The role of mycotoxin challenges in gut health and rumen function

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An introduction to mycotoxins

Mycotoxins are a regular concern for agriculture as they influence feed quality and animal safety. Mycotoxins, or secondary metabolites produced by certain species of molds, are invisible compounds that can contaminate crops both pre- and post-harvest. Although mycotoxins were first identified over 50 years ago, they are gaining more attention due to changing agricultural practices, improved analytical technology, new scientific research, and varying climate conditions. The occurrence and concentration of mycotoxins is influenced by many factors, including drought, excess rainfall, hot or cool temperatures, pests and even agronomic practices (Jouany, 2007). Furthermore, mycotoxins have toxic properties that when consumed in feedstuffs and complete rations can impact ruminant health and performance. Although mycotoxin concentrations and types can vary, mycotoxins remain an ever-present threat for even the best run operations.

The challenge of mycotoxins on-farm

Identification of mycotoxicosis can be difficult in a farm setting where animals are often consuming lower mycotoxin concentrations chronically over time. Symptoms are often non-specific and could be associated with other diseases or health challenges that ruminants are experiencing. In these cases, where chronic mycotoxin intake is occurring, the gastrointestinal tract is one of the most impacted organ systems. Although ruminants are generally considered to be less susceptible to mycotoxins, this is based on the idea that rumen microflora can degrade and deactivate mycotoxins. While this is true to an extent, there are a number of mycotoxins that either resist rumen breakdown or that alter microbial populations and their functions (Fink-Gremmels, 2008; Van Eys et al., 2016). To make the challenge more complex, multiple mycotoxins are often detected together which could increase the risk to the animal (Weaver et al., 2021).

Impact of mycotoxins on rumen microflora populations and function

On a daily basis, the rumen can be exposed to many different types and concentrations of mycotoxins through consumption of contaminated rations. Rumen microflora can provide some defense against mycotoxins as there is potential to degrade a portion of some mycotoxins such as aflatoxins and deoxynivalenol (DON) to their less toxic metabolites (Fink-Gremmels, 2008). However, this is not true of all mycotoxins where for example, fumonisins and mycophenolic acid, pass through the rumen without being degraded while mycotoxins such as T-2 toxin (T-2) and zearalenone (ZEA) may actually be converted by microflora to metabolites of equal or greater toxicity (Fink-Gremmels, 2008; Debevere et al. 2020). As a result, these mycotoxins pass

2022 Pacific Northwest Animal Nutrition Conference Proceedings

through the rumen into the small intestinal tract where they can cause direct damage or be absorbed into the body to cause additional internal harm.

In an ideal world, mycotoxins would be degraded in the rumen to minimize the effect on the cow. However, the rumen environment is influenced by a number of factors that can lessen the degradation of mycotoxins and therefor increase the mycotoxin risk to the cow. For example, research by Debevere et al. (2020) showed that rumen fluid at a lower pH resulted in slower disappearance of DON. Stressed or sick cows, and those with increased rumen passage rate, may also have lower rumen degradation of mycotoxins (Van Eys et al., 2016). Mycotoxins themselves can also negatively impact the activity of rumen microorganisms. Patulin, one of the *Penicillium* mycotoxins, has antimicrobial activity for Gram+ and Gram- bacteria and protozoa (Fink-Gremmels, 2008). In addition to having negative effects on the viability of microflora, the presence of patulin in the rumen is also shown to lower the production of total volatile fatty acids (Tapia et al., 2005). Another mycotoxin that can have direct effects on the microflora is fusaric acid. Research monitoring the growth of two different microbes, *Ruminoccus albus* and *Methanobrevibacter ruminatium*, showed that with increasing fusaric acid concentrations the growth of these organisms was decreased, and they were unable to adapt to the presence of the mycotoxin over time (May et al., 2000). Consumption of DON by dairy cows can also result in changes to rumen output. Research by Danicke et al. (2005) showed that the microbial protein output of cows consuming DON was significantly lowered by about 20%. In summary, the presence of mycotoxins could lead to changes to microbial populations that may increase mycotoxins escaping rumen degradation. Mycotoxin presence may also lead to changes in rumen stability, function and output as well as downstream effects such as poor feed conversion, reduced milk production or diarrhea.

Impact of mycotoxins on intestinal health and function

Once mycotoxins pass through the rumen, they enter the small intestine where they can cause direct damage to intestinal tissues or be absorbed to a similar extent as that observed with monogastric animals. *Fusarium* mycotoxins such as DON, T-2 and fumonisins are shown to reduce intestinal cell proliferation which in turn can reduce villus height and increase intestinal damage (Antonissen et al., 2014). These rapidly regenerating epithelial cells maintain the intestinal barrier which is important for not only absorption of nutrients but also maintenance of intestinal immunity and protection from pathogens (Vancamelbecke and Vermeire, 2017). Beyond damaging epithelial cells, mycotoxins can also increase intestinal permeability through their role in weakening the tight junctions between cells thus further weakening the intestinal barrier (Gao et al., 2020). Many of the *Fusarium* mycotoxins, and particularly the combination of mycotoxins, also reduce mucus production by goblet cells. As such, the combination of these effects on the intestinal structure often leads to increased growth of pathogenic microorganisms and greater penetration of these pathogens across the epithelial lining. This effect then contributes to greater inflammatory responses and disease.

Damage and inflammation of the intestinal tract, as well as increased gut pathogens, could lead to a variety of secondary symptoms in cattle. The mycotoxin T-2 is associated with the occurrence of gastroenteritis, intestinal hemorrhaging, diarrhea, and bloody feces (Whitlow and Hager, 2005). Simultaneous to the damage and negative effects occurring at the intestinal tract level, the intake of mycotoxin contaminated feed materials can also lead to other downstream effects on the performance, health, and reproductive status of cattle. These negative effects could lead to decreased farm productivity, increased veterinary costs, and loss of profitability.

Minimizing animal performance and health issues associated with mycotoxins

Although mycotoxins are a challenge for the agricultural industry, management strategies are available for reducing the concentration of mycotoxins in feeds or reducing the negative effects on animals. One of the most important strategies for understanding mycotoxin risk is the pre- and post-harvest use of analytical technologies that allow for mycotoxin quantification and monitoring. These technologies may include enzyme linked immunosorbent assay (ELISA) based technology or liquid chromatography tandem mass spectrometry (LC-MS/MS) that allow for rapid detection of mycotoxins (Weaver et al., 2020). Through analysis, mycotoxin challenge can be identified. Additionally, the use of feed additives or supplements may be used that minimize the effects of mycotoxins on the animal. Of these, yeast cell wall extract (YCWE) material that is rich in complex insoluble carbohydrates, has demonstrated considerable ability for the binding of several mycotoxins both *in vitro*, *ex vivo*, and *in vivo* (Yiannikouris et al., 2013; Santos and Fink-Gremmels, 2014; Kolawole et al., 2019). As such, the performance, health, and welfare of animals reared using an appropriate mycotoxin management program may be improved.

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