THE VALUE OF CARBADOX\textsuperscript{a} (METHYL 3-(2-QUINOXALINYL- LMETHYLENE) CARBAZATE N\textsuperscript{1}, N\textsuperscript{4}DIOXIDE) IN THE DIETS OF WEANER PIGS IN THE HUMID TROPICAL ENVIRONMENT

By

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SUMMARY

Two experiments were carried out with 108 weaner pigs of the Large White and Large X Landrace breeds, to determine the effects of feeding graded levels of Carbadox (Mecadox), a relatively new synthetic feed medicant with bactericidal and growth-promotion properties, to weaner pigs on their levels of performance and their nutrient utilization abilities in the hot humid tropical environment. Two management conditions, a clean and an untidy conditions were tried. The basal diet was a 19% crude protein diet to which were added 0.0, 10.0, 25.0 and 50.0 ppm levels of Carbadox to give a total of our diets which were fed either individually or in groups to the piglets within each of the four treatment groups. Digestibility trial was carried out in the middle of experiment 1 only. In both experiments, pigs on the 50 ppm diet grew at a faster rate than the pigs on the other diets, but significantly faster in experiment 2 only. Feed consumption was slightly stimulated by the presence of Carbadox, though not significantly, while the efficiency of feed utilization was significantly improved in experiment 2, being best for the 50 ppm diet and worst for the control Carbadox-free diet. The digestibility trial in experiment 1 showed no significant differences in the nutrients digestion coefficients and nitrogen retention, all of which were close for all treatments, with no consistent trends.

\textsuperscript{a}A Pfizer International Product.

INTRODUCTION

Carbadox is a relatively new synthetic chemical compound made by Pfizer International Incorporated, New York. Its chemical name is Methyl 3-(2-quinoxalinylmethylene) Carbazate N, N\textsuperscript{4} dioxide, and its generic name is “Carbadox.” Pfizer markets it under the trade name “Mecadox.” Its molecular formula is C\textsubscript{51}N\textsubscript{10}M\textsubscript{10}N\textsubscript{4}O\textsubscript{4}, and its molecular weights is 262.23. This synthetic chemical compound classified as quinozaline di-N-oxide has both anti-bacterial and growth promoting properties, and it is supposed to be unique in its efficacy against swine dysentery and has inhibitory action against a very wide range of Gram-positive and Gram-negative bacterial specie. It is usually recommended for pigs below the weight of 35kg., with the warning that withdrawal of the compound should take place at least 10 weeks prior to slaughter.

Before the compound was put in the market, Pfizer International commissioned a large number of research stations in different parts of the world to investigate the effects of using this compound on growth rate, feed/gain ratio, nutrient digestion coefficients and the prevalence of vibrio-like organism and salmonella spp. in the faecal swabs of pig and the results of these are summarized in Pfizer Technical Bulletins on Mecadox (Anon, 1970 & 1971). Other than the extensive information summarized in this Bulletin, one does not often find information on this compound in the literature. The few available on weaner pigs showed significant improvements on growth rates and efficiency of feed utilization through the use of carbadox (Trasher et al 1969, 1970), as well as better digestion and retention of nutrients (Yen et al 1976).

The studies reported here were carried out to evaluate the relative merits of feeding graded levels of Carbadox to weaner pigs in a humid tropical environment which was not one of the climatic environments covered by the Pfizer studies using this product.
VALUE OF CARBODOX IN THE DIETS OF WEANER PIGS

MATERIALS AND METHODS

The studies reported here were carried out in Ibadan, Nigeria, with a hot, humid tropical climate, Ibadan city is located at Latitude 07° 20.7 N and Longitude 03° 50 E, with an altitude of 212 metres. Average maximum and minimum temperatures during the period of experimentation were 33° and 24°C respectively, and the average relative humidity at 10.00 and 16.00 hrs. were 85 and 68% respectively while the total hours of bright sunshine were 170 per month. The average monthly precipitation was about 108 mm.

These studies involved 108 weaner pigs of the Large White and the Large White X Landrace crossbreeds randomly assigned to various treatments as described below. Experiment 1.

Forty-eight newly-weaned piglets of both sexes were selected. They weighed 10kg. on average, at the time of selection. The males had earlier been castrated and their wounds had healed about three weeks before the trial started. They were randomly divided into four equal treatment groups of 12 pigs, each group having equal breed ratios, equal average initial liveweight, and equal sex ratios, although the females slightly outnumbered the males (7.5, females to males). Before they were selected for the trial, they were all on the standard weaners' diet containing 24% crude protein. At the start of the trial, the pigs were placed on one of the four test diets formulated to contain approximately 19% crude protein (basal) to which were added 0.0 10.0, 25.0 or 50.0 ppm., Carbadox. These diets were also randomly assigned to the treatment groups. In this trial, all pigs were individually fed four times per day at 08.00hr., 12.00hr., 15.00hr. and 18.00hr., each feeding lasting one hour, after which the pigs were led out into the play pens where they drank water freely until the next feeding period. This feeding arrangement was the only way we could get accurate individual feed intake of the pigs. The composition of the diets used appear in table 1. Records were taken weekly of body weights and consumption.

After the pigs had been on the trial for three weeks, three pigs were randomly selected from each treatment group and placed in the pig metabolism cages designed and described by Oyenuga (1961). In these cages, the pigs were given weighed quantities of their previous feeds daily as well as liberal quantities of water in feeding and watering compartments of these cages. The first four days were used for acclimatization, while faeces and urine were collected for the next six days, using chromic oxide powder as marker to signal the times to start and stop faecal collections. They were returned to their various groups after the metabolism trial, and their records of feed consumption and weight gained were all considered along with the rest throughout the trial. All the analyses of feed, faeces and urine were carried out in accordance with the AOAC methods of Analysis (A.O.A.C., 1971). This trial lasted 8 weeks under what is hereby described as 'clean management conditions' in which the pens were regularly cleaned thrice per day with water.

Experiment 2.

This involved 60 weaner pigs of the same breeds as those in experiment 1, although they were heavier (approximately 15kg., average initial weight) at the start of the trial. They were randomly divided into four equal treatment groups of 15, each group having equal sex and breed ratios. Each group of 15 was further subdivided into three equal replicated groups of 5 pigs, the three replicate groups being fed the same diets ad libitum according to their treatments. The four diets which were also randomly assigned to each main treatment group were the same as those for the pigs in experiment 1, and hence their composition are the same as in Table 1. Watering was also ad libitum throughout the day.
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TABLE 1
Composition of Experimental Diets (Expts. 1 and 2)

<table>
<thead>
<tr>
<th>Ingredients (%)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow maize</td>
<td>40.90</td>
<td>40.90</td>
<td>40.90</td>
<td>40.90</td>
</tr>
<tr>
<td>Groundnut meal</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
</tr>
<tr>
<td>Blood meal</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Fish meal</td>
<td>1.50</td>
<td>1.50</td>
<td>1.50</td>
<td>1.50</td>
</tr>
<tr>
<td>Brewers’ yeast</td>
<td>1.50</td>
<td>1.50</td>
<td>1.50</td>
<td>1.50</td>
</tr>
<tr>
<td>Dicalcium phosphate</td>
<td>2.50</td>
<td>2.50</td>
<td>2.50</td>
<td>2.50</td>
</tr>
<tr>
<td>Oyster shell</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>Palm Oil</td>
<td>2.50</td>
<td>2.50</td>
<td>2.50</td>
<td>2.50</td>
</tr>
<tr>
<td>Carbadox premix</td>
<td>0.00</td>
<td>5.00</td>
<td>12.30</td>
<td>24.70</td>
</tr>
<tr>
<td>Wheat offals(a))</td>
<td>24.70</td>
<td>19.70</td>
<td>12.40</td>
<td>0.00</td>
</tr>
<tr>
<td>Pfizer’s Agricare mix(b))</td>
<td>0.40</td>
<td>0.40</td>
<td>0.40</td>
<td>0.40</td>
</tr>
<tr>
<td>Salt</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
</tr>
<tr>
<td><strong>Analysed crude protein</strong></td>
<td>18.97</td>
<td>18.84</td>
<td>18.68</td>
<td>18.89</td>
</tr>
<tr>
<td><strong>Concentration of carbadox (ppm)</strong></td>
<td>0.00</td>
<td>10.00</td>
<td>25.00</td>
<td>50.00</td>
</tr>
</tbody>
</table>

(a) Wheat offals was added to balance the amount present in the Carbadox premix.
(b) A Pfizer Livestock Feeds product supplying the following per kg of finished diets: Vitamin A, 9823 IU; D₃, 1965 IU; Vit. E, 69 IU; K, 20mg; B₁₂, 10mg/ton; Riboflavin, 41mg; Nicotinic acid, 246mg; Iodine, 20mg; Maganese, 341mg; Zinc, 100mg; Iron, 100mcg; Oxytetacycline hydrochloride, 20g/ton.

In this trial, the cleaning of the pens was done only once a day (at 07.00h) in contrast to the thrice per day cleaning in experiment 1 to stimulate a “dirty condition.” Metabolism trial was not carried out on these pigs because the results of the first metabolism trial showed no statistically significant differences among treatments. Records of weight gains and feed consumption were taken for all the pigs. This trial lasted only 28 days because the pigs were getting to the heavier weight not recommended for Carbadox medications by the manufacturers.

All the data on growth rate, feed consumption, feed efficiency ratios, and nutrient digestion coefficients were subjected to the analysis of variance followed by Dunca’s Multiple Range Test (Steel and Torric 1960) to isolate the significant treatment means.

RESULTS

Tables 2 and 3 show the summaries of the performance characteristics and nutrient digestion coefficients for the pigs in trials 1 and 2 respectively.

AVERAGE DAILY GAIN (ADG).

In both trials, the pigs on the 50 ppm Carbadox diet outgained the pigs on all the other diets. In experiment 1, although there were no significant differences in the ADG for the treatments, the growth improvement index showed that pigs on 50 ppm Carbadox outgained the pigs on the control, zero Carbadox diet by 22%, while those on 25 ppm level outgained the control pigs by 17%. All the pigs on the Carbadox diet by 22%, while those on 25ppm level outgained the control pigs by 17%. All the pigs on the Carbadox medicated diets were superior gainers than to those given the control diet.

In experiment 2, (Table 3) the pigs on the 50 ppm Carbadox diet grew at a significantly faster (P<0.05) rate than the pigs on the control diet only, having a
growth improvement index of 27% over the control pigs. Pigs on the 25 ppm. and 10 ppm Carbadox diets also outgained the control pigs by 17 and 15% respectively but the differences were not significant. Overall, the pigs in trial 2 were superior gainers to those in experiment 1, although their average starting weight was heavier.

**Table 2**

Performance Characteristics and Nutrients Digestion Coefficient of Pigs fed Graded Levels of Carbadox: Experiment 1

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Dietary Treatment Means 1/</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Levels of Carbadox (ppm)</td>
<td>0.0</td>
</tr>
<tr>
<td>Average number of pigs</td>
<td>12.00</td>
</tr>
<tr>
<td>Average initial liveweight (kg)</td>
<td>10.0</td>
</tr>
<tr>
<td>Average final liveweight (kg)</td>
<td>33.04</td>
</tr>
<tr>
<td>Average daily gain (kg)</td>
<td>0.41</td>
</tr>
<tr>
<td>Growth improvement index</td>
<td>1.00</td>
</tr>
<tr>
<td>Average daily feed consumed (kg)</td>
<td>0.96</td>
</tr>
<tr>
<td>Average feed/gain ratio</td>
<td>2.34</td>
</tr>
<tr>
<td>Feed efficiency index</td>
<td>1.00</td>
</tr>
<tr>
<td>Crude protein digestibility (%)</td>
<td>88.50</td>
</tr>
<tr>
<td>Ether extract digestibility (%)</td>
<td>89.54</td>
</tr>
<tr>
<td>Crude fibre digestibility (%)</td>
<td>65.61</td>
</tr>
<tr>
<td>Nitrogen retained (%)</td>
<td>55.51</td>
</tr>
<tr>
<td>Apparent Biological Value</td>
<td>67.04</td>
</tr>
</tbody>
</table>

1/ There were no significant differences in the treatment means for all the characteristics investigated in this trial. (P. 0.05).

**Table 3**

Performance Characteristics of Pigs fed Graded Levels of Carbadox: Experiment 2

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Dietary Treatment Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Levels of Carbadox (ppm)</td>
<td>0.0</td>
</tr>
<tr>
<td>Number of pigs</td>
<td>15</td>
</tr>
<tr>
<td>Average initial liveweight (kg)</td>
<td>15.32</td>
</tr>
<tr>
<td>Average final liveweight (kg)</td>
<td>29.88</td>
</tr>
<tr>
<td>Average daily gain (kg)</td>
<td>0.52a</td>
</tr>
<tr>
<td>Growth improvement index</td>
<td>1.00</td>
</tr>
<tr>
<td>Average daily feed (kg)</td>
<td>1.70</td>
</tr>
<tr>
<td>Average feed/gain ratio</td>
<td>3.27a</td>
</tr>
<tr>
<td>Feed Efficiency index</td>
<td>1.00</td>
</tr>
</tbody>
</table>

a,b........ Treatment means in the same horizontal columns not underscored by the same surfix are significantly different from each other (P. 0.05).
AVERAGE DAILY FEED INTAKE (ADF)

As the data in Tables 2 and 3 show for both trials, there was a general tendency towards improved feed intake as the levels of Carbadox increased in both trials but the differences in ADF data in both experiments were not significant. It was observed that pigs in experiment 2 also consumed much larger quantities of feed than those in experiment 1, most probably because they were on ad libitum feeding regime unlike those in experiment 1 that were slightly restricted. Average Efficiency of Feed Conversion (EFC).

A direct comparison of this parameter for both trials 1 and 2 showed that pigs in experiment 1 had much better EFC than those in experiment 2. In trial 1, although there was a trend of better feed efficiency of feed utilization as the Carbadox levels increased, with the pigs on the 50 ppm Carbadox having the best conversion efficiency and the control pigs the worst converters, the differences in treatment means were not significant. In experiment 2, however, while a similar improvement in feed conversion efficiency was found as the Carbadox levels increased, the pigs on the Control, unmedicated diet (P 0.05) but were not significantly better than the other medicated diets. Similarly, the differences in the EFC ratios for the pigs on the control, 10 ppm and 25 ppm Carbadox diets were not significant. The feed efficiency improvement index was very much higher for pigs in trial 2 than those in experiment 1, with the pigs on the 50 ppm Carbadox diet being 19% and 4% more efficient than the pigs on the control diet for experiments 2 and 1 respectively. Nutrient Digestion Results.

The results of the nutrient digestion and retention (trial 1 alone) appear at the bottom of Table 2. For the major fractions studied, crude protein, either extract, and crude fibre, there were no significant differences among the treatment means and in fact, the figures were similar with no trends except in the apparent Biological Value which slightly increased nonsignificantly with increases in the Barbadox levels.

DISCUSSION

This synthetic chemical compound can be likened to any one of the major, well known, antibiotics since it has anti-bacterial and growth-promoting properties. It is unique in view of its efficiency against those micro-organisms that cause swine dysentery or bloody scour and swine enteritis.

The claim that the compound promotes better growth and feed efficiency in pigs has been vindicated in these trials even though the growth improvement was significant in one trial and not so in the other one. In virtually all the experiments summarized in the Mecadox Technical Bulletins (Anon, 1970, 1971) and more recently by Trasher et al (1969, 1970) and Yen et al (1976) the growth-promoting ability of Carbadox was demonstrated, and in all of them, the recommended level of 50 to 55 ppm Carbadox gave the best results as obtained in the trials described here. The differences in the growth responses between the two trials could be attributed to a number of reasons, the most significant one being the differences in the feeding regimes. The pigs in trial 2 were on ad libitum regime and hence they consumed much more feed which enabled them to grow faster than those pigs in trial 1 that were on a semi-restricted feeding regime. However, a comparison of the growth improvement indices in the two trials shows higher indices for pigs in trial 2 than those in trial 1. While the ad libitum regime of feeding could be a contributing factor, it was possible that the Mecadox was more effective in the medicated versus non-medicated diet in this trial because their
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environment was “dirtier” than those in

the first trial. This finding further con-

irms those of Braude, Wallace and

Cunha (1953), and Cunha, Burnside,

Meadows, Edwards, Benson, Pearson

and Glasscock (1950), among others who

had earlier said that under conditions of

stress, such as poor sanitation and low

quality rations, the improvement in

growth and feed utilization are much

greater when antibiotics are fed than

under sanitary conditions. Furthermore,

the finding is in line with those of

Carpenter (1951), Catron et al (1950), Speer

et al (1951, 1950) and Wallace, Hay and

Cunha (1951), who claimed that in swine

nutrition, the degree of effectiveness of

antibiotic feeding is largely determined by

the level of sanitation and hence disease level in

the feed-lot. The absolute levels of improve-

ment indices in the growth and feed conver-
sion efficiency of our pigs were not as great

as many of those summarized in the

Mecadox Technical Bulletins (Anon, 1969,

1970) probably because we used higher pro-

tein diets which would tend to mask the dif-
fences in the inadequacies of the diets as

had earlier been indicated by Braude et al

(1953, 1955) who found significant dif-
fences in the performance characteristics of

their pigs when they fed Carbadox to

pigs on low protein diets but not so when

the diets were high in protein.

The nutrient digestibility data were,

however, contrary to what most workers

had reported for pigs on various levels of

antibiotics in the past. Yen et al (1976) also

obtained mixed results with respect to

nutrient digestibility and retention but

overall, they confirmed the findings of

previous workers who obtained significant

improvements in nutrient utilization as a

result of antibiotics therapy. Catron et al

(1952), Braude et al (1953, 1955), and

Coates et al (1955) obtained significant

improvements in nutrient utilization by the

pigs or chicks fed antibiotics and postulated

that the animals on antibiotics generally
developed more efficient digestive enzyme

system as well as a thinner intestinal lining

that absorbed nutrients more readily than

the thicker walls of those animals on the an-
tibiotic free diets. The pigs in our studies did

not show any significant differences in their

nutrient digestion and retention abilities,

but a possible reason could be the high pro-

tein intake levels and the high level of

fibrous feed incorporation due to the need
to equalize the fibre levels in all the diets,

since the Carbadox was supplied premixed

with wheat offals.

In conclusion, these studies have shown

that in the humid tropical environment, the

feeding of Carbadox at 50 ppm level

would improve growth rate, feed con-
sumption and the feed conversion effi-
ciency of weaner pigs, but its effects on

the nutrient digestion and retention

abilities of the pigs is still inconclusive,

although the level of dietary protein used

in the basal diet might be a major factor
to consider.

ACKNOWLEDGEMENT

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