Mycotoxin Mystery in Pigs: What are the Causes?

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In the last news letter we all learned about the challenges we are facing this year with mycotoxins. As the weather is getting warmer, storage mycotoxins will add up to the existing problem of field mycotoxins. We all know mycotoxins cost money to swine industry, but exactly how much is a question that has been asked for a long time. At last a recent publication in Journal of Agricultural and Food Chemistry (Wu and Munkvold, 2008) shed light on this area. They estimated an annual loss of $147 million to US swine industry if DDGS contaminated with one mycotoxin (fumonisin) is included in all the grower/finisher pig diets. Imagine what the loss could be if feed has two, three or more mycotoxins? This could easily run into billions of dollars. What could be the loss from 500 known mycotoxins and thousands of unknown or masked mycotoxins?

Why the subject of mycotoxins a mystery?
Some times we all hear the comments that if you don't know why your animals are not doing well on your farm, blame it on mycotoxins! Though this sounds silly, there is a reason why people feel so. It is virtually very difficult to relate a specific farm problem to mycotoxins until and unless a through investigation is made. These investigations usually involve on-farm symptoms, post-mortem findings and mycotoxin analysis in feed.

Are these investigations accurate enough to result in a perfect diagnosis? The answer is probably, No. Can we ever accurately diagnose on-farm mycotoxin issues? The answer is may be, but still a long way to go in solving the mysteries around this unique subject. Having said so, pig industry is bit lucky in a way that some of mycotoxin symptoms are specific. This can include zearalenone-induced reproductive problems and vomitoxin-induced feed refusal. But for most of the other mycotoxins, the problems of non-specific symptoms still exist. This News Letter talks about two key factors that contribute to mycotoxin mystery- mycotoxin interactions and masked mycotoxins.

1. Mycotoxin Interactions:
For long scientists and industry professionals were caught up in the dilemma of why pigs in the field conditions show symptoms of mycotoxins at very low or even undetectable levels of mycotoxins? One possible reason could be the additive and synergistic interactions among mycotoxins even at low concentrations (Table 1; Smith et al., 2005) and interactions of mycotoxins with other nutritional and management disorders.

Consequences of mycotoxin interactions:
1. Increases the overall toxicity to animals.
2. Alter classical clinical signs of individual mycotoxin toxicity.
3. Make field diagnosis of mycotoxin cases even more difficult.
4. Interactions also pose challenges to the development of uniform methodologies for the prevention of mycotoxicosis.

5. Although a preventative protocol may effectively reduce the toxicity of one mycotoxin, other mycotoxins may persist at harmful concentrations and cause toxicity.

2. Masked mycotoxins: Can they explain part of the mycotoxin mystery?

The answer is probably yes. Scientific terminology for masked mycotoxins is conjugated mycotoxins, wherein mycotoxin is usually bound to a more polar substance like glucose (Berthiller et al., 2005). They got the name masked mycotoxins as these substances escape routine mycotoxin detection methods but can release their toxic precursors after hydrolysis inside gastrointestinal tract (GIT) and ultimately causing toxicity (Figure 1. Gareis et al., 1990).

Masked Zearalenone

Gareis et al. (1990) examined the stability of zearalenone conjugate (zearalenone-glycoside) during digestion in the GIT of pigs. The metabolites detected in feces and urine samples were only zearalenone and alpha-zearalenol. These results demonstrated that zearalenone conjugates are decomposed during digestion in the GIT and zearalenone is released.

Masked Deoxynivalenol

Berthiller et al. (2005) for the first time reported the natural occurrence of a glucoside of DON in *Fusarium*-infected wheat and maize. The results of this study indicated the importance of considering both DON and DON-3-glucoside with regard to food and feed safety. Masked DON can be present in wheat and barley up to 63 and 88% of actual DON concentrations, respectively (Liu et al., 2005; Zhou et al., 2007). In simple words if DON concentration is 1 ppm in barley, pigs may get exposed to 1.88 ppm at the GIT level. Recent study from University of Guelph looking at masked DON levels in corn revealed similar results (Table 2). Although there was a big variation from sample to sample on % of masked DON, one sample recorded as high as 70% of DON in the masked form.

Does the conjugated mycotoxins story stop with DON and Zearalenone?

The answer is no. In 1986 fatty acid esters of trichothecene *Fusarium* mycotoxins such as trichothecolone, scirpenetriol and T-2 tetraol were detected in banana fruits grown in India (Chakrabarthi and Ghosal, 1986). There are reports of masked fumonisins as well. Further research is needed on the potential occurrence of other masked mycotoxins in various feed ingredients.

Consequences of Masked Mycotoxins

1. Under estimation of the levels of mycotoxins in feeds and feed ingredients and therefore questioning the validity of mycotoxin analysis as a tool to diagnose mycotoxin issues.
2. Mycotoxin regulation authorities setting up inaccurate limits on mycotoxin levels in feeds and feed ingredients.
3. Under estimation of the potential mycotoxin toxicity ultimately leading to mycotoxin outbreaks in animals and hence the economic losses.
4. Failure to implement mycotoxin prevention strategies.
5. Greater chances of mycotoxins getting into food chain and causing public health hazard.

The aforementioned information certainly is enough to call the subject of mycotoxins a mystery and therefore, it is recommended to follow mycotoxin prevention steps at each stage of agriculture and animal production (Jouany, 2007).

Summary

Pigs are highly sensitive to several mycotoxins as reflected in frequent field outbreaks and economic losses. Clear understanding of swine mycotoxicoses has been hindered by many factors. The research findings on mycotoxin interactions and masked mycotoxins have been able to throw some light on why at low or even undetectable levels of mycotoxins pigs exhibit reduced performance and health. There is a need for continued research in looking at various ways of solving mysteries surrounding the topic of mycotoxins. Finally, mycotoxin control is an integrated approach and should be applied at various levels of crop and animal production.

Table 1. Scientifically proven mycotoxin interactions in pigs

Mycotoxins involved	Type of interaction	Reference paper
DON and Fusaric acid	Synergistic	Smith et al., 1997
DON and fumonisin B1	Additive	Harvey et al., 1996
Aflatoxin and T-2 toxin	Additive or less than additive	Harvey et al., 1990
Aflatoxin B1 and Fumonisin B1	Additive or more than additive	Harvey et al., 1995
Ochratoxin A and T-2 toxin	Additive	Harvey et al., 1994
Ochratoxin A and DON	Additive	Lusky et al., 1998
Ochratoxin A and penicillic acid	Synergistic	Stoev et al., 2001

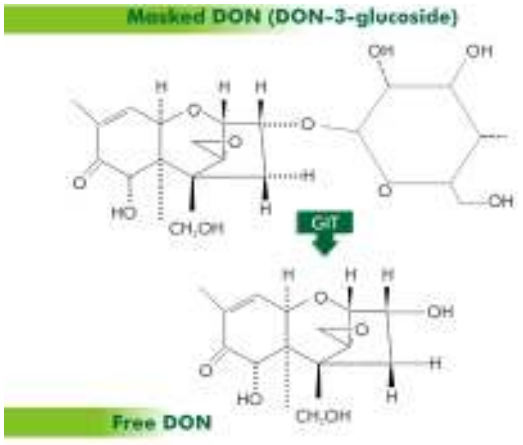

Figure 1. Conversion of masked DON into free DON molecule inside GIT

Table 2. Percent of masked DON out of total DON concentration in Ontario corn samples

Sample	Free DON (ppm)	Masked DON (ppm)	Total DON (ppm)	% masked DON
1	0.60	0.13	0.73	22
2	0.77	0.33	1.10	43
3	0.87	0.22	1.09	25
4	1.87	0.29	2.16	16
5	2.20	1.54	3.34	**70**
6	2.84	0.35	3.19	12
7	6.09	4.12	10.21	68
8	7.06	0.99	8.05	14
9	7.21	1.06	8.27	15
10	7.33	0.55	7.88	8
Average	3.684	0.958	4.602	**29.3**

Tran and Smith, 2009