INTERNATIONAL JOURNAL OF APPLIED BIOLOGY AND PHARMACEUTICAL TECHNOLOGY

www.ijabpt.com Volume-4, Issue-3, July-Sept-2013 Coden : IJABPT Copyrights@2013

ISSN : 0976-4550

Received: 19th June-2013 *Revised: 23rd June-2013* *Accepted: 29th June-2013*

Research article

THE USE OF MYCOTOXIN BINDERS IN REDUCING CONTAMINATION OF SWINE DIETS BY FEED BORNE FUSARIUM MYCOTOXINS AND ITS EFFECTS ON METABOLISM AND REPRODUCTION IN FIRST PARITY GILTS.

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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 a control diet, a diet with contaminated grains and a diet with contaminated grains + 0.2% mycotoxin binder in the 1st experiment. In the 2nd experiment a 4th diet was included. There were no significant (P>0.05) effects of diet on average daily feed intake of gilts during gestation. Weight gain and feed: gain ratios however were reduced by contaminated grains. The percentage of stillbirths was higher and total piglets born were lower for gilts fed contaminated grains compared with 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, 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 materials. There are numerous reports indicating that weanling piglets (Friend et al., 1982; Danike 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 in sows. Friend *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 during the last 90 days of pregnancy did not result in reduced feed intake, although, a significant reduction in weight was observed with higher levels of DON. The use of different binders to prevent mycotoxicosis by preventing intestinal uptake of mycotoxins has been reviewed (Ramos et al., 1996). The polymeric glucomannan mycotoxin binder mycosorb which is 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).

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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, Oyo State Nigeria. The experiment was conducted over a period of 90 days. In the first experiment, 36 first parity Yorkshire gilts (12 per diet) were housed in individual stalls for 21 days before farrowing. During gestation, feed was restricted to 2.4 kg/pig/day. Diets included the control diet (diet 1), a diet with contaminated grains (diet 2) and a diet formulated with contaminated grains plus 0.2% mycosorb (diet 3). Parameters measured include body weight changes, feed consumption, numbers and weights of piglets born, number of still births, milk composition and viability of piglets up till weaning, blood chemistry and weaning-to-estrus interval. In the second experiment, a total of 32 first parity Yorkshire gilts were used under similar conditions to those in the first experiment. However, four (4) diets were used as against three in experiment one. Eight gilts were allotted to each diet. The diets were a control diet (diet 1), a diet with contaminated grains (diet 2), a diet with contaminated grains plus 0.2% mycosorb (diet 3) and restricted feeding of the control diet (diet 4:80% of the control diet consumed). Blood samples were taken one 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, Diacetoxyscripentriol (DAS), neosolaniol, zearalenone, aflatoxin and fumosin were analyzed by gas chromatography and mass spectrometry (Raymond *et al*., 2003). The detection limits were 0.2mg kg^{-1} with the exception of aflatoxin and fumosin, which were detected at 0.02 and 2mg kg^{-1} respectively. All data collected were subjected to a one way analysis of variance in a completely randomized design. Probability was accepted at 5% level and means were separated using Duncan's multiple range procedure (1955).

RESULTS AND DISCUSSION

Dietary mycotoxin concentrations: The concentrations of detected mycotoxins in diets fed in experiments one and two 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)

Diets	DON	15-Acetyl-DON	Zearalenone
Experiment 1			
Diet 1	0.4	not detected	not detected
Diet 2	5.7	0.7	0.7
Diet 3	5.9	0.7	0.5
Experiment 2			
Diet 1	0.5	not detected	not detected
Diet 2	3.8	0.5	0.4
Diet 3	4.0	0.5	0.4
Diet 4	0.5	not detected	not detected

Table 2: Effect of feeding grains naturally contaminated with fusarium mycotoxins on performance of gestating gilts (experiment 1)

Diets	ADFI (kg d^{-1})	ADG (kg d^{-1})	F:G (%)	Still births %)	Live births (%)
Diet 1	2.51^{a}	1.24^{a}	0.47^{a}	4.70^{c}	90.6^{b}
Diet 2	2.22^{a}	0.72^{c}	0.29^{b}	15.62^{a}	80.9^{c}
Diet 3	2.25^{a}	0.90^{b}	0.47^{a}	6.37^{b}	95.5^{a}

^{a,b,c} Means with different superscripts within columns differ ($P<0.05$) significantly.
ADFI: Average daily feed intake, ADG: Average daily gain, F: G, Feed: Gain ratio

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Experiment 1: There were no effects of diet on average daily feed intake of gilts during gestation (Table 2). Weight gain and feed: gain ratios were however reduced by diets containing contaminated grains and this was prevented by dietary addition of mycosorb. The percentage of still births was higher and total piglets born was lower for gilts fed contaminated grains compared to those fed contaminated grains plus mycosorb. Results obtained show that feeding grains naturally contaminated with fusarium mycotoxins to gestating and lactating sows results in increased number of stillborn piglets, but piglets that are born alive are viable and thrive throughout the lactating period. This is possibly achieved by a marked depletion of body reserves resulting in increased weaning-to-estrus intervals. There was no effect of diet on frequency of deaths at birth or body weight of piglets at birth. During the lactation period, feed intake and weight gain were reduced by diets containing contaminated grains (Table 3). There was a strong trend to increased weaning-to-estrus interval when sows were fed contaminated grains.

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

Diets	ADFI(kg d^{-1})	ADG(kg d^{-1})	Weaning-to-estrus interval (days)
Diet 1	5.87^{a}	0.006^{a}	7.33^{c}
Diet 2	4.56^{b}	-0.602^{b}	16.00^{a}
Diet 3	5.43^{b}	-0.175^{b}	9.33^{b}

^{a,b,c} Means with different superscripts within columns differ (P<0.05) significantly

Experiment 2: The second experiment was conducted to determine the relative importance of reduced feed intake and impaired protein metabolism in causing protein 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 experiment 1, with feed intake being significantly (P<0.05) reduced in sows fed the contaminated diet during lactation.

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

Groups	Diet 1	Diet 2	Diet 3	Diet 4
Gestation(kg/day)				
Feed intake	1.94^{a}	1.70^{c}	1.72^{c}	1.81^{b}
Body weight gain	0.50^{b}	0.10^{d}	0.39^{c}	0.62^{a}
Lactation(kg/day)				
Feed intake	4.15^{a}	2.96^{c}	3.20^{b}	3.60^{b}
Body weight gain	-0.58^{a}	-1.37^{d}	-1.12^{c}	-0.77^{b}

^{a,b,c} Means with different superscripts within rows differ (P<0.05) significantly

Table 5: Effect of feeding grains naturally contaminated with fusarium mycotoxins on serum chemistry of gestating and lactating sows (experiment2)

Groups	Diet 1	Diet 2	Diet 3	Diet 4
Gestation				
Ammonia (µmol L^{-1})	54.7^{c}	71.3^{a}	42.8^{d}	65.5^{b}
Protein (g L^{-1})	75.5^{a}	70.0^{c}	73.8^{b}	74.6^{a}
Urea (m mol L^{-1})	5.5^{c}	6.3^{a}	5.8^{bc}	6.0^{b}
Lactation				
Ammonia (µmol L^{-1})	47.8^{a}	40.5^{c}	42.1^{b}	41.6^{b}
Protein (g L^{-1})	77.3^{a}	72.1^{c}	76.5^{b}	77.5^{a}
Urea (m mol L^{-1})	6.7^{b}	7.5^{a}	5.5^{c}	5.6^{c}

^{a,b,c} Means with different superscripts within rows are differ (P<0.05) significantly

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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, Protein:RNA, Protein:DNA and RNA:DNA ratios in restricted pigs compared to the pigs fed the other diets. This would suggest reduced cellular transcription rates in pigs undergoing restricted feeding. The reduced Protein:DNA ratio suggests a reduced rate of muscle protein synthesis. In lactation, the pigs fed restricted amounts of the control diet had increased muscle DNA concentrations compared to the controls, suggesting a 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 effect of fusarium mycotoxins on protein metabolism.

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	Diet 1	Diet 2	Diet 3	Diet 4
Gestation				
DNA (µg mg^{-1})	2.10	2.28	2.31	2.18
RNA (µg mg^{-1})	0.88^{b}	0.75^{c}	0.90^{a}	0.48^{d}
Protein (µg mg^{-1})	169^{a}	164^{a}	157^{b}	138^{c}
RNA:DNA	0.46^{a}	0.35^{b}	0.42^{a}	0.25^{c}
Protein: RNA	329^{a}	307^{b}	228^{c}	216^{d}
Protein: DNA	89.0^{a}	86.5^{a}	74.9^{b}	66.4^{c}
Lactation				
DNA (µg mg^{-1})	2.61^{d}	3.87^{b}	3.19^{c}	4.41^{a}
RNA (µg mg^{-1})	0.61^{c}	0.61^{c}	0.80^{a}	0.64^{b}
Protein (µg mg^{-1})	157^{b}	166^{a}	147^{c}	160^{b}
RNA:DNA	0.28^{a}	0.25^{b}	0.30^{a}	0.18^{c}
Protein: RNA	303^{a}	305^{a}	279^{b}	214^{c}
Protein: DNA	72.0^{a}	54.6^{b}	48.2^{c}	40.9^{d}

^{a,b,c} Means with different superscripts within rows differ ($P<0.05$) significantly

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