EFFECT OF FEEDING CORN INOCULATED WITH NIGROSPORA ORYZAE AND CLADOSPORIUM ON THE PERFORMANCE OF GROWING SWINE AND RATS

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CHRISTENSEN (1964) included Cladosporium and Nigrospora oryzae in the field fungi group. These molds invade the kernels while they are developing or after they have matured but before the grains are harvested. They do not develop after storage and, as such, are mainly a field problem.

Teague (1966) reported the growth of molds on the 1965 corn crop in certain areas of America. Nigrospora and Cladosporium were two of the molds identified in these outbreaks. Feeding of mold-invaded corn caused reduced feed intake, vomiting and estrogen stimulation of both males and females.

Mitchell et al. (1947) reported that corn infected with Nigrospora fungus was less digestible for rats and that its energy value was also slightly less than that of sound corn.

The object of this study was to determine the susceptibility of rats to the toxic metabolites produced by these molds and to learn if the white rat can be used as a pilot animal for studies of the toxicity of these molds in swine. An attempt also was made to learn if Cladosporium caused substantial mycotoxicosis in swine.

Materials and Methods

Three trials, two with rats and one with young Yorkshire pigs, were conducted. The experimental design and distribution of animals by diets are presented in table 1.

Animals were allotted to the different diets randomly to get an unbiased estimate of experimental error and differences among treatment means. Animals were of uniform size, weight and age. Both rats and pigs were fed ad libitum in separate cages or pens. Animals were allowed to adjust to the new environments before being put on trial.

Composition of diets used is presented in table 2. Autoclaved corn (AC), AC inoculated with Nigrospora oryzae and AC inoculated with Cladosporium were used in formulating diets 1, 2 and 3, respectively. The corn was autoclaved for 2.5 hr. at 130°C. AC was then inoculated with the molds in accordance with the procedure set forth by Christensen, Nelson and Mirocha (1965). No determination of degree of infestation of the corn with these fungi was made following incubation, however, this technique when carefully conducted would be expected to cause essentially 100% of the kernels to be infected with the fungi.

Trials with rats were conducted for 28 days and with pigs for 26 days. Times 1, 2, 3 and 4 refer to periods of 1 to 7, 8 to 14, 15 to 21, and 22 to 28 days, respectively, for the rat trials.

To get additional information on the effect of sex on live weight gains and feed conversion efficiency of pigs and rats, animals of both sexes were used for rat trial I and the pig trial.

The response of animals to the molds was determined by the average daily live weight gains, average daily feed consumed as a percentage of body weight at the end of the feeding period, feed consumed per unit of gain and estrogenic effect on rat uteri.

Data were analyzed by the method of least squares (Harvey, 1960). Tests of significance for effects of time and animals within treatment were made against the residual of the analysis. Animals/treatment mean square was used to test the significance of treatments and interaction of time with treatment. Duncan’s Multiple Range test as modified by Kramer (1957) was employed to make comparisons among different times. Standard errors were calculated by the method of Harvey (1960).

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3 The authors acknowledge the cooperation and assistance of Richard Ritter and Getz Reed at the Ohio Agricultural Research and Development Center and Harold Delong at the Ohio State University.
TABLE 1. EXPERIMENTAL DESIGN AND DISTRIBUTION OF ANIMALS USED IN THE STUDY

<table>
<thead>
<tr>
<th>Trial No.</th>
<th>Animals specie</th>
<th>No.</th>
<th>Sex</th>
<th>Age at start, week</th>
<th>No. days on trial</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Rat</td>
<td>9</td>
<td>M</td>
<td>4</td>
<td>28</td>
</tr>
<tr>
<td>I</td>
<td>Rat</td>
<td>11</td>
<td>F</td>
<td>6</td>
<td>28</td>
</tr>
<tr>
<td>II</td>
<td>Rat</td>
<td>20</td>
<td>F</td>
<td>10</td>
<td>28</td>
</tr>
<tr>
<td>III</td>
<td>Pig</td>
<td>8</td>
<td>C</td>
<td>3</td>
<td>26</td>
</tr>
<tr>
<td>III</td>
<td>Pig</td>
<td>12</td>
<td>F</td>
<td>7</td>
<td>26</td>
</tr>
</tbody>
</table>

*a F=female, M=male, C=castrate.

b Diet 1 contained autoclaved corn, diet 2 contained autoclaved corn in which *Nigrospora oryzae* had been grown and diet 3 contained autoclaved corn on which *Cladosporium* had been grown.

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Results and Discussion

**Effect of Feeding Corn Inoculated with a Pure Culture of Nigrospora oryzae to Rats.** Results of tests of significance of main effects and interaction are presented in table 3. Least square means and their standard errors are given in table 4. Average weekly live weights of rats fed the two diets are shown in figure 1.

Male rats had a greater live weight gain (P < .01) while consuming somewhat smaller amounts of feed as a percentage of their final body weight and per gram of gain than females, as expected.

The presence of AC inoculated with *Nigrospora oryzae* in diet 2 depressed live weight gains of rats (P < .01). Rats fed diet 2 consumed larger amounts of feed per gram of gain and as a percentage of the body weight at the end of feeding period than those fed diet 1 (P < .01). Acceptability of the diet was not a problem.

Time effect was significant for all the traits studied (P < .01). The interaction of treatment with time was found to be significant (P < .01) both for weekly live weight gains and feed consumed. It indicated different patterns for these characteristics for rats fed the two diets. Gain of rats fed diet 1 was maximized during the second week, after which it decreased progressively. Rats fed diet 2 adjusted to the moldy feed with time as evidenced by an increase in weight gains after a decrease during the second week. Feed consumption by these rats was greater after the second week. Feed/gain, however, progressively decreased with increasing number of days on study for all rats.

Mold depressed the weight of rat uteri (P < .01). Average uterine weights expressed as a percent of the final body weight were .16 ± .012 and .08 ± .012% for rats fed diets 1 and 2, respectively. No estrogenic effect as measured by increase in weight of the uteri was thus observed.

**Effect of Feeding Corn Inoculated with Pure Cultures of Cladosporium to Rats and Pigs.** Results of test of significance are presented in table 3. Least square means and their standard errors are given in table 4. Effect of time and the average weights of rats fed the two diets are shown in figure 1.

**Rat Trial II.** Rats fed diets 1 and 3 had similar average weights at different time periods as revealed by figure 1. The live weight gains of rats fed diet 3 were slightly greater than those fed diet 1. Rats fed diet 3 consumed smaller amounts of feed and their feed/gain was smaller than that of those fed diet 1. The mean differences were, however, not large enough to be detected by tests of significance. These results indicated a beneficial effect of the fungus on growth and feed conversion of rats.

Time effect was significant for all traits

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TABLE 2. COMPOSITION OF DIETS

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Diet, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground shelled corn</td>
<td>76.77</td>
</tr>
<tr>
<td>Alfalfa meal (17% C.P.)</td>
<td>5.00</td>
</tr>
<tr>
<td>Soybean meal (44% C.P.)</td>
<td>12.53</td>
</tr>
<tr>
<td>Meat and bone scrap (50% C.P.)</td>
<td>4.18</td>
</tr>
<tr>
<td>Vitamin premix b</td>
<td>0.18</td>
</tr>
<tr>
<td>Trace mineralized salt</td>
<td>0.50</td>
</tr>
<tr>
<td>Calcium-phosphorous supplement (23% Ca and 17.5% P)</td>
<td>0.50</td>
</tr>
<tr>
<td>Feeding limestone (38% Ca)</td>
<td>0.34</td>
</tr>
</tbody>
</table>

*a The corn in diet 1 consisted of autoclaved corn, that in diet 2 consisted of autoclaved corn inoculated with *Nigrospora oryzae* and diet 3 consisted of autoclaved corn inoculated with *Cladosporium*.

b The vitamin premix contributed the following per kilogram of diet: vitamin A, 2,000 IU; vitamin D₂, 220 IU; vitamin B₁₂, 10.6 mcg; riboflavin, 2.64 mg; calcium pantothenate, 5.28 mg; niacin, 11.88 mg; and choline chloride, 15.2 milligrams.

c The trace mineralized salt contributed the following per kilogram of diet: sodium chloride, 4.8 g; manganese, 100 mg; iron, 80 mg; copper, 16.5 mg; cobalt, 5 mg; zinc, 2.3 mg; and iodine, 3.5 milligrams.
TABLE 3. ANALYSIS OF VARIANCE TABLE SHOWING MEAN SQUARES FOR LIVE WEIGHT
GAIN (L.W.G.)\(^a\), FEED CONSUMED (F.C.)\(^b\), FEED/GAIN (F/G)\(^c\) AND UTERINE WEIGHT
(U.W.)\(^d\)

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sex</th>
<th>Time</th>
<th>Lin.(^e)</th>
<th>Quad.(^f)</th>
<th>Cubic(^g)</th>
<th>Treatment x time</th>
<th>Animal/treatment</th>
<th>Residual</th>
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</thead>
<tbody>
<tr>
<td>Rat trial I</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>df</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>L.W.G.</td>
<td>29.9*</td>
<td>5.1*</td>
<td>7.4*</td>
<td>6.4*</td>
<td>1.6</td>
<td>95.4**</td>
<td>9.7**</td>
<td>0.61</td>
</tr>
<tr>
<td>F.C.</td>
<td>0.02</td>
<td>0.30**</td>
<td>0.67***</td>
<td>0.21**</td>
<td>0.02</td>
<td>0.26**</td>
<td>0.21</td>
<td>0.02</td>
</tr>
<tr>
<td>F/G</td>
<td>12.4*</td>
<td>34.8**</td>
<td>103.3**</td>
<td>0.0</td>
<td>1.0</td>
<td>12.6**</td>
<td>6.7</td>
<td>0.8</td>
</tr>
<tr>
<td>df</td>
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<td></td>
<td></td>
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<td>1</td>
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<td>9</td>
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<tr>
<td>U.W.</td>
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<td></td>
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<td></td>
<td>148.6**</td>
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<td></td>
<td>1</td>
<td></td>
<td>18</td>
</tr>
<tr>
<td>L.W.G.</td>
<td>7.5*</td>
<td>13.2**</td>
<td>3.5</td>
<td>5.8*</td>
<td>0.4</td>
<td>2.2</td>
<td>2.2</td>
<td>1.1</td>
</tr>
<tr>
<td>F.C.</td>
<td>1.21**</td>
<td>3.59**</td>
<td>0.04</td>
<td>0.0</td>
<td>0.06</td>
<td>0.02</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>F/G</td>
<td>21.9**</td>
<td>59.4**</td>
<td>0.1</td>
<td>6.2*</td>
<td>0.3</td>
<td>3.4</td>
<td>1.8</td>
<td>1.2</td>
</tr>
<tr>
<td>df</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
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<tr>
<td>U.W.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>Pig trial</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>df</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>L.W.G.</td>
<td>0.26**</td>
<td>0.37**</td>
<td>1.02**</td>
<td>0.06</td>
<td>0.02</td>
<td>0.00</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>F.C.</td>
<td>0.01</td>
<td>0.12</td>
<td>0.01</td>
<td>0.34**</td>
<td>0.01</td>
<td>0.00</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>F/G</td>
<td>0.2**</td>
<td>2.8*</td>
<td>1.2</td>
<td>6.8*</td>
<td>0.3</td>
<td>0.4</td>
<td>0.2</td>
<td>0.9</td>
</tr>
</tbody>
</table>

\(^a\) Average daily live weight gains.
\(^b\) Average daily feed consumed as a percentage of body weight at the end of the feeding period.
\(^c\) Grams feed consumed per gram gain.
\(^d\) Expressed as a percent of the final body weight.
\(^e\) Linear, quadratic and cubic components of the effect of time.
\(^*\) P<.05.
\(^**\) P<.01.

studied. Time x treatment interaction was not found to be significant indicating a similar behavior for rats on two treatments over time. Maximum live weight gains were observed during the second time period. Results were similar to those observed in rat trial I. Feed consumption and feed conversion efficiency decreased progressively over the period of time rats were kept on the study.

Average uterine weights were found to be .13±.001 and .16±.001% of the final body weight for animals fed diets 1 and 3, respectively. The difference of .03% between the two means was not significant.

**Pig Trial.** Sex affected the traits studied, except feed consumption. Barrows had larger live weight gains and consumed smaller amounts of feed per kilogram of gain than gilts (P<.01). Feed consumption of gilts did not differ significantly from that of barrows.

The performance of pigs fed the two diets was similar as indicated in figure 1. The differences among means for weekly live weight gain, feed consumed and feed/gain of pigs fed the two diets were not statistically significant.

The effect of time was significant for live weight gains and feed conversion (P<.01). Live weight gain decreased progressively with increasing days on treatment. For feed consumption and feed conversion, the response was quadratic.

**Summary**

Corn inoculated with *Nigrospora oryzae* proved toxic to rats as shown by a depression in live weight gains with no reduction in feed consumption when compared with rats fed autoclaved corn in diets. The fungus did not produce any estrogenic effect on rat uteri.

The performance of male rats was better than that of females when live weight gains and feed conversion were compared.

Corn molded with *Cladosporium* proved beneficial to rats and pigs in weight gains as well as feed/gain. No estrogenic effect of the fungus was observed in rats. This field fungus appears not to be a practical problem in swine mycotoxicoses.

The performance of barrows was better than that of gilts in weight gains as well as feed conversion efficiency. The effect of time was significant for all traits studied, except feed consumption of the pigs. In general, there was a tendency for live weight gains and feed
Table 4. Least square means and standard errors for live weight gain (L.W.G.) and feed/gain (F.G.) of rats and pigs fed diet 1 (control), diet 2 (containing corn molded with nigrospora) and diet 3 (containing corn molded with cladosporium). The pigs were on test for 26 days and the rats for 28 days.

<table>
<thead>
<tr>
<th>Item</th>
<th>Diet</th>
<th>Sex</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rat Trial I</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>L.W.G., kg</td>
<td>3.0 ± 1</td>
<td>3.7 ± 1</td>
<td>4.6 ± 1</td>
<td>4.9 ± 1</td>
</tr>
<tr>
<td>F.G., kg</td>
<td>1.6 ± 1</td>
<td>1.6 ± 1</td>
<td>4.6 ± 1</td>
<td>4.6 ± 1</td>
</tr>
<tr>
<td>Pig Trial I</td>
<td>0.65 ± 1</td>
<td>0.65 ± 1</td>
<td>3.7 ± 1</td>
<td>3.7 ± 1</td>
</tr>
<tr>
<td>L.W.G., kg</td>
<td>0.5 ± 0.03</td>
<td>0.6 ± 0.03</td>
<td>0.5 ± 0.01</td>
<td>0.5 ± 0.01</td>
</tr>
<tr>
<td>F.G., kg</td>
<td>0.4 ± 0.03</td>
<td>0.4 ± 0.03</td>
<td>0.4 ± 0.03</td>
<td>0.4 ± 0.03</td>
</tr>
</tbody>
</table>

Figure 1. Average weekly live weight of rats and pigs fed diet 1 (control), diet 2 (contained corn molded with nigrospora) and diet 3 (contained corn molded with cladosporium). The pigs were on test for 26 days and the rats for 28 days.

Conversion efficiency to decrease as the animals grew older.

Literature Cited


