Effect of Aflatoxin on Feed Conversion Ratio in Broilers: A Meta-analysis

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ABSTRACT: Aflatoxins are natural contaminants of poultry feeds and feed ingredients and cause liver damage, immunosuppression, reduction in performance and mortality in broilers. A number of studies have been carried out to study the effects of aflatoxin on feed conversion ratio in broilers. The results on feed conversion ratio of 10 research articles in broilers fed with aflatoxin from first day of age to six weeks of age were compiled and were subjected to meta-analysis. Chi-square test and Tau^2 (heterogeneity co-efficient) were applied to test for significance of heterogeneity of studies. To integrate results, fixed effect model by Inverse Variance method (IV method) was used when heterogeneity was insignificant and otherwise random effect model by DerSimonian and Laird Method (DL method) was used. The results of meta-analysis showed that the adverse effect of aflatoxin on feed conversion ratio at the end of first week was negligible, second week was medium and third to six weeks was very large. (**Key Words :** Aflatoxin, Feed Conversion Ratio, Broilers, Meta-analysis)

INTRODUCTION

Mycotoxins are toxic secondary metabolites of certain fungi and cause illness or death when ingested by animals or human beings (Qazi and Fayyaz, 2006). One of the most toxic group of mycotoxins are the aflatoxins (AFs), produced by the fungi, *Aspergillus flavus* and *Aspergillus parasiticus.* Aflatoxins were first discovered in 1960 in England after the outbreak of "Turkey-X-disease" during which 1 million turkey poults died in England due to the toxin (Blount, 1961). They are natural contaminants of poultry feeds and feed ingredients, maize, sorghum, pearl millet, rice, peanut meal and cottonseed meal (Reddy et al., 2000). Contamination of feeds and feed ingredients may occur at any time before and after harvest and drying, during storage, processing and manufacturing. Chemically, aflatoxins are a group of difuranocoumarin derivatives and the major types of aflatoxins are aflatoxin B1 (AFB1), aflatoxin B2 (AFB2), aflatoxin G1 (AFG1) and aflatoxin G2 (AFG2). Among the aflatoxins, AFB1 was identified to be the most toxic and most prevalent compound, followed by G1, B2 and G2 with decreasing toxicity (Murphy et al., 2006). Aflatoxin intake in broilers is associated with liver damage, poor performance, immunosuppression and mortality. Aflatoxin toxicity in poultry is also associated with biochemical, hematological, reproductive and pathological changes (Ortatatli and Oguz, 2001). Some of the metabolites formed during the metabolism of AFB1 are transmitted to edible animal products, liver, muscle ((Bintvihok and Davitiyananda, 2002) and eggs, which exert immunosuppressive, embryotoxic and teratogenic effects (Celik et al., 2000; Oliveira et al., 2000). Besides affecting the health of birds and consumers, aflatoxins also cause economic losses to poultry industry. The Council for Agricultural Sciences and Technology recorded an annual crop losses of $932 million due to mycotoxin contamination and additional losses of $466 million in efforts to prevent or reduce contamination (Richard and Payne, 2003).

In poultry, particularly in broilers, a number of studies on the effect of aflatoxins on Feed Conversion Ratio (FCR) have been carried out by researchers worldwide. However a precise estimate of the effect of aflatoxins on the FCR during 1-6 weeks of age of broilers is not available. Hence the present study was undertaken to understand and reveal the effects of aflatoxins on FCR during different weeks of broiler production, by meta-analysis.

MATERIAL AND METHODS

The data of 10 research articles involving 15 studies

(Diaz and Sugahara, 1995; Kubena et al., 1998; Oguz et al., 2000; Oguz and Kurtoglu, 2000; Verma et al., 2004; Celik et al., 2005; Abousadi et al., 2007; Modirsanei et al., 2008; Kermanshahi et al., 2009; Shabani et al., 2010) were selected for meta-analysis.

The results on feed conversion ratio in broilers fed with aflatoxin from first day of age to six weeks of age were compiled and were subjected to meta-analysis to determine the effect of aflatoxin on FCR without any bias. Given a vast quantity of heterogeneous literature, the type of items that were collected includes, the characteristics on the report of the study (such as author, year and source), the study itself, research design (duration of exposure, treatment assignment mechanism or sampling mechanism) and the effect size (sample size, nature of outcome, estimates and standard error). The method applied for meta-analysis was similar to that described earlier (Mondal et al., 2010; Suresh et al., 2010).

The unit of data for meta-analysis was mean and standard deviation reported in the studies. The data were extracted for control and experimental groups in the pre-specified proforma. The following were the inclusion criteria applied to select the study 1). Research conducted on broilers and anywhere in the world; 2). Only studies presented in English and 3).Those studies with complete information is available.

The effect size which is the standardized mean difference of control and experimental setting is defined by Cohen's g and is computed as

$$g = (\frac{\overline{Ye} - \overline{Yc}}{Sp}),$$ where $\overline{Ye}$ is mean of the

experimental group, $\overline{Yc}$ is the mean of the control group and Sp is the pooled standard deviation with

$$Sp = \sqrt{\frac{(n_e - 1)s_e^2 + (n_c - 1)s_c^2}{n_e + n_c - 2}},$$ Since g is biased estimator

of the population effect size and hence g has to be

multiplied by correction term $j = 1 - \frac{3}{4m - 1}$ where

$m = n_e + n_c - 2$, The resulting effect size statistic is as follows

$$d = g(1 - \frac{3}{4m - 1})$$ and the variance of d is

$$\sigma^2 = \frac{n_e + n_c}{n_e n_c} + \frac{d^2}{2(n_e + n_c)}.$$

After testing for significance of heterogeneity of studies based on chi-square test and Tau^2 (heterogeneity co-efficient), fixed effect model or random effect model were selected for integrating the results. When heterogeneity was insignificant, fixed effect model by Inverse Variance method (IV method) was used with zero heterogeneity co-

efficient, otherwise a random effect model by DerSimonian and Laird Method (DL method) was used. Random effect model allows the study variation by co-efficient of heterogeneity to some extent while integrating results and in the present study, the maximum Tau^2 allowed was 100 so as to avoid the larger heterogeneity among the studies (Glass, 1976; Eugene et al., 2004; Sauvant et al., 2008).

Inverse-Variance method

The Inverse-Variance Method (IV method) was used to pool either binary, continuous or correlation data. This approach has wide applicability since it can be used to combine any estimate that has standard error available. The effect size or mean are combined to give a pooled estimate (denoted by θ) by calculating weighted average of the treatment effects from the individual studies as given below.

$$\theta_{IV} = \frac{\sum w_i \theta_i}{\sum w_i}$$

Where the weights w_i are calculated as, $w_i = \frac{1}{SE(\theta_i)^2}$.

That is, the weight for the ith study is equal to its precision of the estimate.

The standard error of θ$_{IV}$ is given by, $SE(\theta_{IV}) = \frac{1}{\sqrt{\sum w_i}}$.

The heterogeneity statistic (denoted by Q$_w$) is given by,

$$Q_w = \sum w_i (\theta_i - \theta_{IV})^2$$

The Q_w follows chi-square distribution with (k-1) degrees of freedom, where k is the number of studies included in the meta-analysis.

DerSimonian and Laird method

The DerSimonian and Laird method (DL method) of meta-analysis is based on the random effects model. Under the random effects model, the assumption of common effect is relaxed, and the effect size or mean θ$_i$ are assumed to have a normal distribution with mean θ and variance τ^2. The usual DL estimate for τ^2 is given by,

$$\tau^2 = \frac{Q_w - (k - 1)}{\sum w_i - \frac{\sum w_1^2}{\sum w_i}}$$

where Q$_w$ is the heterogeneity statistic, and the weights w$_i$ are calculated as in the IV Method, and k is the number of studies. The τ^2 is set to zero if Q$_w$<(k-1). In this approach, the weights for each study effect size w_i' are as given

below.

$$w_i' = \frac{1}{SE(\theta_i)^2 + \tau^2}$$

The pooled estimate is given by,

$$\theta_{DL} = \frac{\sum w_i' \theta_i}{\sum w_i'}$$

With standard error,

$$SE(\theta_{DL}) = \frac{1}{\sqrt{\sum w_i'}}$$

The heterogeneity statistic and its test of significance is as given in the IV method.

RESULTS

Meta-analysis on the effect of feeding aflatoxin during day one to six weeks of age on FCR in broilers

Figure 1 depicts the meta-analysis results on effect of feeding aflatoxin on FCR at 1st week, 2nd week, 3rd week, 4th week, 5th week and 6th week of age of broilers. The results
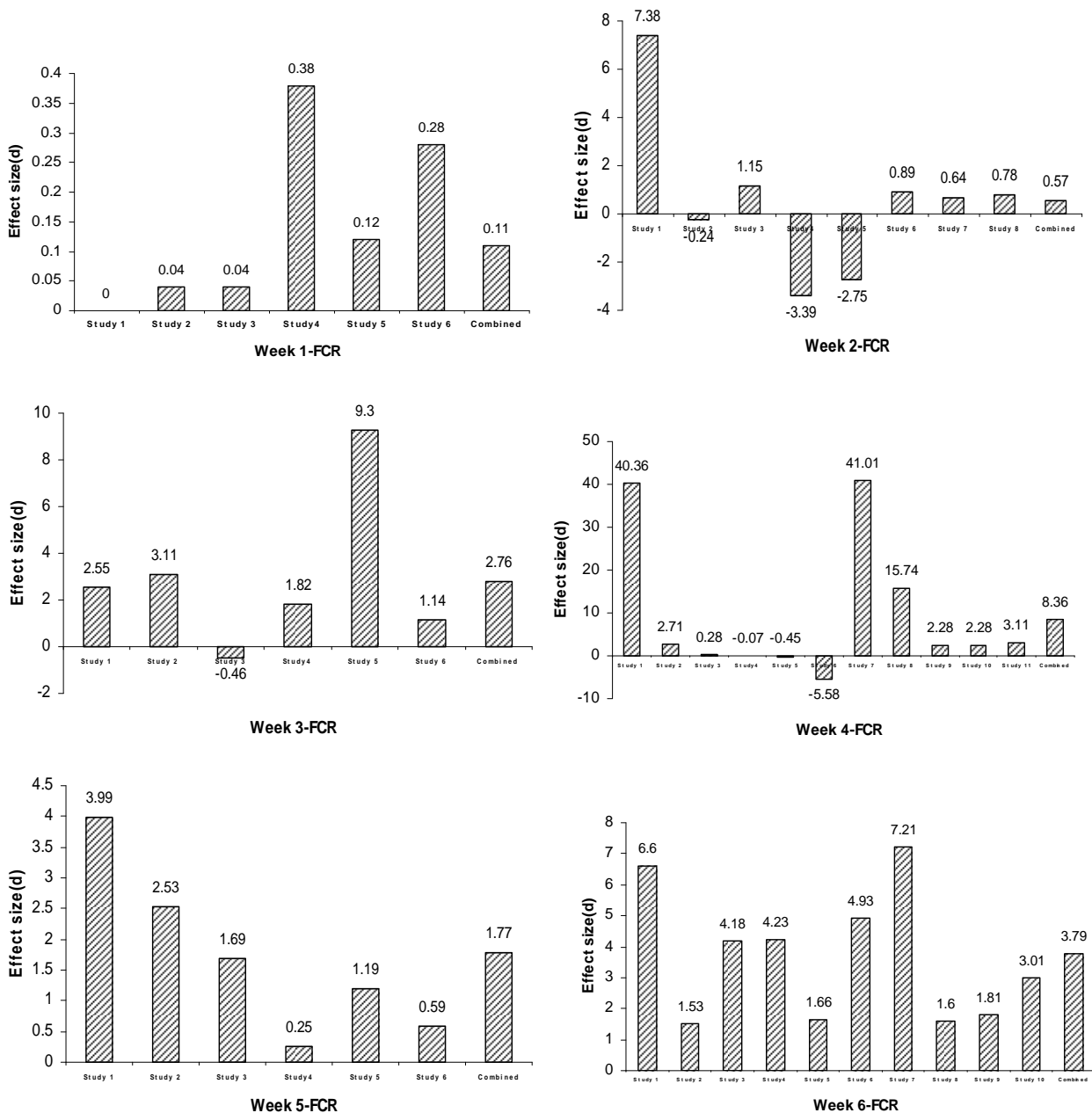

Figure 1. Effect of aflatoxin on feed conversion ratio in broilers during 1-6 weeks of age.

were presented on effect size which is the standardized difference of means of control and experimental groups. Effect reflects the effect of aflatoxin on FCR i.e., higher the effect size, more the toxic effect on FCR. The variation due to dose, setting, birds, breed and laboratory were controlled as effective size and estimated by random effect method.

First week : Among the six studies subjected to meta-analysis, four showed no effect or a negligible effect (effect size d<0.20) on FCR by feeding aflatoxin from first day to one week of age whereas two other studies showed a small effect (0.20<d<0.50). Independent analysis of the results did not confirm the effect of aflatoxin. On the other hand, the meta-analysis of random effect model by DL method showed positive results but with negligible effect (d = 0.112).

Second week : At two weeks of age, feeding aflatoxin to broilers exhibited negligible effect on FCR in five studies (d<0.20) and a small effect (0.20<d<0.50) in one study. In contrary to these results, two other studies revealed a very large effect (d>1.0) of aflatoxin on FCR. But the meta-analysis of random effect model by DL method showed positive results with a medium effect (d = 0.57) of aflatoxin on FCR.

Third week : Meta-analysis of five of the six studies selected showed a negligible effect (d<0.20) on FCR in broilers fed aflatoxin for three weeks whereas one study showed a small effect (0.20<d<0.50). But the results of meta-analysis of random effect model by DL method showed positive effect of aflatoxin on FCR that was very large (d = 2.76) and adverse.

Fourth week : In the fourth week, varied effect of aflatoxin on FCR was observed. Among eleven studies evaluated, nine exhibited a negligible effect (d<0.20). A small effect (0.2<d<0.5) was observed in one study and a very large effect was observed in other study (d>1.2). However, the meta-analysis of random effect model by DL method performed, showed positive effect of aflatoxin on FCR that was very large (d = 8.36) and highly adverse.

Fifth week : Independent analysis of the results of all the six studies subjected to meta-analysis showed negligible effect of aflatoxin on FCR (d<0.20). However, the meta-analysis of random effect model by DL method performed exhibited positive effect of aflatoxin on FCR and the effect was observed to be very large (d = 1.77).

Sixth week : Independent analysis of ten studies at six weeks of age of broilers revealed negligible effect of aflatoxin on FCR (d<0.20). But the meta-analysis of random effect model by DL method performed showed positive effect of aflatoxin on FCR and the effect was very large (d = 3.79).

DISCUSSION

Meta-analysis is a rapidly expanding area of research. It refers to the statistical analysis of large collections of results from individual studies for the purpose of integrating the findings and it is a quantitative study design used to systematically assess previous studies to derive the conclusions about the body of research. Outcomes from meta-analysis may include a more precise estimate of the effect of treatment or the risk factors for disease or condition than any individual studies contributing to the pooled analysis. Identification of the source of variation in responses or heterogeneity of group of studies and generalising of responses can lead to a more effective treatment or modification of management. Examination of heterogeneity is perhaps the most important task in meta-analysis. Meta-analysis places a less emphasis on significance testing and larger emphasis on determining the magnitude and precision of an effect of interest. The poultry industry is one of the fastest growing sectors and a major problem in it is the occurrence of aflatoxins in feed (Caldier, 2007). In the poultry industry, any factor that affects the feed conversion ratio of birds affects the economic gain. Hence the present study is focused to meta-analytically study the effect of feeding aflatoxin on feed conversion ratio in broilers.

The studies selected for meta-analysis were conducted using different doses of aflatoxins ranging from 0.05 ppm to 5.0 ppm. Aflatoxin feeding at 0.6 ppm dose (Diaz and Sugahara, 1995) is shown to decrease FCR at the end of first week of age. Contrary reports indicating no change in FCR by feeding aflatoxins (0.5-3.0 ppm) in diet for 1 week are also available (Oguz and Kurtoglu, 2000; Celik et al., 2005). However, the meta-analysis shows the positive effect which is negligible and this could be attributed to feed intake and weight gain as FCR may depend on feed intake and weight gain. Oguz and Kurtoglu (2000) did not show any reduction in FCR after feeding 2.5 ppm aflatoxin B1 for 2 weeks. However, meta-analysis shows a medium effect which reflects the toxicity induced by aflatoxin. The reports on effect of aflatoxin on FCR at three weeks of age of broilers are contrary. A significant increase in FCR by 17% to 24% is shown in chicks fed a diet containing 2.5 ppm aflatoxin (Huff et al., 1986; Oguz, 1997) and 5.0 ppm aflatoxin (Kubena et al., 1998) from 1 to 21days of age, which in turn indicates the adverse effect of aflatoxins on feed utilization. In contrary to the above findings, Oguz and Kurtoglu (2000) did not observe any significant difference in FCR in birds fed 2.5 ppm up to three weeks of age. In the present study, meta- analysis indicates very large adverse effect of aflatoxin on FCR.

Shabani et al. (2010) demonstrated a reduction in FCR at the end of 4 weeks in birds fed with 0.5 ppm aflatoxin, which is in agreement with earlier studies (Verma et al., 2004; Pandey and Chauhan, 2007) and meta-analysis indicates adverse effect which is very large. Verma et al.

(2004) found a significant reduction in FCR of birds fed 1.0 ppm and 2.0 ppm of aflatoxins at four and seven weeks of age, suggesting an inverse relationship between aflatoxin concentration in feed and FCR. Aflatoxin levels as low as 0.1 ppm for 5 weeks or 8 weeks could affect the FCR in birds (Oguz et al., 2000). Even 50 ppb aflatoxins in feed could be harmful to birds if there are subclinical diseases. Many a time, under the field conditions, birds are exposed to low levels of aflatoxins; chronic exposure of poultry to aflatoxins without clinical symptoms is a major concern in the poultry industry as the diagnosis and treatment are difficult. Celik et al (2005), recorded reduction in FCR in chicks fed diets supplemented with 1.0 ppm aflatoxin B1 for 6 weeks, and this is in agreement with earlier report of Allameh et al. (2005). Kermanshahi et al. (2009) showed that 0.5 and 1.0 ppm aflatoxin did not negatively influence feed conversion ratio even after six weeks of feeding and Edrington et al. (1997) has reported similar results. The meta-analysis indicates very large effect of aflatoxin on FCR which reflects the adverse effect of aflatoxin. The manifestation of chronic or acute toxicosis in broilers depends on strain, duration of exposure and rate of metabolism of aflatoxin to less toxic metabolites (Kermanshahi et al., 2009; Shabani et al., 2010). The adverse effects of aflatoxins are due to anorexia, listlessness, impaired liver functions and protein/lipid utilization mechanisms. Aflatoxin B1 may cause a dose-dependent induction or inhibition of liver mixed function oxygenase activities, which may affect the metabolism of endogenous and exogenous substrates by liver (Shabani et al., 2010). The reduction in activities of specific enzymes involved in digestion of carbohydrates, proteins, lipids nucleic acids and the absorption of essential nutrients by aflatoxin contaminated feed (Abousadi et al., 2007) contributes to reduction in feed efficiency in broilers.

CONCLUSION

In conclusion, the results of the present meta-analysis study indicate adverse effect of aflatoxin on FCR and it is very large from third to six weeks of age of broilers. Such information is of importance to all poultry farmers and the industry.

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