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Mycotoxin detoxifying agents for use in animal feed explained

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MYCOTOXINS are secondary metabolites formed by several fungi species. Some fungi can produce multiple mycotoxins, and some mycotoxins can be produced by more than one fungus. More than 300 types of mycotoxins are currently known.

The mycotoxins of highest importance due to their frequent occurrence and the harm they cause in livestock are aflatoxin, deoxynivalenol (DON), fumonisin, ochratoxin and zearalenone (Chaytor et al., 2011a).

Strategies to prevent growth of mycotoxins in grains in the field and in storage do exist; however, these are not always implemented and do not guarantee the absence of mycotoxins in grains. Some compounds have been shown to reduce the toxicity of mycotoxins when included in animal feeds. These are commonly known as mycotoxin detoxifying agents and can be split into two groups: adsorbing agents/binders and biotransforming agents/modifiers (Vila-Donat et al., 2018).

Adsorbing agents or binders physically bind mycotoxins through the gastrointestinal tract to prevent absorption into the bloodstream. Biotransforming agents or modifiers can transform mycotoxins into less toxic substances through a variety of routes to lessen their impact in the animal.

Adsorbing agents/binders

Inorganic absorbing agents consist primarily of aluminosilicates, which are a common group of rock-forming minerals, or clays, containing silicon and oxygen. Mycotoxins with flat chemical structures, such as aflatoxins, can be "trapped" between layers in the clay, preventing uptake into the bloodstream.

Clay groups that have shown mycotoxin binding efficacy include hydrated sodium calcium aluminosilicate, bentonites and zeolites. Hydrated sodium calcium aluminosilicates have been shown to effectively bind aflatoxin but have not shown impacts on other fusarium mycotoxins (Vila-Donat et al., 2018). Most bentonites have been shown to bind aflatoxins more effectively than zearalenone and ochratoxin (Huwig et al., 2001). Zeolites have demonstrated effective adsorption of aflatoxins and fumonisins; modified zeolites are more effective in adsorption of fumonisins than natural zeolites (Dakovic et al., 2010; Baglieri et al., 2013).

Organic absorbents have also been proposed, including yeast cell wall, lactic acid bacteria, micronized fibers and bio-sorbents and activated carbon. Yeast cell wall has demonstrated some binding efficacy across many mycotoxins, including zearalenone, ochratoxins and fumonisins (Faucet-Marquis et al., 2014; Pfohl-Leszkowicz et al., 2015).

Some lactic acid bacteria strains have been shown to bind certain aflatoxins and zearalenone, likely due to the cell wall peptidoglycans, polysaccharides and teichoic acid (Vila-Donat et al., 2018).

Micronized wheat fibers have shown efficacy with ochratoxin (Aoudia et al., 2009). Humic acids have also demonstrated some efficiency in binding zearalenone and ochratoxin (Sabater-Vilar et al., 2007; Santos et al., 2011).

Activated carbon has demonstrated high affinity for different mycotoxins *in vitro*, but these results have not been confirmed *in vivo* (Avantaggiato et al., 2005). Activated carbon is a non-specific absorber; thus, it is capable of absorbing key dietary nutrients as well.

Biotransforming agents/modifiers

DON (vomitoxin) was the most frequently occurring mycotoxin in feed components, including corn, wheat, barley, rice, soybean meal, corn gluten meal, dried distillers grains, silage and others, according to BIOMIN's 2017 survey (biomin.net).

In the 2016 U.S. corn crop, 75% of analyzed samples were positive for DON, at an average concentration of 955 parts per billion, or 0.9 parts per million (Hendel et al., 2017). As of June 2018, 29% of corn samples had DON levels greater than 1 ppm, which is above the threshold level in complete feeds established by the Food & Drug Administration (FDA Mycotoxin Regulatory Guidance, 2011).

Many studies have confirmed the inability of various commercially available products (including mineral clays, yeast products and enzymes) to recover the decrease in performance of pigs consuming DON (Danicke et al., 2004; Patience et al., 2014; Frobose et al., 2015, 2016, 2017). This is likely due to the chemical structure not being as flat as other toxins.

However, products containing sodium metabisulfite have consistently shown to improve performance of pigs fed DON-contaminated feed (Danicke et al., 2005; Patience et al., 2014; Frobose et al., 2017). More recently, Shawk (2018) found that there were benefits in performance when

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nursery pigs received products containing sodium metabisulfite for longer (42 days) versus shorter (35 days) periods in diets containing DON at 1.5 mg/kg. Sodium metabisulfite reacts with DON, generating DON-sulfonate, and its lower toxicity derives from the faster urinary excretion of sulfonate products (Beyer et al., 2010).

The Bottom Line

Growth and storage conditions can leave grain susceptible to mycotoxin contamination. This is aggravated by the complexity of diets and different sources of ingredients, which can make it difficult to predict which toxins will be present in the complete feed.

Moreover, some types of molds produce different toxins; for example, fusarium species produce zearalenone, fumonisin and DON, and those are frequently found in combination (Hendel et al., 2017). Further, low levels of multiple toxins may still be detrimental to animals (Chaytor et al., 2011b; Frobose et al., 2016).

Because mycotoxin detoxifying agents are only effective on certain mycotoxins, a combination of products providing wide-spectrum coverage of toxins is recommended.

References

Aoudia, N., P. Callu, F. Grosjean and Y. Larondelle. 2009. Effectiveness of mycotoxin sequestration activity of micronized wheat fibers on distribution of ochratoxin A in plasma, liver and kidney of piglets fed a naturally contaminated diet. Food Chem. Toxicol. 47:1485-1489.

Avantaggiato, G., M. Solfrizzo and A. Visconti. 2005. Recent advances on the use of adsorbent materials for detoxification of Fusarium mycotoxins. Food Addit Contam. 22:379-388.

Balieri, A., A. Reyneri, M. Gennari and M. Negre. 2013. Organically modified clays as binders of fumonisins in feedstocks. J. Environ. Sci. Health. B. 48:776-783.

Beyer, M., S. Danicke, D. Rohweder and H.-U. Humpf. 2010. Determination of deoxynivalenol-sulfonate (DONS) in cereals by hydrophilic interaction chromatography coupled to tandem mass spectrometry. Mycotoxin Res. 26:109-117.

Chaytor, A.C., J.A. Hansen, E. van Heugten, M.T. See and S.W. Kim. 2011a. Occurrence and decontamination of mycotoxins in swine feed. Asian-Aust. J. Anim. Sci. 24:723-738.

Chaytor, A.C., M.T. See, J.A. Hansen, A.L.P. de Souza, T.F. Middleton and S.W. Kim. 2011b. Effects of chronic exposure of diets with reduced concentrations of aflatoxin and deoxynivalenol on growth and immune status of pigs. J. Anim. Sci. 89:124-135.

Dakovic, A., M. Kragovic, G.E. Rottinghaus, Z. Sekulic, S. Milicevic, S.K. Milonjic and S. Zaric. 2010. Influence of natural zeolitic tuff and organozeolites surface charge on sorption of ionizable Fumonisin B1. Collids. Surf. B. 76:272-278.

Danicke, S., H. Valenta, S. Doll, M. Ganter and G. Flachowsky. 2004. On the effectiveness of a detoxifying agent in preventing fusario-toxicosis in fattening pigs. Anim. Feed Sci. Technol. 114:141—157.

Danicke, S., H. Valenta, M. Gareis, H.W. Lucht and H. von Reichenbach. 2005. On the effects of a hydrothermal treatment of deoxynivalenol (DON)-contaminated wheat in the presence of sodium metabisulfite ($Na_2S_2O_5$) on DON reduction and piglet performance. Anim. Feed Sci. Technol. 118:93-108.

Faucet-Marquis, V., C. Joannis-Cassan, K. Hadjeba-Medjdoub, N. Ballet and A. Pfohl-Leszkowicz. 2014. Development of an *in vitro* method for the prediction of mycotoxin binding on yeast-based products: Case of aflatoxin B1, zearalenone and ochratoxin A. Appl. Microbiol. Biotechnol. 98:7583-7596.

Food & Drug Administration. 2011. Mycotoxin regulatory guidance: A guide for grain elevators, feed manufacturers, grain processors and exporters. Accessed October 2018 at www.ngfa.org/wp-content/uploads/NGFAComplianceGuide-FDARegulatoryGuidanceforMycotoxins8-2011.pdf.

Frobose, H.L., J.A. Erceg, S.Q. Fowler, M.D. Tokach, J.M. DeRouchey, J.C. Woodworth, S.S. Dritz and R.D. Goodband. 2016. The progression of deoxynivalenol-induced growth suppression in nursery pigs and the potential of an algae-modified montmorillonite clay to mitigate these effects. J. Anim. Sci. 94:3746-3759.

Frobose, H.L., E.D. Fruge, M.D. Tokach, E.L. Hansen, J.M. DeRouchey, S.S. Dritz, R.D. Goodband and J.L. Nelssen. 2015. The effects of deoxynivalenol-contaminated corn dried distillers grains with solubles in nursery pig diets and potential for mitigation by commercially available feed additives. J. Anim. Sci. 93:1074-1088.

Frobose, H.L., E.W. Stephenson, M.D. Tokach, J.M. DeRouchey, J.C. Woodworth, S.S. Dritz and R.D. Goodband. 2017. Effects of potential detoxifying agents on growth performance and deoxynivalenol (DON) urinary balance characteristics of nursery pigs fed DON-contaminated wheat. J. Anim. Sci. 95:327-337.

Hendel, E.G., P.N. Gott, G.R. Murugesan and T. Jenkins. 2017. Survey of mycotoxins in 2016 United States corn. J. Anim. Sci. 95(suppl. 2):36(abstr.).

Huwig, A., S. Freimund, O. Kappeli and H. Dutler. 2001. Mycotoxin detoxication of animal feed by different adsorbents. Toxicol. Lett. 122:179-188.

Patience, J.F., A.J. Myers, S. Ensley, B.M. Jacobs and D. Madson. 2014. Evaluation of two mycotoxin mitigation strategies in grow-finish swine diets containing cord dried distillers grains with solubles naturally contaminated with deoxynivalenol. J. Anim. Sci. 92:620-626.

Pfohl-Leszkowicz, A., K. Hadjeba-Medjdoub, N. Ballet, J. Schrickx and J. Fink-Gremmels. 2015. Assessment and characterization of yeast-based products intended to mitigate ochratoxin exposure using *in vitro* and *in vivo* models. Food Addit. Contam. Part A. 32:604-616.

Sabeater-Vilar, M., H. Malekinejad, M.H.J. Selman, M.A.M. van der Doelen and J. Fink-Gremmels. 2007. *In vitro* assessment of adsorbents aiming to prevent deoxynivalenol and zearalenone mycotoxicoses. Mycpah. 163:81-90.

Santos, R.R., S. Vermeulen, A. Haritova and J. Fink-Gremmels. 2011. Isotherm modeling of organic activated bentonite and humic acid polymer used as mycotoxin adsorbents. Food. Addit. Contam. Part A. 28:1578-1589.

Shawk, D.J. 2018. Effects of sodium, chloride and sodium metabisulfite in nursery and grow-finish pig diets. MSc. thesis, Kansas State University. Viewed Oct. 16.

Vila-Donat, P., S. Marin, V. Sanchis and A.J. Ramos. 2018. A review of the mycotoxin adsorbing agents, with an emphasis on their multi-binding capacity, for animal feed decontamination. Food. Chem. Toxicol. 114:246-259. ■