

Contamination of Swine Diets by Feed Borne Fusarium Mycotoxins and its Effect on Metabolism and Reproduction in First Parity Gilts: Use of Mycotoxin Binders

¹I.A. Amata, ²D.O. Adejumo and ¹L. Bratte

¹Department of Animal Science, Faculty of Agricultural,
Delta State University, Anwai Campus Asaba, Delta State, Nigeria

²Department of Animal Science, Faculty of Agricultural,
University of Ibadan, Ibadan, Oyo State, Nigeria

Abstract: In an experiment to determine, the effects of feed-borne fusarium mycotoxins on metabolism and reproduction in first parity gilts, a total of 36 first parity Yorkshire gilts (3 diets with 12 gilts per diet) were housed in individual stalls for 21 days before farrowing and 21 days after farrowing in the first experiment and a total of 32 first parity gilts (4 diets with 8 gilts per diet) were used in the 2nd experiment. Experimental conditions were similar in the 2 experiments. Diets included control, contaminated grains and contaminated grains + 0.2% binder, for the 1st experiment and a 4th diet in the 2nd experiment. There was no effect of diet on average daily feed intake of gilts in gestation. Weight gain and feed: Gain ratios however were reduced by contaminated grains. Percentage of stillbirths was higher and total piglets born was lower for gilts fed contaminated grains compared to those fed contaminated grains plus mycotoxin binders. During lactation, feed intake and weight gain were reduced by diets containing contaminated grains. Blood chemistry, milk composition and piglet weights at weaning were not affected by diet.

Key words: Fusarium mycotoxins, mycotoxin binders, feed consumption, body weight gain, stillbirths and blood chemistry

INTRODUCTION

Mycotoxins are toxic secondary metabolites secreted by moulds on crops in the field, during handling and storage. They enter the animal production system via feed concentrate, silage or forage, or via bedding.

There are numerous reports indicating that weanling piglets (Friend *et al.*, 1982; D'Ill *et al.*, 2003) and growing finishing pigs (House *et al.*, 2002; Danike *et al.*, 2004) are particularly sensitive to feed-borne mycotoxins. More than 200 mycotoxins have been identified but only a few are believed to affect swine performance. Aflatoxin, zearalenone and deoxynivalenol are the most often reported mycotoxins in swine feed. Deoxynivalenol (DON, vomitoxin) is a common feed borne mycotoxin that has been extensively researched. Major symptoms seen in pigs consuming deoxynivalenol contaminated feed is reduced feed intake resulting from altered brain neurochemistry including elevated brain concentrations of serotonin (Swamy *et al.*, 2002). Other symptoms include reduced tissue protein synthesis (Danike *et al.*, 2006) and immunomodulation (Swamy *et al.*, 2003).

Much less is known about the potential for feed-borne mycotoxins to influence metabolism, reproduction and lactation of sows. Freind *et al.* (1983) reported that sows fed naturally contaminated wheat containing 3.465 mg DON kg⁻¹ feed exhibited a significant reduction in feed intake, weight gain, fetal length and fetal weight at 50-54 days of gestation. Chavez (1984) reported that feeding diets based on naturally contaminated wheat containing 1.3, 2.4 or 3.3 mg DON kg⁻¹ to sows for the last 90 days of pregnancy did not result in reduced feed intake, although, a significant reduction in weight was observed with the highest levels of DON.

The use of different mycotoxin binders to prevent mycotoxicosis by preventing intestinal uptake of mycotoxins has been reviewed (Ramos *et al.*, 1996). The polymeric glucomannan mycotoxin binder mycosorb extracted from the cell wall of yeast, has been shown to prevent many aspects of mycotoxicosis in starter pigs (Swamy *et al.*, 2002), horses (Raymond *et al.*, 2003), broilers (Swamy *et al.*, 2004), breeders (Swamy *et al.*, 2003) and layers (Chowdhury and Smith, 2004).

MATERIALS AND METHODS

Two experiments were conducted to determine the effects of feed-borne fusarium mycotoxins on reproduction and metabolism in sows and to determine the efficacy of the mycotoxin binder, mycosorb in preventing any side-effects.

The experiments were conducted at the University Research and Teaching Farm, University of Ibadan, Ibadan, Oyo State Nigeria. The experiment was conducted over a period of 90 days.

In the 1st experiment, 36 first parity Yorkshire gilts (12/diet) were housed in individual stalls for 21 days before farrowing and 21 days after farrowing. During gestation, feed was restricted to 2.4 kg/pig/day. Diets included, control, contaminated grains and contaminated grains + 0.2% mycosorb.

Parameters measured include: Body weight changes, feed consumption, numbers and weight of piglets born, number of still births, milk composition and viability of piglets until weaning, blood chemistry and weaning-to-estrus interval.

In the 2nd experiment, a total of 32 first parity Yorkshire gilts were used under similar conditions to those in the 1st experiment. However, 4 diets were used as against 3 in experiment one. Eight gilts were allotted to each diet. The diets were: Control, contaminated grains, contaminated grains + 0.2% mycosorb and restricted feeding of control diet (80% of control diet consumption).

Blood samples were taken 1 week before farrowing and 10 days after farrowing. Serum was analyzed for concentrations of ammonia, protein and urea. Biopsies of triceps muscle were taken at the same times and analyzed for DNA, RNA and protein concentrations.

Dietary concentrations of 13 mycotoxins including DON, 3-acetyl DON, 15-acetyl DON, nivalenol, T-2 toxin, acetyl T-2 toxin, HT-2 toxin, Diacetoxyscirpentriol (DAS), neosolaniol, zearalenone, aflatoxin and fumosin were analyzed by gas chromatography and mass spectrometry (Raymond *et al.*, 2003). The detection limits were 0.2 mg kg⁻¹ with the exception of aflatoxin and fumosin, which were detected at 0.02 and 2 mg kg⁻¹, respectively.

RESULTS AND DISCUSSION

Dietary mycotoxin concentrations: The concentrations of detected mycotoxins in diets fed in experiments 1 and 2 are given in Table 1. The major contaminant in both experiments was DON with lesser amounts of 15-acetyl DON and zearalenone. All other mycotoxins were found in concentrations below the limits of detection.

Table 1: Dietary mycotoxin content (mg kg⁻¹, as-fed basis)

Diet	DON	15-Acetyl-DON	Zearalenone
Experiment 1			
Control	0.4	Not detected	Not detected
Contaminated	5.7	0.7	0.7
Contaminated + 0.2% Mycosorb	5.9	0.7	0.5
Experiment 2			
Control	0.5	Not detected	Not detected
Contaminated	3.8	0.5	0.4
Contaminated + 0.2% Mycosorb	4.0	0.5	0.4
Control (restricted)	0.5	Not detected	Not detected

Table 2: Effect of feeding grains naturally contaminated with fusarium mycotoxins on performance of gestating gilts

Diet	ADFI (kg d ⁻¹)	ADG (kg d ⁻¹)	F:G (%)	Still births (%)	Born alive(%)
Control	2.51 ^a	1.24 ^a	0.47 ^a	6.37 ^{ab}	90.6 ^b
Contaminated grains	2.22 ^a	0.72 ^b	0.29 ^b	15.62 ^b	80.9 ^b
Contaminated grains + 0.2% mycosorb	2.25 ^a	0.9 ^{ab}	0.47 ^{ab}	4.7 ^a	95.5 ^a

^{a,b} Means within columns differ (p<0.05); ADFI: Average Daily Feed Intake; ADG: Average Daily Gain; F:G: Feed:Gain ratio

Experiment 1: There was no effect of diet on average daily feed intake of gilts during gestation (Table 2). Weight gain and feed:gain ratios however, were reduced by contaminated grains and this was prevented by dietary addition of mycosorb. Serum chemistry was unaffected by diet. The percentage of stillbirths was higher and total piglets born was lower for gilts fed contaminated grains compared to those fed contaminated grains plus mycosorb.

There was no effect of diet on frequency of deaths at birth or body weight of piglets at birth. In the lactation period, feed intake and weight gain were reduced by diets containing contaminated grains (Table 3). Blood chemistry, milk composition and piglet weights at weaning were not affected by diet. There was a strong trend however, to increased weaning-to-estrus interval when sows were fed contaminated grains.

Results obtained show that feeding grains naturally contaminated with fusarium mycotoxins to gestating and lactating sows results in increased numbers of stillborn piglets, but piglets that are born alive are viable and thrive throughout the lactation period. This is possibly achieved by a marked depletion of body reserves resulting in increased weaning-to-estrus intervals.

Experiment 2: The 2nd experiment was conducted to determine the relative importance of reduced feed intake and impaired protein metabolism in causing weight loss in lactation.

The effects of diet on weight gain and feed consumption during gestation and lactation are given in Table 4. These parameters followed the trends seen in

Table 3: Effect of feeding grains naturally contaminated with fusarium mycotoxins on performance of lactating sows (experiment 1)

Diet	ADFI (kg d ⁻¹)	ADG (kg d ⁻¹)	Wean-to-estrus interval (days)
Control	5.87 ^a	0.0060 ^a	7.33 ^a
Contaminated grains	4.56 ^b	-0.602 ^b	16.00 ^a
Contaminated grains + 0.2% mycosorb	4.43 ^b	-0.475 ^b	16.33 ^a

^{a,b}Means within columns differ (p<0.05)

Table 4: Effects of feeding grains naturally contaminated with fusarium mycotoxins on performance of gestating and lactating sows (experiment 2)

Groups	Control	Contaminated grains	Contaminated grains +0.2% mycosorb	Control (restricted)
Gestation (kg day⁻¹)				
Feed intake	1.94	1.70	1.72	1.81
Body weight gain	0.50	0.10	0.39	0.62
Lactation (kg day⁻¹)				
Feed intake	4.15 ^a	2.96 ^b	3.20 ^b	3.60 ^a
Body weight gain	-0.58	-1.37	-1.12	-0.77

^{a,b}Means within row differ (p<0.05)

Table 5: Effect of feeding grains naturally contaminated with fusarium mycotoxins on serum chemistry of gestating and lactating sows (experiment 2)

Groups	Control	Contaminated grains	Contaminated grains +0.2% mycosorb	Control (restricted)
Gestation				
Ammonia (μmol L ⁻¹)	54.7	65.5	42.8	71.3
Protein L ⁻¹	75.5	73.8	70.0	74.6
Urea (m mol L ⁻¹)	5.5	6.3	5.8	6.2
Lactation				
Ammonia (μmol L ⁻¹)	47.8	40.5	42.1	41.6
Protein (g L ⁻¹)	77.3	75.1	76.3	77.5
Urea (m mol L ⁻¹)	6.7 ^a	5.6 ^b	5.5 ^b	7.5 ^a

^{a,b}Means within row differ (p<0.05)

experiment 1, with feed intake being significantly reduced in sows fed the contaminated diet during lactation.

Serum ammonia, protein and urea concentrations are given in Table 5. Results show an increase in ammonia levels in sows fed the contaminated diet during gestation. This might have contributed to the increase in stillborn piglets in this group. Reduced serum ammonia levels in pigs fed mycosorb may be due to the ability of mycosorb to adsorb ammonia in the lumen of the intestinal tract and thereby reduce blood ammonia levels and the frequency of stillborn piglets.

Protein, DNA and RNA content of muscles are given in Table 6. Results show a significant decrease in RNA, protein and RNA:DNA ratios in restricted fed pigs compared to controls. This would suggest reduced cellular transcription rates in pigs undergoing restricted feeding. These pigs also showed a trend towards reduced protein: DNA ratio, which could indicate a reduced rate of muscle protein synthesis.

In lactation, the pigs fed restricted amounts of the control diet had increased muscle DNA concentrations

Table 6: Effect of feeding grains naturally contaminated with fusarium mycotoxins on muscle DNA, RNA and protein content in gestating and lactating sows (experiment 2)

Groups	Control	Contaminated grains	Contaminated grains +0.2% mycosorb	Control (restricted)
Gestation				
DNA (μg mg ⁻¹)	2.10	2.28	2.31	2.18
RNA (μg mg ⁻¹)	0.88 ^a	0.75 ^a	0.90 ^a	0.48 ^b
Protein (μg mg ⁻¹)	169 ^a	164 ^a	157 ^a	138 ^b
RNA:DNA	0.46 ^a	0.35 ^{ab}	0.42 ^a	0.25 ^b
Protein:RNA	228	307	216	329
Protein:DNA	89.0	86.5	74.9	66.4
Lactation				
DNA (μg mg ⁻¹)	2.61	3.87	3.19	4.41
RNA (μg mg ⁻¹)	0.61	0.61	0.80	0.64
Protein (μg mg ⁻¹)	157	166	147	160
RNA:DNA	0.28	0.25	0.30	0.18
Protein:RNA	303	305	214	279
Protein:DNA	72.0 ^a	54.6 ^b	48.2 ^{ab}	40.9 ^{ab}

^{a,b}Means within a row differ (p<0.05)

compared to controls, indicating shrinking of muscle cells. The significant decline in the muscle protein: DNA ratios in these pigs reflect reduced cellular protein synthesis.

CONCLUSION

Results obtained show that feeding naturally contaminated grains with fusarium mycotoxins reduces reproductive performance of gestating and lactating sows. Many of these adverse effects can be prevented by supplementation with the mycotoxin adsorbent, mycosorb. Much of these catabolic effects of feeding such diets in lactation can be accounted for by reduced feed intake rather than due to direct effects of fusarium mycotoxins on protein metabolism.

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