Long-term feeding of graded levels of deoxynivalenol in grower-finisher pigs

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SUMMARY

Mycotoxin-contaminated grains are commonly downgraded for use in livestock feed and, while the best strategy for producers is to avoid feeding mycotoxin contaminated grain altogether, this may no longer be possible. Therefore, strategies that allow the use of these grains in livestock feed are necessary. With a lack of effective strategies (i.e., feed additives) available for mitigation of DON, it is important to evaluate alternative strategies, including re-evaluating the recommended level of DON in feed. There is the potential for pigs to adapt to mycotoxins therefore the use of mycotoxin-contaminated grain in the grower-finisher period presents a possible strategy to minimize the impact on growth performance and profitability. Results from this project indicate while there was an initial reduction in performance, pigs seem to be able to adapt to DON intake of > 1 ppm, and < 5 ppm).

INTRODUCTION

The mycotoxin DON (vomitoxin) is of significant importance since it commonly contaminates corn, wheat, oats, and barley, and is one of the most prevalent mycotoxins. In the 2016 World Mycotoxin Survey conducted by BIOMIN, DON reported to be the most prevalent mycotoxin in many ingredients of importance in swine, occurring in 77, 70, 46, and 48% of corn, barley, wheat, and soybean samples tested, respectively. In North America, 58% of all grain samples analyzed contained DON, representing a 'severe risk' (Biomin, 2016). Data for wheat in Saskatchewan shows an increase in the incidence of fusarium, with 80-90% of wheat downgraded due to DON .

Typical negative effects of mycotoxin consumption include reduced feed intake, digestive dysfunction, immune suppression, and reduced growth, with the primary physiological effect dependent on the mycotoxin present.

There have been many strategies proposed to eliminate or reduce the negative effect of mycotoxins in feed. Most of these strategies try to deactivate the mycotoxin through binding of the mycotoxin using adsorbents, such as silicate clays and activated carbon, which can be included in feed as non-nutrient additives. In general, current feed additives are relatively ineffective in mitigating the negative effects of mycotoxins and may not be effective for all mycotoxins.

Given the increasing incidence of DON-contamination there is an obvious economic impact of mycotoxin contamination for both the grain and pork industries. In addition, with the lack of effective mitigation strategies further information is required on long-term DON exposure in grower-finisher pigs. This information can be used to develop feeding programs which maximize inclusion of DON-contaminated grains while minimizing the impact on growth performance and profitability of both pork and grain producers.

EXPERIMENTAL PROCEDURES

Study 1. *Effect of long-term feeding of graded levels of deoxynivalenol on finisher pig performance, nutrient utilization, and health status.*

Two-hundred mixed-sex finishing pigs with an initial body weight (BW) of 76.6 +/- 3.9 kg were grouped of five pigs/pen, and assigned to one of four dietary treatments (n=10 pens/treatment; Table 1). Dietary treatments consisted of a control diet (CONT) containing no deoxynivalenol (DON) or a diet containing 1, 3, or 5 ppm DON (DON1, DON3, or DON5). The basal diet was wheat- barley-soybean meal-based and formulated to be isonitrogenous and isoenergetic with

Table 1. Analyzed mycotoxin content (ppm) of diets used in Study 1 (as-fed basis)[1]

	Finisher Diet							
	Growth Performance Diets				Nitrogen-Balance Diets			
Mycotoxin, ppm	**CONT[2]**	**DON1[3]**	**DON3[4]**	**DON5[5]**	**CONT**	**DON1**	**DON3**	**DON5**
Deoxynivalenol	0.11	1.34	3.59	5.72	1.56	1.32	3.09	4.94
3-acetyldeoxynivalenol	ND6	ND	ND	ND	ND	ND	ND	ND
15-acetyldeoxynivalenol	ND	ND	ND	ND	ND	ND	ND	ND
HT-2 toxin	ND	ND	ND	0.050	ND	ND	ND	0.03
Nivalenol	0.15	0.18	0.53	0.64	0.12	0.11	0.12	0.08
Ochratoxin A	0.01	0.03	0.01	0.01	0.01	0.03	0.07	0.09
Zearalenone	ND	0.002	0.009	0.014	0.003	0.002	0.009	0.013
Total Ergot alkaloids	0.99	0.57	1.03	1.26	0.24	0.16	0.39	0.67

[1]Mycotoxin contents analyzed in diet samples by BIOMIN., [2]CONT, 0 ppm DON Control diet, [3]DON1, 1 ppm DON diet, [4]DON3, 3 ppm DON diet, [5]DON5, 5 ppm DON diet, and [6]ND, Not detected or below the limit of detection.

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nutrients meeting or exceeding the recommended requirement for finisher pigs (NRC, 2012). Dietary DON levels were achieved by replacing DON-free wheat with DON- contaminated wheat and wheat screenings proportionally according to the target DON levels. Pigs had ad libitum access to feed and water.

***Study 2**. Effect of long-term feeding of graded levels of deoxynivalenol on grower-finisher pig performance, nutrient utilization, health status, and carcass quality.*

A total of 240 grower pigs (initial body weight of 35.9 +/- 1.1 kg) were housed in groups of six pigs/pen and randomly assigned to one of four dietary treatments over two blocks (n=10/trt). Dietary treatments (Table 2) consisted of a control diet with no DON contamination (CON), or one of three DON-contaminated diets containing 1, 3, or 5 ppm DON (DON1, DON3, DON5). DON diets consisted of replacing clean wheat with naturally contaminated wheat and wheat screenings. Diets were isonitrogenous and isocaloric in order to meet or exceed nutrient requirements according to NRC (2012). Pigs were fed ad libitum for a total of 11 weeks (six weeks grower, five weeks finisher). Blood samples were obtained at 0, 2, 6, 8, and 11 weeks for liver and kidney blood chemistry panel as indicators liver and kidney function.

RESULTS AND DISCUSSION

***Study 1**. Effect of long-term feeding of graded levels of deoxynivalenol on finisher pig performance, nutrient utilization, and health status.*

Body weight was reduced in DON3 and DON5 fed pigs by day seven of the study, with the greatest reduction observed with DON5 ($P > 0.05$) and was maintained throughout the study. Throughout the study, ADG in DON1 fed pigs was not different compared to pigs receiving the CONT diet ($P > 0.05$). From d 0-7, DON3 fed pigs had reduced growth compared to both CONT and DON1 fed pigs ($P < 0.05$) but was not different from CONT fed pigs from d 8-42 ($P > 0.05$). Pigs fed DON5 had reduced ADG from d 0-21 compared to all other dietary treatments ($P < 0.05$).

Overall (d 0-42), ADG was reduced in DON3 and DON5 fed pigs compared to both CONT and DON1 (Table 3), with the greatest reduction observed with DON5 ($P < 0.05$) with no impact of DON1 on ADFI compared to CONT ($P > 0.05$).

Overall (d 0-42), ADFI was only reduced in DON5 fed pigs (Table 3) ($P < 0.05$). Feed efficiency, measured as GF, was reduced in DON5 fed pigs from d 0-7 compared to all other dietary treatments ($P < 0.05$), which were not different from each other ($P > 0.05$). There was no effect of dietary treatment on GF from 8-42 or overall (d 0-42) ($P > 0.05$).

***Study 2**. Effect of long-term feeding of graded levels of deoxynivalenol on grower-finisher pig performance, nutrient utilization, health status, and carcass quality.*

There was a significant decrease in body weight of DON3 and DON5 compared to CON-fed pigs by day 35, with no effect of DON1 (Table 5) to the end of the study. DON3 and DON5 reduced average daily gain in the grower phase and overall compared to CON-fed pigs. There was no DON effect on average daily gain in the finisher phase. There was a reduction in average daily feed intake during the first week of the study in DON3 and DON5-fed pigs compared to CON, with no effect of treatment in grower phase overall. Compared to CON,

DON fed pigs experienced a reduction in feed intake throughout the finisher phase and over the entire study, with no effects on feed efficiency. Feed intake of DON-fed pigs was reduced compared to control fed pigs, while feed efficiency was only reduced in week one, suggesting that the capacity for growth is not affected in these pigs but feed intake is insufficient to support maximum growth. Based on these preliminary results, while feeding 3 or 5 ppm DON resulted in reduced body weight and growth performance, there is evidence that pigs can adapt to DON-contaminated diets. There was no impact of dietary treatment on any measures of kidney and liver health (data not shown).

IMPLICATIONS

Two growth performance studies were conducted to examine the impact of long-term feeding of graded levels of DON in finisher (75 – 120 kg) and grower-finisher (35 – 120 kg) pigs. In finisher pigs we found that there was a rapid negative response to > 1 ppm DON intake, resulting in a decrease in average daily gain and feed intake as well as reduced body weight within the first week. The reduction in body weight was maintained throughout the study, however, after a period of approximately four weeks, the feed intake and average daily gain of all pigs had recovered. In grower-finisher pigs, the response to DON intake was less pronounced and not as rapid, resulting in variability in the response over time and across treatments. Overall there was reduction in average daily gain, feed intake, and body weight in pigs fed > 1 ppm DON, however, this negative effect was less than observed in finisher pigs. Overall, this study provides further evidence for an upper limit of 1 ppm DON in finished feed to avoid reduced performance. While there was an initial reduction in performance, pigs seem to be able to adapt to DON intake of > 1 ppm, and < 5 ppm).

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Table 2. Analyzed mycotoxin content of finishing diets used in Study 2 (as-fed basis)[1]

	Growth Performance Diets				Nitrogen-Balance Diets			
Mycotoxin, ppm	**CONT2**	**DON13**	**DON34**	**DON55**	**CONT**	**DON1**	**DON3**	**DON5**
Deoxynivalenol	0.20	1.02	3.28	4.13	1.04	1.35	3.22	5.43
3-acetyl-deoxynivalenol	ND[2]	ND	0.03	0.04	ND	ND	ND	0.02
15-acetyl-deoxynivalenol	ND	ND	ND	ND	ND	ND	ND	ND
HT-2 toxin	ND	ND	ND	ND	ND	ND	ND	0.04
Nivalenol	0.53	0.63	0.55	0.16	0.10	0.09	0.12	0.09
Ochratoxin A	ND	0.02	0.02	0.07	0.01	0.03	0.09	0.12
Zearalenone	0.001	0.004	0.004	0.007	0.006	0.004	0.008	0.014
Total Ergot alkaloids	0.32	0.63	0.61	0.36	0.18	0.20	0.28	0.77

[1]Mycotoxin content analyzed in diet samples by BIOMIN, [2]CONT, 0 ppm DON Control diet, [3]DON1, 1 ppm DON diet, [4]DON3, 3 ppm DON diet, DON5, 5 ppm DON diet, [6] ND, Not detected or below the limit of detection

Table 3. Growth performance of grower-finisher pigs fed diets with graded levels of deoxynivalenol (DON)1

	CONT[2]	**DON[3]**	**DON[4]**	**DON[5]**	**SEM[6]**	**P-value**
Body weight, kg						
Day 0	36.0	35.6	35.7	36.4	0.34	NS7
Day 7	42.5	41.6	40.7	41.7	0.44	NS
Day 14	50.1a	49.8a	47.8b	49.2ab	0.49	0.01
Day 21	58.0a	57.7a	55.7ab	56.7b	0.60	0.04
Day 28	68.1	67.6	65.4	65.7	0.84	NS
Day 35	75.9a	74.5ab	72.7b	72.7b	0.86	0.03
Day 42	85.2a	83.7ab	81.9b	81.6b	0.91	0.03
Day 49	94.7a	93.1ab	90.9bc	89.8c	0.96	0.005
Day 56	102.7a	100.9ab	98.3bc	97.7c	1.00	0.004
Day 63	110.6a	108.6ab	106.3bc	105.0c	0.91	<0.001
Day 70	118.4a	116.2ab	114.6bc	112.9c	0.91	0.001
Day 77	124.9a	123.0ab	121.0bc	120.0c	0.91	0.002
Average daily gain, kg/d						
Day 0-42	1.17a	1.15ab	1.10bc	1.08c	0.02	<0.01
Day 42-77	1.14	1.13	1.11	1.10	0.01	NS
Overall (d 0-77)	1.15a	1.14a	1.11b	1.09b	0.01	<0.001
Average daily feed intake, kg/d						
Day 0-42	2.29	2.27	2.20	2.18	0.03	NS
Day 42-77	3.12a	2.97b	2.96b	2.88b	0.05	<0.001
Overall (d 0-77)	2.62a	2.55ab	2.47b	2.47b	0.03	0.003

1Values are least squares means with n=10 pens/treatment, 2CONT, 0 ppm DON Control diet, 3DON1, 1 ppm DON diet, 4DON3, 3 ppm DON diet, 5DON5, 5 ppm DON diet, 6 SEM, Standard error of the mean, 7NS, Not significant, a, b, c Means without a common superscript are significantly different (P < 0.05)