bias

In this study, the Hedges (g') effect size model with random effects was used to combine the findings of multiple studies on zeolite effectiveness as a mycotoxin mitigator for the growth performance of broiler chickens through statistical analysis. The decision to use the random-effects model was based on the fact that it allowed for heterogeneity between studies, which could be influenced by differences in study design, population, and measurement methods. The size of the effect was determined by the following criteria: g' = 0.2 was considered small, g' > 0.5' indicated medium, and g' > 0.8' represented large. An I^2 value represented only 25% heterogeneity, while 25-50% represented moderate heterogeneity, and over 50% indicated high heterogeneity. $g'=(X\ treatment-\ Xcontrol)/\ SD\ pooled)\times(1-3/(4(n-1)-9))$. $SE=\sqrt{(1/(\sum w_i)+\tau^2)}$.

In this context, g represents the Hedges effect size of the random-effects model, $\bar{x}$ denotes the mean of the broiler chicken group exposed to mycotoxins that received treatment (zeolite) and control (without zeolite), SD_{pooled} indicates the pooled standard deviation of the treatment and control groups, n represents the number of repetitions, SE signifies the standard error, w denotes the weight of each study, and τ indicates the variation between studies. $Egger=\beta_0+\beta_1\cdot SE+\epsilon$. $t=\beta_0/(SE(\beta_0))$.

Table 1: Characteristics of studies included in the meta-analysis on the effects of zeolite on broiler chickens exposed to mycotoxins experimentally

Type	Addition	Type	Exposure (mg/kg)	Duration (day)	Total bird	References
Zeolite	0.5-1	Aflatoxin B_1	0.3	1-42	384	Silambarasan, *et al.* (23)
Zeolite	0.25-1	Aflatoxin	0.5	1-35	336	Shabani *et al.* (24)
Clinoptilolite	0.1-0.2	Aflatoxin B_1	0.5	1-56	270	Aikore *et al.* (25)
Clinoptilolite	0.1-0.3	Ochratoxin A	0.5	1-10	240	Riahi *et al.* (26)
Zeolite	0.40	Aflatoxin B_1	0.25	11-30	360	Alharthi *et al.* (29)
HSCA	0.50	Aflatoxin B_1	5-7.5	1-21	160-240	Kubena *et al.* (30)
HSCA	0.50	Aflatoxin	5	1-21	144	Kubena *et al.* (31)
Zeolite	0.75	Aflatoxin B_1	1	1-35	600	Modirsanei *et al.* (32)
Clinoptilolite	1.5-2.5	Aflatoxin	2.5	1-21	360	Oguz and Kurtoglu (33)
Clinoptilolite	1.5-2.5	Aflatoxin	2.5	1-21	360	Oguz *et al.* (34)
Clinoptilolite	0.1-0.2	Mycotoxin	0.12-0.55	1-42	375	Raj *et al.* (35)
Clinoptilolite	0.1-0.3	Mycotoxin	0.1	1-42	160	Tsiouris *et al.* (36)
Clinoptilolite	0.5	Aflatoxin B_1	2	1-21	200	Vekiru *et al.* (37)

HSCA, hydrated sodium calcium aluminosilicate.

Subgroup analyses were presented according to mycotoxin type, zeolite, and growth phase to determine the influence of these factors on the effectiveness of zeolite mitigation. Each of these analyses was run using statistical software, such as R version 4.3.2. The *P*-value was considered significant at less than 0.05. Publication bias was assessed with the Egger test (t), in which a significance lower than 0.05 indicated the presence of bias. The parameters are defined as follows: B_0 is the expected effect size, B_1 denotes the change in effect size, SE represents the standard error, and ϵ indicates the variation unexplained by the model.

Results

According to table 2, the addition of zeolite significantly improved ADG in broiler chickens challenged by mycotoxins (g' > 0.8, P<0.001). Similarly, supplementation with clinoptilolite, zeolite, and HSCA resulted in a significant improvement in ADG (g' > 0.5, P<0.001). Overall, zeolite supplementation significantly alleviated the toxic effects of mycotoxins, particularly aflatoxin, aflatoxin B1, and ochratoxin A, as indicated by a strong effect size (g' > 0.8, P<0.05). Besides, supplementation of zeolite improved broiler rearing phases of starter and total rearing periods (g' > 0.8, P<0.01).

Zeolite supplementation improved DFI of broiler chickens significantly (Table 3, g' > 0.8, P<0.001). The main moderators, clinoptilolite and other forms of zeolite improved DFI significantly (g' > 0.8, P<0.001). Mycotoxins responding to the supplementation with zeolites were aflatoxin, aflatoxin B_1, and ochratoxin A, which were significant as related to DFI (g' > 0.8, P<0.001). All results except aflatoxin B_1 did not have a significant publication bias. It was noted that most of the DFI increases during the starter, finisher, and total rearing periods were statistically significant (g' > 0.8, P<0.05). Also, publication bias appeared to exist among the all-phase data in the current meta-analysis.

In general, the addition of zeolite significantly improves FCR in broilers challenged with mycotoxins (Table 4, g' > |0.8|, P<0.01). Subgroup meta-analyses for clinoptilolite and unspecified types of zeolites are also associated with significant improvement in FCR (g' > |0.5|, P<0.05), and clinoptilolite's effect is influenced by publication bias. For different mycotoxin types, aflatoxin B_1, ochratoxin A, and unspecified mycotoxins are strongly related to significant FCR improvement (g' > |0.8|, P<0.01). Rearing phases were also considered significant factors for FCR during finisher and total periods at g' > |0.8|, P< 0.001, as identified by meta-analysis.

Zeolite supplementation did not significantly influence overall mortality rates (Table 5). However, the use of clinoptilolite resulted in a notable reduction in the mortality rate among broiler chickens exposed to mycotoxins (g' > |0.8|, P<0.05). Additionally, a significant decrease in mortality was observed throughout the entire rearing period (g' > |0.8|, P<0.05), although both instances exhibited considerable publication bias.

Table 2: Influence of mycotoxin exposure and zeolite additives on broiler chicken average daily weight gain

	k	g'	SE	Lower	Upper	P	I²	Egger
Overall effect	70	1.66	0.267	1.13	2.18	<0.001	87.3	0.312
Type of zeolite								
Clinoptilolite	34	0.95	0.208	0.541	1.36	<0.001	70.4	0.141
Zeolite	24	2.08	0.449	1.2	2.96	<0.001	81.4	0.975
Hydrated sodium calcium aluminosilicate	12	3.47	0.568	2.36	4.58	<0.001	69.1	0.883
Type of mycotoxin								
Aflatoxin	29	1.74	0.348	1.06	2.42	<0.001	82.3	0.541
Aflatoxin B_1	16	2.49	1.01	0.504	4.48	0.014	93.8	0.778
Mycotoxin	12	0.68	0.203	0.281	1.08	0.001	0.001	0.247
Ochratoxin A	9	1.55	0.613	0.345	2.75	0.012	90.2	0.211
Rearing phase								
Starter	37	1.84	0.394	1.07	2.62	<0.001	87.8	0.524
Finisher	14	0.897	0.516	-0.114	1.91	0.082	87.2	0.969
Total	19	1.19	0.32	0.565	1.82	<0.001	68.2	0.909

k = number of recorded experiments, g' = Hedges' effect size, SE = standard error, I^2 = inconsistency index (if I^2 > 50%, the random-effects model is preferred), Egger = publication bias evaluated using the Egger test.

Table 3: Evaluation of daily feed intake in broiler chickens exposed to mycotoxins and treated with zeolite

	k	g'	SE	Lower	Upper	P	I^2	Egger
Overall effect	50	1.42	0.255	0.923	1.92	<0.001	82.8	<0.001
Type of zeolite								
Clinoptilolite	28	1.31	0.336	0.653	1.97	<0.001	87.9	0.833
Zeolite	22	1.52	0.465	0.608	2.43	0.001	85.5	0.963
Type of mycotoxin								
Aflatoxin	20	0.94	0.33	0.293	1.59	0.004	76.1	0.562
Aflatoxin B_1	13	2.35	0.777	0.831	3.88	0.002	91.2	<0.001
Mycotoxin	6	-0.02	0.369	-0.744	0.704	0.957	46	0.031
Ochratoxin A	9	1.86	0.656	0.574	3.15	0.005	89.7	0.679
Rearing phase								
Starter	21	1.31	0.315	0.695	1.929	<0.001	76.1	0.003
Finisher	12	1.84	0.712	0.447	3.236	0.01	90.2	0.001
Total	17	1.4	0.475	0.469	2.332	0.003	83.5	0.001

k = number of recorded experiments, g' = Hedges' effect size, SE = standard error, I^2 = inconsistency index (if $I^2 > 50\%$, the random-effects model is preferred), Egger = publication bias evaluated using the Egger test.

Table 4: Effect of mycotoxin exposure and zeolite additives on feed conversion ratio in broiler chickens

	k	g'	SE	Lower	Upper	P	I^2	Egger
Overall effect	56	-0.456	0.149	-0.749	-0.164	0.002	70	0.761
Type of zeolite								
Clinoptilolite	34	-0.546	0.194	-0.927	-0.166	0.005	67.3	0.033
Zeolite	22	-1.4	0.155	-1.7	-1.09	<0.001	<0.001	0.967
Type of mycotoxin								
Aflatoxin	20	-0.381	0.298	-0.966	0.203	0.201	73.9	0.462
Aflatoxin B_1	13	-1.2	0.191	-1.57	-0.823	<0.001	-	0.198
Mycotoxin	12	-1.17	0.339	-1.83	-0.502	0.001	56.9	0.08
Ochratoxin A	9	-0.64	0.214	-1.06	-0.222	0.003	46.5	0.377
Rearing phase								
Starter	23	-0.222	0.142	-0.499	0.056	0.118	20.7	0.899
Finisher	14	-1.26	0.301	-1.85	-0.673	<0.001	63.9	0.897
Total	19	-0.911	0.228	-1.36	-0.464	<0.001	47.9	0.715

k = number of recorded experiments, g' = Hedges' effect size, SE = standard error, I^2 = inconsistency index (if $I^2 > 50\%$, the random-effects model is preferred), Egger = publication bias evaluated using the Egger test.

Table 5: Assessment of mortality in broiler chickens following mycotoxin exposure and zeolite supplementation

	k	g'	SE	Lower	Upper	P	I^2	Egger
Overall effect	7	-3.99	5.36	-14.5	6.52	0.457	94.7	0.568
Type of zeolite								
Clinoptilolite	4	-12.1	4.77	-21.5	-2.76	0.011	86.8	<0.001
Hydrated sodium calcium aluminosilicate	3	-2.75	10.7	-23.7	18.2	0.797	93.9	<0.001
Type of mycotoxin								
Aflatoxin B_1	5	-4.05	6.25	-16.3	8.21	0.517	95.5	0.322
Rearing phase								
Starter	3	-2.75	10.7	-23.7	18.2	0.797	93.9	<0.001
Total	4	-12.1	4.77	-21.5	-2.76	0.011	86.8	<0.001

k = number of recorded experiments, g' = Hedges' effect size, SE = standard error, I^2 = inconsistency index (if $I^2 > 50\%$, the random-effects model is preferred), Egger = publication bias evaluated using the Egger test.

Discussion

The findings of the meta-analysis suggest that incorporating zeolite into the feed enhances the ADG of broiler chickens subjected to mycotoxins. This observation is consistent with earlier research that identifies zeolite as a potent mycotoxin binder (38,39). Of note is that clinoptilolite, a type of zeolite, has been shown to effectively adsorb aflatoxins, mitigate their toxic effects, and promote broiler chicken growth (35,40). Clinoptilolite has effective ion exchange properties that allow it to exchange ions, bind, and eliminate heavy metals and toxins from the body (41-43). Moreover, clinoptilolite can adsorb mycotoxins and ammonia, which can further improve gut health and reduce systemic toxicity. Structurally, clinoptilolite represents a network of interconnected silicate tetrahedra SiO_4 with pores that contain metal cations that enable ion exchange with cations from the environment, including Cs^+. These processes depend, among other things, on the ion exchange capacity, the selectivity of the cation, and the physical conditions around it. As an example, Cs^+ may replace Ca^{2+} in the pores of the zeolite (42,44).

Furthermore, based on the meta-analysis, it is evident that there is a significant trend for some kinds of aflatoxins, particularly aflatoxin B_1, to be reduced when they come into contact with zeolites. Some types of aflatoxins function like direct carcinogens by interacting directly with DNA and/or RNA, such as exo-aflatoxin B_1-8,9-epoxide (45,46). Aflatoxin B_1 can produce conjugation with proteins and nucleic acids, thus causing cytotoxicity within cells, affecting apoptosis (45). The meta-analysis showed that among the various types of zeolites, HSCA has the highest affinity to absorb mycotoxins, which was supported by earlier studies. The results showed that HSCA was more effective in absorbing aflatoxin B_1 than clay minerals such as zeolite and bentonite in simulated gastric and intestinal environments (47).

The mechanisms of action through which zeolite works, mitigating its effects on mycotoxins, are through ionic binding and lowering markers responsible for oxidative stress. The detoxification effect that it exerts is related to the intrinsic chemical and physical properties of this substance, making effective ion exchange and adsorption of mycotoxins feasible (48). Previous studies have shown that the zeolite can do ion exchange with Li^+, Cu^{2+}, and Co^{2+}, bringing about critical antifungal efficiency. The inhibition zones observed for the samples are in the range of 24.7-45.3 mm (49). Additionally, the decrease in oxidative stress markers and the changes in gene expression related to the glutathione system indicate that zeolite may contribute to the modulation of the oxidative stress response in poultry (50).

However, the addition of zeolite in the feed of broilers experiencing mycotoxins dramatically increases DFI not only in both starter and finisher periods but over the total growth period. There is publication bias, but consistency across the results between several varying studies underlines the possible interest of zeolites in poultry feeding. Application of zeolite at different levels has been reported to positively enhance feed intake and overall growth performance (51,52). On the other hand, some works reported that supplementation with zeolite may actually reduce DFI (25). The large increase in DFI during the finisher phase and over the whole rearing period indicates that the possible advantage of zeolite can be more easily detected during the last stage of growth. That may be a consequence of better nutrient absorption and less accumulation of toxins, which have an effect on better growth and feed efficiency (17).

Meta-analysis results did not indicate significant outputs related to mortality parameters. However, previous studies also could not point out significant results regarding the reduction in mortality rate (25,30,33,53). However, FCR showed a remarkable change due to zeolite supplementation. This improvement is especially significant when clinoptilolite and other forms of zeolites are applied, as they greatly reduce the adverse effects of mycotoxins such as aflatoxin B_1 and ochratoxin A. Furthermore, in FCR, improvements could be enhanced by using zeolite since it showed effectiveness in the capacity of ochratoxin A binding (26,54). Besides this, some other additives acting on mycotoxin reduction were detailed in previous meta-analysis studies (55,56).

A notable limitation of the meta-analysis is that the included studies primarily concentrated on aflatoxin, fumonisin, and ochratoxin, which may have led to the neglect of other types of mycotoxins that could also influence the growth performance of broiler chickens (3). A more comprehensive investigation into a wider array of mycotoxins is essential to fully evaluate the efficacy of zeolite. This is a limitation and shows that there is still a need for further studies on the interactions of zeolite and its derivatives with other mycotoxins. Furthermore, it is important to consider the dosage of sodium zeolite, as its properties may lead to reduced growth and bone calcium deposition (57). Additionally, the response to bone mineralization may be impaired by the zeolite additive due to low phosphorus content in the feed (58,59). Excessive zeolite supplementation may cause toxicity, disrupt the microbial balance, and compromise the immune system of broilers (42,60). Therefore, it is essential to assess the optimal dosage of zeolite. In addition, further studies are recommended to look for more feed additives that could act as mycotoxin mitigants, including probiotics, prebiotics, and phytobiotics (61-64).

Conclusion

The meta-analysis indicates that zeolite additions effectively mitigate the adverse effects of mycotoxins in broiler chickens. Specifically, during the starter phase, clinoptilolite enhances weight gain and feed intake by counteracting the detrimental effects of mycotoxins and improving feed efficiency. It also reduces the mortality rate attributable to mycotoxins. Both aflatoxin B_1 and ochratoxin A exhibit inhibitory effects due to zeolite treatment, particularly on parameters such as weight gain and feed efficiency. Consequently, all findings suggest that zeolite is a valuable feed additive due to its capacity for mycotoxin adsorption and its ability to enhance the growth performance of broiler chickens.

Acknowledgment

The authors acknowledge the Research Center for Animal Husbandry - BRIN for technical support during the data collection of the meta-analysis database.

Conflict of interest

The authors have no conflicts of interest to declare regarding this work.

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تقييم ثبات الزيوليت باعتباره مادة رابطة للسموم الفطرية في أداء نمو دجاج التسمين: تحليل تلوي

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الخلاصة

التلوث بالميكوتوكسينات في علف دجاج التسمين يؤثر سلبًا على الصحة والنمو وكفاءة التغذية. هدفت هذه الدراسة إلى تقييم فعالية إضافات الزيوليت في تعزيز أداء النمو وتقليل النفوق في دجاج التسمين المعرض للميكوتوكسينات. تم إجراء مراجعة منهجية، وتحليل الدراسات ذات الصلة المنشورة بين عامي ١٩٧٠ و٢٠٢٥، والتي تم الحصول عليها من قواعد البيانات مثل BASE وJSTOR وPubMed وScienceDirect وScopus. من بين ١٦٩ مقالًا محددًا، استوفت ١٣ مقالًا معايير الإدراج، تغطي ٧٠ تجربة. تم تقييم تحيز النشر باستخدام اختبار إيجر، وتم تطبيق نموذج التأثيرات العشوائية هيدجز (g') لحساب أحجام التأثير. حسنت مكملات الزيوليت بشكل كبير من متوسط الزيادة اليومية في الوزن (ADG)، وتناول العلف اليومي (DFI)، ونسبة تحويل العلف (FCR) في دجاج التسمين المعرض للميكوتوكسينات، مع أحجام تأثير تتجاوز باستمرار ($P<0.01$) $g' > 0.8$. أظهر الأفلاتوكسين والأفلاتوكسين B1 والأوكراتوكسين A أعلى استجابة للزيوليت. لوحظت تحسينات في جميع مراحل التربية، خاصة خلال مرحلتي البدء والإنهاء. قلل الزيوليت القائم على الكلينوبتيلوليت بشكل كبير من نسبة تحويل العلف ومعدلات النفوق ($|g'| > |0.8|$، $P<0.05$)؛ ومع ذلك، ظلت معدلات النفوق الإجمالية دون تغيير إلى حد كبير. تشير هذه النتائج إلى أن مكملات الزيوليت، وخاصة الكلينوبتيلوليت، تمثل استراتيجية غذائية قابلة للتطبيق للتخفيف من التعرض للميكوتوكسينات في أنظمة إنتاج الدواجن من خلال تعزيز أداء النمو وتخفيف الآثار السلبية المرتبطة بالميكوتوكسينات.