DIETARY SUPPLEMENTS FOR THE REDUCTION OF MYCOTOXIN INTESTINAL ABSORPTION IN PIGS

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Abstract: Mycotoxins are secondary metabolic products of several moulds that can be found as contaminants of feedstuffs (mainly cereals) and exert toxic effects in animals and human beings. Contamination can already occur in-field but is usually a consequence of poor storage conditions. Pigs are particularly sensitive to the toxic effect of trichothecenes and zearalenone that are produced by Fusarium strains but animal health and production can be compromised also by the ingestion of other mycotoxins, such as aflatoxins, ochratoxins, and fumonisins. While ingestion of all mycotoxins usually result in reduced animal growth, other possible symptoms include reduced feed intake, vomiting and diarrhoea (trichothecenes), reduced reproductive capability (aflatoxins and zearalenone), suppressed immune function (aflatoxins), nephropathy (ohcratoxins), and pulmonary edema (fumonisins). Moreover, to some extent, some mycotoxins can be found in animal organs such as liver (aflatoxins) and kidneys (ochratoxins) and represent a potential threat to consumers health. Several methods have been developed in order to reduce the intestinal absorption of mycotoxins in farm animals. Modern detoxification methods are based on the utilization of dietary supplements such as absorptive materials that can bind the toxins and microbes and enzymes that can inactivate them. Some lactic acid bacteria are able to bind and biotransform mycotoxins while absorptive agents such as aluminosilicates, clays, and mannan oligosaccharides have shown the ability to bind aflatoxins. Similarly, biotransformation of mycotoxins can be achieved through the use of specific enzymes.

Key words: absorptive materials, dietary supplements, enzymes, lactic acid bacteria, mycotoxins, pigs

Introduction

Cereal grains and associated by-products are widely used as energy sources for farm animals. Unfortunately, a variety of moulds can grow on cereals both in
field and during storage and contaminate feedstuffs with mycotoxins that exert toxic effects on animals and human beings.

_Aflatoxins_ are produced by fungal strains belonging to the *Aspergillus flavus* and _A. parasiticus_ species. Aflatoxins can be mainly found on cereals (corn in particular), peanuts and cottonseed (Richard, 2007). Moreover, aflatoxin M₁, a hydroxylated metabolite, is found in milk and cheese. Aflatoxins cause liver damage in animals and are carcinogenic, teratogenic and mutagenic (Miller and Wilson, 1994) but the greatest impact comes from reduced productive and reproductive capability, suppressed immune function, and various pathological effects on organs and tissues (Hoerr and D’Andrea, 1983).

_Trichotheccenes_ are produced by _Fusarium_ species and occur in various cereal crops. At least 50 different trichotheccenes have been identified and deoxynivalenol (DON) and HT-2 toxin are the most frequently detected (Placinta et al., 1999). In particular, DON produces a variety of toxic effects in pigs, including reduction of feed intake, vomiting and diarrhoea, thus affecting animal growth performances (Tiemann and Dänicke, 2007).

_Zearalenone_ is another toxic metabolite produced by many _Fusarium_ species and is often found in cereals with trichotheccenes. Zearalenone causes estrogenic effects in young gilts and also leads to weak piglets and small litter size (Prelusky et al., 1994).

_Fumonisins_ are a group of toxic metabolites produced by _Fusarium_ strains which contaminate cereals worldwide. Among fumonisins, fumonisin B₁ is always the most abundant. Porcine pulmonary edema is caused by fumonisins but reduction of weight gain has also been observed in pigs (Dilkin et al., 2003).

_Ochratoxins_ are secondary metabolites of some _Penicillium_ and _Aspergillus_ strains and are usually found in cereals. Ochratoxin A is nephrotoxic in all animals and particularly in pigs (Milicevic et al., 2008).

### Dietary supplements for the reduction of mycotoxin intestinal absorption

Because mycotoxins are widely distributed, interventions for the detoxification of feedstuffs and prevention of toxicosis in farm animals are critical needs. Several physical and chemical detoxification methods have been proposed (Young et al., 1986; Trenholm et al., 1992; Huwig et al., 2001), but these strategies are expensive and not practical to implement on farms. Conversely, reduction of mycotoxins intestinal absorption in farm animals can be achieved through the utilization of specific dietary supplements.
Absorptive agents

Absorptive agents have been the object of many studies. Among aluminosilicates, hydrated sodium aluminosilicates (HSCAS) have shown a high affinity for aflatoxin B$_1$ and the ability to reduce its growth inhibitory effects in chicks (Phillips et al., 1988). In a study with piglets fed diets contaminated with aflatoxins, different clays (including zeolite, sepiolite, and bentonite) improved animal performance (Schell et al., 1993).

Yeast cell walls constituents such as mannan oligosaccharides (MOS) and beta-glucans have shown the ability to bind aflatoxins (Zaghini et al., 2005) and zearalenone ZEN (Yiannikouris et al., 2004), respectively. Clays and MOS have also shown the ability to bind ZEN (Sabater-Vilar et al., 2007) but have no affinity for trichothecenes (Huwig et al., 2001; Döll et al., 2005; Sabater-Vilar et al., 2007).

Cholesteryamine is an anion exchange resin that has shown the ability to bind fumonisins and ZEN (Avantaggiato et al., 2005).

In general, absorptive agents have little or no effect on the intestinal absorption of trichothecenes and ochratoxins (Huwig et al., 2001). Moreover, many studies that showed the ability of adsorbants to bind mycotoxins were conducted only under in vitro conditions and were not confirmed by in vivo results.

Biotransformation

Recently, research has focused on the utilization of specific strains of bacteria that are able to bind and/or biotransform mycotoxins.

In a trial with contaminated corn silage, Niderkorn et al. (2007) were able to identify some Lactobacillus and Leuconostoc strains that biotransformed ZEN and several Streptococcus and Enterococcus strains that were capable of binding DON, ZEN, and fumonisins. Strains of Lactobacillus rhamnosus have been shown to be effective in binding aflatoxin B$_1$ both in vitro (Haskard et al., 2001; Lahtinen et al., 2004) and in rats (Gratz et al., 2006). Similarly, El-Nezami et al. (2002) observed that some Lactobacillus and Propionibacterium strains were able to bind and remove trichothecenes in vitro. In another study (Schatzmayr et al., 2006), a strain of Eubacterium was found to deactivate trichothecenes. Molnar et al. (2004) identified a yeast strain that was effective against ochratoxin A and ZEN and this strain was named Trichosporon mycotoxionivorans.

Biotransformation of mycotoxins can be achieved also through the use of specific enzymes. Poppenberger et al. (2003) observed that a UDP-glucosyltransferase from Arabidopsis thaliana was able to biotransform DON.

In a study with piglets fed diets contaminated with high levels of DON, Biagi (2008) observed that the utilization of Mycofix® Plus (Biomin, Austria), a
commercial product containing a combination of binding agents (mix of minerals and inactivated yeast cells), enzymes for the biotransformation of mycotoxins, and extracts from plants and algae, reduced the toxic effects of DON, improving piglets growth performance. Conversely, the same commercial product failed to alleviate the growth-depressing effects of DON in fattening pigs (Dänicke et al., 2004).

Tulayakul et al. (2007) observed that feeding piglets with a diet containing green tea extracts or coumarin enhanced aflatoxin B₁ detoxification in the animal tissues.

**Conclusion**

Because efficacy of adsorbing agents has been observed only with aflatoxins and ZEN, strategies to protect pigs from mycotoxicosis should include the utilization of dietary supplements containing not only absorptive materials but also microbes and enzymes that can inactivate the mycotoxins.

Cereal grains and associated by-products are often contaminated by a variety of moulds that can contaminate feedstuffs with mycotoxins that exert toxic effects on animals and human beings.

Aflatoxins are produced by *Aspergillus flavus* and *A. parasiticus* strains and are carcinogenic, teratogenic and mutagenic but their greatest impact comes from reduced productive and reproductive capability and suppressed immune function. Trichotheecenes are produced by *Fusarium* species and occur in various cereal crops. Among trichotheecenes, DON is responsible of reduction of feed intake, vomiting and diarrhoea, thus affecting animal growth performances. Zearalenone is another toxic metabolite produced by *Fusarium* species and is often found in cereals with trichotheecenes. Zearalenone causes estrogenic effects in young gilts and also leads to weak piglets and small litter size. Fumonisins are also produced by *Fusarium* strains and are the cause of porcine pulmonary edema and poor animal growth performance. Ochratoxins are secondary metabolites of some *Penicillium* and *Aspergillus* strains and are usually found in cereals. Ochratoxin A is nephrotoxic in all animals and particularly in pigs.

Several methods have been developed in order to reduce the intestinal absorption of mycotoxins in farm animals. Modern detoxification methods should be based on the utilization of dietary supplements such as absorptive materials that can bind the toxins and microbes and enzymes that can inactivate them. Among absorptive agents, hydrated sodium aluminosilicates (HSCAS) as well as other clays (including zeolite, sepiolite, and bentonite) have shown a high affinity for aflatoxin B₁ and the ability to reduce its growth inhibitory effects in chicks and pigs. Yeast cell walls constituents such as mannan oligosaccharides (MOS) and beta-glucans are able to bind aflatoxins and zearalenone (ZEN), respectively.
Clays and MOS have also shown the ability to bind ZEN but have no affinity for trichothecenes and ochratoxins.

Recently, research has focused on the utilization of specific strains of bacteria that are able to bind and/or biotransform mycotoxins. It has been observed that some strains of *Lactobacillus* and *Leuconostoc* are able to biotransform ZEN and that several *Streptococcus* and *Enterococcus* strains are capable of binding DON, ZEN, and fumonisins. Moreover, strains of *Lactobacillus rhamnosus* are effective in binding aflatoxin B₁ and a strain of *Eubacterium* has been found to deactivate trichothecenes. Biotransformation of mycotoxins can be achieved also through the use of specific enzymes.

Because efficacy of adsorbing agents has been observed only with aflatoxins and ZEN, it seems reasonable that strategies to protect pigs from mycotoxicosis should include the utilization of dietary supplements containing not only absorptive materials but also microbes and enzymes that can inactivate the mycotoxins.

**Dodaci obrocima za redukciju intestinalne apsorpcije mikotoksina kod svinja**

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**Rezime**

Mikotoksinii su sekundarni metabolički proizvodi nekoliko plesni koje se mogu naci kao kontaminanti u hranivima (uglavnom žita) i imaju toksični efekat na životinje i ljude. Do kontaminacije može doći još u polju, ali obično je posledica loših uslova skladištenja.

Svinje su posebno osetljive na toksični efekat trihotecena i zearalenona koje proizvode *Fusarium* sojevi, ali zdravstveno stanje životinja i proizvodnja mogu biti ugroženi unošenjem drugih mikotoksina u organizam, npr. aflatoksa, ohratoksina i fumonizina. I dok unošenje svih mikotoksina u organizam obično rezultira u smanjenju porasta životinja, ostali mogući simptomi uključuju smanjen unos hrane, povraćanje i dijareju (trihoteceni), smanjenu reproduktivnu sposobnost (aflatoksi i zearalenon), smanjene imunološke funkcije (aflatoksi), nefropatiju (ohratoksi), i pulmonarni edem (fumonizini). Takođe, u određenoj meri, neki mikotoksinii se mogu naći u organima životinja kao što su jetra (aflatoksi) i bubrezi (ohratoksi) i predstavljaju potencijalnu opasnost za zdravlje potrošača. Razvijeno je nekoliko metoda kako bi se smanjila intestinalna apsorpcija mikotoksina kod domaćih životinja. Moderne metode detoksifikacije se zasnivaju na korišćenju dodataka obrocima, a to su apsorptivne materije koje mogu da vežu

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