Decontamination Strategies To Reduce The Impact Of Deoxynivalenol (DON)-Contaminated Grain On Farm Animals Particularly Swine – A Review

Johnson, N. C., Iorliam, B.

Rivers state University, Department of Animal Science,
Nigeria, 234 909 462 4825

Federal University of Agriculture, Makurdi, Department of Food Science and Technology,
Nigeria, 234 813 902 9781
biorliam@gmail.com

Abstract: Due to the negative impacts of DON on the growth performance of pigs it is recommended that DON in the diets of pigs should not be above 1 ppm. It is however further recommended that for pregnant and lactating pigs, their diets should be 'DON-free.' However, based on data from recent studies it is recommended that DON should not be more than 2 ppm in the diets meant for barrows. Nevertheless, although DON effects on swine is dose-dependent and for the fact that DON occurrence in grains can be sporadic in some growing seasons, the establishment of the threshold of DON would be difficult. In support of findings of some studies, barrows could tolerate DON level of 2 ppm in their diets without reduction in performance. Therefore, in growing seasons of heavy fusarium challenge grains can be highly contaminated by DON thereby making it difficult to feed or use such grains in the diets of swine. Strategies are therefore required to reduce DON loads of such grain if they are intended for swine feeding. During such seasons DON in grains can be as high as 5 ppm. An effective strategy of DON decontamination of the grain therefore may be capable of converting such grains to usable feedstuffs for swine, especially barrows. This paper highlights strategies that can be adopted to better manage DON in grains. The strategy to adopt is dependent on the available technology in the environment. They come under biological, chemical and physical strategies.

Key words: Decontamination, DON, Grain, Strategies and Swine

1 Introduction

Deoxynivalenol (DON) is also known as vomitoxin as one of its negative impacts on swine is emesis [1]. Vomitoxin therefore is very toxic to farm animals, especially swine [2], [3]. It is actually the metabolite of fungi of crops in the field during production as well as in storage. Although there are many fungi-producing mycotoxins species at present mycotoxins of fusaria-species are more ubiquitous and thus more prevalent in crops world-wide producing DON in addition to zearalenone and nivalenol mycotoxins [1], [4]; this probably can explain in part why fusaria mycotoxins are very toxic to swine leading to significant reductions in their performance [5]. Therefore, in seasons when environmental conditions favour fusarium growth and the production of DON in grains contamination will certainly be unavoidable problem to grain producers [6]. This in turn will affect the cost of livestock production, particularly swine that grain forms majority part of its diet [7]. Here, due to economic considerations barley more readily comes to mind as barley is primarily used as an energy source in swine diets; although it also supplies some crude protein, amino acids and minerals, such as calcium and phosphorus [7]. The digestible energy (DE) of barley has been shown to be similar to that of corn in pig feeding [8]. Economically, barley is cheaper in cost compared with corn and wheat for use in swine diets. For instance, according to Canada statistics 2003 records, while a tonne of wheat costs $161, a tonne of corn cost $142 while a tonne of barley costs $139, respectively. Therefore, the use of barley in swine diets in place of more expensive corn and wheat would create revenue for the hog farmer. As a result of these advantages of barley over corn and wheat for swine use one of the major goals of the agricultural industry has been the search for a suitable means for removing DON from DON-contaminated grains, especially barley to alleviate its negative impacts on swine production efficiency. To this point therefore, in order for a decontamination method or strategy to be viable for adoption for use by the agricultural industry it needs to be effective in removing DON and other mycotoxins, such as zearalenone and nivalenol that are co-produced with DON [4]. Furthermore, the strategy needs to be simple and inexpensive; ideally suitable to the use of existing technology in the environment [6]. Additionally, the strategy should work without the possibility of producing new toxins and also should not significantly alter the nutritional and palatability properties of the grain or grain products [6]. To these standpoints, until a cost-effective applicable strategy of removing DON from grains to diminish or at least minimize its effects on animals is available, the feed, food and agricultural industries will continue to experience problems associated with DON in feed grains [9] - [10]. This poses a serious threat and challenge to users of grain and grain products in any fusarium endemic region of the globe. At this point, some major strategies that can be adopted in managing DON in grains depend on what is less expensive and more importantly the available technology in the environment as to avoid increase in the overall cost of production. These strategies come under biological, chemical and physical strategies.

2 Biological Strategies

Different biological approaches of decontaminating DON-contaminated grains have evolved with respect to feeding swine. The major aim and technique in adopting the biological strategy basically involved manipulations targeted in minimizing the effects of DON on the animal by manipulating the contaminated diet. These manipulations take or use different concepts and approaches. One of such strategies is the dilution of DON-contaminated grain with non-contaminated grain. Improving the nutritional content of the diet to compensate for DON-induced reductions in feed intake, such as fortification by the addition of fat to the diet to increase the energy content of the diet; addition of protein, essential amino acids like lysine, minerals and vitamins [11]. This also involves the addition of flavouring agents to the diet to improve feed palatability and intake [12]; addition of potential DON-binding agents to the diet to inhibit absorption and stimulate metabolism of the toxin by the animal, including the use of dietary adsorbents [6]. Here, biological agents such as micro-organisms and enzymes of animals can be used to detoxify DON-containing diets [13]. For instance, the incubation of DON-contaminated grains with bacteria from chicken intestines reduced DON contents of grains to the extent that when such grains were fed to pigs the animals exhibited improved feed intake and weight gain [14]. From the data of the cited studies biological strategies of managing DON in grain for pigs appear promising but without drawbacks. Thus these drawbacks should be surveyed especially cost-wise before adopting them in your location or environment. The dilution of DON-contaminated grain with 'DON-free' grains requires sourcing for the 'clean grain.' This implies that a source of uncontaminated grain with DON must first be guaranteed for the strategy to be applicable. When mold inhibitor propionate was added to pigs' diets the overall performance of the pigs improved but toxicological effects of DON were not completely eliminated [15]. A study [11] showed that increasing the energy, crude protein, mineral and vitamin content of a DON-contaminated diet improved weight gain of pigs by 20%. This finding provided the evidence that the negative impact of DON on performance was tied to the reduction in feed intake. Therefore, for an effective use of this manipulation concept to be effective it would require a fairly precise estimate of the expected reduction in feed intake to overcome its limitation. The treatment of DON-contaminated diet with the microbial inoculum from the digestive tract of poultry for pigs is capable of reducing the DON negative impacts and thus subsequently can improve feed intake [14]; this can therefore be effective if the concentration of the DON is well evaluated and handled accordingly. Again, [16] demonstrated that inoculating DON-contaminated diet with 5mg/kg of DON with inoculum from poultry reduced DON concentration by about 56%. In another study [17] the use of dietary adsorbents such as clays, organic polymers, including yeast cell wall extracts was effective in alleviating the anorectic effects of DON in pigs and thus improved feed intake and growth performance. Nevertheless, in years of 'heavy DON-pressure' the biological strategies in dealing with DON may be challenging thus for it to be cost-effective DON concentrations in grains should be well-evaluated and properly calibrated as to know the biological strategies' approach to be adopted as such periods.

3 Chemical Strategies

As the name implies, this strategy employs the use of chemicals such as hydrogen peroxide, sodium bisulfite, hydrochloric acid, sodium hypochlorite, ascorbic acid and ammonium hydroxide to decontaminate DON in the DON-contaminated diet. Amongst these chemicals used under this strategy, sodium bisulfite had proven to be the most effective in decontaminating DON [18]. Others were partially effective or even increase DON concentration in the diet [18]. For example when sodium hypochlorite was used DON concentration increased [18]. The apparent increase in DON concentration with sodium hypochlorite probably might be due to the conversion of a precursor into DON. Treatment with chemical and exposure to heat for drying also reduced DON. However, heat treatment per se is not effective in decontaminating DON as DON is known to be stable even at very high temperature. Gas treatment also proved to be a chemical means of removing DON from grains but it was only minimal or marginal. For example, dry gaseous dioxide when percolated for 3 hours through Ikg of grain contaminated with 1mg/kg of DON only marginally removed DON [18]. Overall, some chemical strategies of DON decontamination were only capable of marginally reducing DON concentration in most cases [19]. From the fore-discussed the chemical strategies in decontaminating DON is time-consuming, capital intensive due to equipment required for some of its operations, such as drying coupled with the difficulty in handling a wet product. Additionally, the heating process has a negative effect on the nutritional status of heat-treated grain, particularly on protein (CP) and amino acid (AA) profiles of the grain as a feed material. Due to these drawbacks most farmers might not be able to adopt this strategy in managing DON in grains. However, some large commercial hog producers do employ chemical approach to reduce DON in grains because of their high scales' operations without losses [19].

4 Physical Strategies

The different physical strategies employed in removing DON from contaminated grains include heating, cleaning, washing and de-hulling of the contaminated grain before use. However, the effectiveness of each physical approach depends on the initial level of DON concentration in the grain. The use of heat while effective in removing other mycotoxins does not work for DON. DON as previously alluded to is a very stable compound and does not easily degrade at high temperatures [19]. Furthermore, high heat treatment of DON-contaminated grain can also reduce the nutrient contents of the grain, particularly CP and AA contents of the grain. Therefore, this method of decontamination requires fortification of the diet to embellish lost nutrients. The physical cleaning process of contaminated grain had been used to remove DON. Grain contaminated at 0.03 to 3mg/kg of DON using the screening technique in combination with air flow similar to that of most commercial cleaners reduced DON by 16% [20]. Again, a similar cleaning process used on grain contaminated at 0.64 to 5.1mg/kg of DON with additional water washing reduced DON by 40% [20]. Washing grain contaminated at 16mg/kg with water had shown reduction of DON by 69%. Washing the same DON-contaminated grain in distilled water three times showed DON reduction by 90% [21]. In these cases, the grains' DON loads were reduced but its use in swine diets depend on the physiological status of animals to be fed as these often mostly qualify such grains for feeding barrows [9] – [10].

5 Conclusion

There is no straight forward strategy in dealing with DON in grains. Until a dependable, reliable, cost-effective and commercially applicable method of decontamination of mycotoxins, including DON in grains is available the agricultural industry would continue to experience the problem associated with DON contamination of grains and feedstuffs. To this point, the underlying choice of the strategies highlighted in this paper to be adopted is at the discretion of the hog farmer. Nevertheless, it should be driven largely on the level of DON contamination and more importantly the prevailing available technology in order to achieve a cost-effective strategy in DON management for swine. This is hinged on the fact that the overall aim of the farmer is profit-oriented.

6 References

[1] J. P. F. D'Mello, C. M. Placinta, and A. M. C. Macdonald. 1999. Fusarium mycotoxins: A review of global implications for animal health, welfare and productivity. Anim. Feed Sci. Technol. 80:183-205.

[2] S. Danicke, H. Valenta, F. Klobasa, S. Doll, M. Ganter and G. Flachowsky. 2004. Effects of graded levels of fusarium toxin contaminated wheat in diets for fattening pigs on growth performance, nutrient digestibility, deoxynivalenol balance and clinical serum characteristics. Arch. Anim. Nutr. 58:1-17.

[3] Y. Dersjant-Li, M. W. A. Verstegen and W. J. J. Gerrits. 2003. The impact of low concentrations of aflatoxin, deoxynivalenol or fumonisin in diets on growing pigs and poultry. Nutr. Res. Rev. 16:223-239.

[4] J. W. ApSimon. 1994. In: Mycotoxins in Grain. Compounds other than aflatoxin. Miller, J. D. and Trenholm, H. I. (Eds.) Eagan Press, St. Paul, MN, USA, pp. 3-18.

[5] L. L. Charmley, A. Rosenberg and H. L. Trenholm. 1994. In: Mycotoxins in Grain. Compounds other than aflatoxin. Miller, J. D. and Trenholm, H. L. (Eds.) Eagan Press, St. Paul, MN, USA, pp. 471-486.

[6] L. L. Charmley and D. B. Prelusky. 1994. In: Mycotoxins in Grain: Compounds other than aflatoxin. Miller, J. D. and Trenholm, H. L. (Eds.). Eagan press, St. Paul, MN, USA, pp. 421-436.

[7] NRC, (2012). Nutrient Requirements of Swine (11th Ed.). Natl. Acad. Press, Washington, DC.

[8] J. F. Lampe, J. W. Mabry, T. Baas and P. Holden. 2004. Comparison of grain sources (barley, white corn and yellow corn) for swine diets and their effects on meat quality and production traits, Iowa State University Animal Industry Report, ASL-R1954.

[9] J. D. House, D. Abramson, G. H. Crow and C. M. Nyachoti. 2002. Feed intake, growth and carcass parameters of swine consuming diets containing low levels of deoxynivalenol from naturally contaminated barley. Can. J. Anim. Sci. 82:559-565.

[10] J. D. House, C. M. Nyachoti and D. Abramson. 2003. Deoxynivalenol removal from barley intended as swine feed through the use of an abrasive pearling procedure. J. Agric. Food Chem. 51:5172-5175.

[11] R. R. Chavez and J. A. Rheaume. 1986. The significance of the reduced feed consumption observed in growing pigs fed vomitoxin-containing diets. Can. J. Anim. Sci. 66:277-287.

[12] R. M. McNear, R. F. Wilson and G. A. Stitzlein. 1981. Short term swine appetite responses to dietary additive in moldy. Ohio Swine Res. Ind. Rep. Anim. Sci. Ser. 81(2):79-82.

[13] P. Karlovsky. 1999. Biological detoxification of fungal toxins and its use in plant breeding, feed and food production. Nat. Toxins. 7:1-23.

[14] P. He, L. G. Young and C. Forsberg. 1993. Microbially detoxified vomitoxin-contaminated corn for young pigs. J. Anim. Sci. 71:963-967.

[15] B. C. Forster, H. L. Trenholm, D. W. Friend, B. K. Thompson and K. E. Hartin. 1987. The effect of a propionate feed preservative in vomitoxin containing corn diets fed to swine. Can. J. Anim. Sci. 67:1159-1163.

[16] H. E Ping, L. G. Young and C. Forsberg. 1992. Microbial detoxification of vomitoxin contaminated corn for pigs. Ontario Swine Research Review, Ontario Agricultural College Publ. 0292, Pp. 21-22.

[17] H. V. Swamy, T. K. Smith, E. J. MacDonald, H. J. Boermans and E. J. Squires. 2002. Effects of feeding a blend of grains naturally contaminated with Fusarium mycotoxins on swine performance, brain regional neurochemistry and serum chemistry and the efficacy of a polymeric glucomannan mycotoxin in adsorbent. J. Anim. Sci. 80:3257-3267.

[18] J. C. Young, L. M. Subryan, D. Potts, M. E. McLaren and F. H. Gobran. 1986. Reduction in levels of deoxynivalenol in contaminated wheat by chemical and physical treatment. J. Agric. Food Chem. 34:461-465.

[19] D. Abramson, J. D. House and C. M. Nyachoti, 2005. Reduction of deoxynivalenol in barley by treatment with aqueous sodium carbonate and heat. Mycopathologia. 160:297:301.

[20] L. M. Seitz, W. T. Yamazaki, R. L. Clements, H. E. Mohr and L. Andrews. 1985. Distribution of deoxynivalenol in soft wheat mill streams. Cereal Chem. 62:467-469.

[21] H. L. Trenholm, L. L. Charmley, D. B. Prelusky and R. M. Warner. 1992. Washing procedures using water or sodium carbonate solutions for the decontamination of three cereals contaminated with deoxynivalenol and zearalenone. J. Agric. Food Chem. 40:2147-2151.