Review

Avian ochratoxicosis: A review

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Ochratoxicosis is one of the most common mycotoxicoses in poultry, specially commercial poultry. It is caused by most dangerous mycotoxin because it causes oncogenic effects in embryos, that is, ochratoxin A. The presence of ochratoxin-A in poultry feed contributes significantly to health disorders and decreases production. This is one of the causes of economic losses in poultry industry due to increased mortality, reduced body weight gain, reduction of carcass quality, greater feed conversion rate and immunosuppression. The risk associated with ochratoxin residues in poultry meat represents a public health concern. The present article reviews most significant scientific literature on ochratoxin and their possible detrimental effects on poultry birds and subsequent public health hazards. Recent studies have revealed that embryos, new born chicks and young poultry are more sensitive to ochratoxin A than adults. Ochratoxin-A has a high affinity for liver, kidneys, bursa of Fabricius and thymus. It causes an appreciable increase in the size of liver and kidneys where as the size of bursa and thymus is reduced. It also causes nephrotoxicity and hepatotoxicity with carcinogenic effect. In embryo, it causes teratologic defects in the form of anophthalmia followed by mandibular hypoplasia, micropthalmia, maxillary retrognathism, reduced body size, everted viscera, spina bifida and exencephaly. Biochemically it causes hypoproteinemia, hypoalbuminemia, hypoglobulinemia and hypoglycaemia. Similarly, it also causes increased levels of blood urea nitrogen (BUN), serum creatinine, uric acid, alanine transaminase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP) and serum triglycerides. In order to prevent and reduce implications of these mycotoxins in poultry feed, there is needs for both global and national strategic programs to reduce the residual accumulation of mycotoxins in grain, to use advanced analytic techniques and to establish new limits concerning the maximum amount of mycotoxins allowed in poultry feed and products from poultry for human consumptions.

Key words: Ochratoxin, toxicity, teratologic defects, immunoglobulins.

INTRODUCTION

Ochratoxins are the most common and dangerous myco-toxins in the poultry feed. The presence of ochratoxins in poultry feed leads to the development of health disorders in human beings and the decrease in production

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performance of poultry. This contributes to huge economic losses to the poultry industry due to increased mortality, reduced body weight gain, altered egg quality and egg production, increased feed conversion ratio, immunosuppression, early embryonic death and embryonic abnormalities. Residual accumulation of ochratoxins in meat and eggs is of public health concern because of consumption of ochratoxin-contaminated poultry products. Ochratoxins are a member of highly toxic compounds consisting of three members, A, B and C which are structurally related and are produced as secondary metabolites by several species of fungus. The name ochratoxin comes from *Aspergillus ocharaceous*. Ochratoxins are mostly produced by *Penicillium verrucosum* but five other species of *Aspergillus* and six other species of *Penicillium* produce it as well. So far, ochratoxin A (OTA) out of A, B and C is the most commonly detected and the most toxic member of the family. OTA is a common contaminant of cocoa beans, peanuts, soya and coffee in particular, the liver, kidneys and bursa of Fabricius are particularly affected by this toxin (Gibson et al., 1990). They are the second major group of mycotoxins to be characterized after the aflatoxins. Structurally, the three toxins differ only very slightly from each other; however, these differences have marked effects on their respective toxic potentials, with ochratoxin-A (OTA) being the most toxic (Peckham et al., 1971; Chang et al., 1979). Considerable species and sex differences in sensitivity towards OTA acute toxicity and half-life have been demonstrated (O'Brien and Dietrich, 2005). The *Aspergillus* OTA producers include strains of seven species in section Circumdati (*Aspergillus ochraceus*, *Aspergillus melleus*, *Aspergillus auricomus*, *Aspergillus ostianus*, *Aspergillus petrakii*, *Aspergillus sclerotiorum* and *Aspergillus sulphureus*), two species in section Flavi (*Aspergillus alliaceus* and *Aspergillus albertensis*), two species in section Nigri (*Aspergillus niger* and *Aspergillus carbonarius*), and one species in section Aspergillus (*Aspergillus glaucus*) (Bayman et al., 2002). Two Penicillium species, *Penicillium verrucosum* and *Penicillium nordicum*, share the ability to produce OTA (Larsen et al., 2001).

The natural occurrence of OTA in food and feedstuffs of plant and animal origin is very common. Due to its long half-life, OTA accumulates in the food chain, and threatens human and animal health because of its extreme toxicity, widespread occurrence and the variety of commodities that it can contaminate (Scott, 1978). OTA has been implycated in a diverse range of toxicological effects, including renal toxicity, mutagenicity, teratogenicity, neuro-toxicity and immunotoxicity in both animals and man (O'Brien and Dietrich, 2005).

Effect of ochratoxin on body weight

Ochratoxin-A has a multifaceted effect on body weight of poultry. As the exposure to ochratoxin is increased, a decrease in feed consumption has been reported in broilers (Kumar et al., 2003) similarly, decrease in the body weight was reported by different workers in broilers and layers (Elaroussi et al., 2006; Hanif et al., 2008). Exposure of birds for long duration also causes reduced feed consumption. Two most important factors, that is, exposure level and exposure period are the most impor-tant conducive factors for a decrease in body weight. The reduction in feed consumption was more noticeable with time and with the higher level of OTA. Effect of OTA on cumulative feed conversion ratio was dose dependent (Elaroussi et al., 2006). The OTA responses studied in several studies were dose and time dependent. The decrease in broiler body weight due to ochratoxicosis was studied by several workers using dietary OTA inclusion rates of 567 ppb (Garcia et al., 2003), 0.5 to 2 parts/10^6 (Prior et al., 1980; Campbell et al., 1983; Kubena et al., 1988; Raju and Devegowda, 2000; Kumar et al., 2003), 1 to 4 parts/106 (Gibson et al., 1989; Verma et al., 2004), 5 parts/10^6 (Stoev et al., 2002) and up to 8 parts/10^6 (Huff et al., 1974, 1980, 1988).

Effect of ochratoxin on liver and kidneys

The effect of OTA on the liver and kidneys is more pronounced as both the liver and the kidney are involved in detoxification and elimination of OTA from the body. Enlargement in both organs on OTA feeding has been reported (Elaroussi et al., 2008). Increased relative weights of liver and kidneys were observed at lower dietary OTA levels when compared with those reported earlier (Elaroussi et al., 2008). This trend was inversely related with dietary OTA levels (Zahoor-ul-Hassan et al., 2011). The enlargement of both organs is probably due to enlargement of epithelium and increased hyperaemia or mononuclear cell infiltration in these organs. As OTA has high plasma protein binding ability due to which its elimination through glomerular filtration might be retarded. This toxin is excreted through kidney tubules using organic anion transporter proteins and is also reabsorbed in all nephron segments using organic anion transporter proteins or might be by other transporters. The reabsorption process reduces OTA excretion, leading to its accumulation in renal tissue and thus contributing to renal toxicity (Dahlmann et al., 1998; Pfohl-Leszkowicz and Manderville, 2007). Ochratoxin-A is also excreted through hepatobiliary route, enterohepatic circulation, and reabsorption in tubules might lead to degenerative changes and enlargement of epithelial cells of the liver and kidneys (Stoev et al., 2000). Gross enlargement of liver and kidney has also been reported by different workers (Kumar et al., 2004; Elaroussi et al., 2008). Similar findings on enlargement of liver and kidneys have been reported in layer chicks hatched from OTA inoculated eggs (Hassan et al., 2012). Pathological changes in the liver and kidney on feeding ochratoxin to broiler chickens have been reported earlier by Huff et al. (1974), Dwivedi and Burns (1984a), Kubena et al. (1985) and Mohiuddin et al. (1992).

Effect of ochratoxin on embryos

Ochratoxin A causes teratogenic effects in the embryos in the form of anopthalmia, mandibular hypoplasia, maxillary retrognathism, everted viscera, microphthalmia, spina bifida, exencephaly, and reduced body size by Gilani et al. (1978). These effects of OTA may be due to DNA adduct formation and subsequently inhibition of protein synthesis (Petkova-Bocharova et al., 2003). Embryonic mortalities in the OTA contaminated diet may be attributed to cytotoxic effects (Wei and Sulik, 1996; Choudhury and Carlson, 1973) and mice embryos (Wei and Sulik, 1993), intoxicated with different doses. No literature is available on the embryonic mortality induced by OTA in chicken embryos to the stage of development (Celik et al., 2000; Neldon-Ortiz and Qureshi, 1992). Morphometric studies of embryos shows that ochratoxin-A causes reduction in the size of embryos and this reduction is OTA dose dependent.

Effect of ochratoxin on lymphoid organs and biochemical parameters in poultry

Ochratoxin A causes a immunoglobulin levels to decrease in fowl (Dwivedi and Burns, 1984b) together with a regression of almost all the lymphoid organs (Peckham et al., 1971; Dwivedi and Burns, 1984a). OTA has also been shown to result in retarded growth and thymic regression in 3-week-old turkey and poultry (Chang et al., 1981). Study indicates that the effect of dietary ochratoxin on the histology of the bursa of Fabricius and thymus has shown necrosis and degeneration. The exposure of birds to 2 ppm ochratoxin-A, in the presence or absence of aluminosilicate, reduced their humoral immune response and the number of mitotic cells in the bursa and thymus. A decrease in the relative weight of thymus and bursa could be because of the necrotic and degenerative changes in these organs that results in the lower immune responses as described earlier (Stoev et al., 2000), Atrophy of the bursa or a decrease in its relative weight in broiler chicks fed ochratoxin A has been reported by Huff et al. (1974) and Kubena et al. (1985). The necrotic and degenerative changes in lymphoid organs (bursa of Fabricius and thymus) were similar as described earlier (Stoev et al., 2002; Elaroussi et al., 2006; Hanif et al., 2008). Ochratoxin A caused impaired immune function and perhaps explains the increased incidence of air-sacculitis in natural disease outbreaks of ochratoxicosis in turkeys (Hamilton et al., 1982). Creppy et al. (1979) suggested that the immune-suppressive effects of OTA might be due to an inhibition of protein and noted lymphocytopaenia and a significant depression in bursal weight and complement activity in fowls treated with both OTA and aflatoxin.

Ochratoxin A in the poultry diet causes alteration in hematologic parameters as reduction in RBC count, Hb concentration and PCV in broilers. Mohiuddin et al. (1993) who added OTA at concentrations of 0.75 - 3.0 mg/kg diet of broiler chicks similar to Stoev et al. (2000), who showed only a significant decrease of RBC count, a decrease in PCV and Hb concentration levels was reported, and attributed it to iron deficiency anemia or as a consequence of a disturbance in the haemopoietic system (Huff et al., 1988). Feed contaminated with OTA causes a significant decrease in WBC count of broilers (Chang et al., 1979; Mohiuddin et al., 1993). Leucocytopaenia was noted by Chang et al. (1979), for the highest dose of OTA. The decrease in the number of leucocytes was reported to be a reflection of a decrease primarily of lymphocytes, and to a lesser extent monocytes (Chang et al., 1979) or heterophils (Chang et al., 1981; Mohiuddin et al., 1993). Such a lymphocytopaenia may be a sensitive and useful indicator of ochratoxicosis that possibly occur due to a direct effect on germinal centers of lymphoid tissues and implies alteration of the immune function. The detrimental effects of OTA on WBC counts were also found in male turkey fed diets contaminated with (Chang et al., 1981), and in Japanese quail administered with OTA by (Farshid and Rajan, 1996). Therefore, O'Brien and Dietrich (2005) attributed the OTA-impaired immunity to a reduction in the proliferating lymphocytes, activation and differentiation of lymphocytes. OTA Ochratoxin-A and Citrinin have multi-faceted effects on biochemical parameters in poultry, it causes hypoproteinemia, hypoalbuminemia, hypoglobulinemia and hypoglycaemia. Similarly, it also causes increased levels of blood urea nitrogen (BUN), serum creatinine, uric acid, alanine transaminase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP) and serum triglycerides in various studies (Jayaramu et al., 2012). Toxicopathological effects of feeding of OTA ochratoxin-A contaminated feed to broiler chicks for 21 days causes a decrease in the feed intake and body weight with behavioural alterations included diarrhea, depression, increased water intake and ruffled feathers. Synergistic effect of ochratoxin along with *Escherichia coli*-challenged broiler chickens causes increased serum levels of aspartate aminotransferase, alanine aminotransferase, uric acid and creatinine and decreased levels of total proteins, albumin, globulins, calcium, and phosphorus were observed in OTA-fed birds. The presence of OTA in poultry rations increased mortality and the severity of an *E. coli* infection (Kumar et al., 2004). Combinations of OTA and T-2 toxin causes significant decrease on immune function of broiler chickens changing the CD4+/CD3+ and CD4+/CD8+ ratios even at a concentrations as low as 0.25 mg/kg of OTA and 0.5 mg/kg of T-2 toxin (Wang et al., 2009).

Conflict of Interests

The authors have not declared any conflict of interests.

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