EFFECT OF COPPER SOURCE AND LEVEL ON PERFORMANCE AND COPPER METABOLISM IN PIGS

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Introduction

The pig requires copper (Cu) at concentrations no greater than 5 to 6 ppm of the diet. However, pharmacological levels of supplemental Cu (100 to 250 ppm) in the form of cupric sulfate (CuSO₄) have been shown to improve the growth rate of pigs. Research in broiler chickens indicated that an organic form of Cu, cupric citrate (CuCit), was effective in stimulating growth at lower concentrations than CuSO₄ (Pesti and Bakalli, 1996). Reducing dietary Cu concentrations without adversely affecting growth is appealing, because of current environmental concerns regarding the excretion of Cu in animal waste. If CuCit could be used at considerably lower concentrations than CuSO₄, this may allow swine producers to feed moderate concentrations of Cu throughout the nursery, growing, and finishing phases. Therefore, the objective of this study was to determine the effects of Cu source and level on performance and Cu metabolism in pigs.

Materials and Methods

Experiment 1: One hundred ninety-two crossbred gilts and barrows (96 gilts and 96 barrows) were weaned at 18 to 22 d of age and allotted to 24 pens based on weaning weight, litter origin, and sex. Pens were randomly assigned to one of six dietary treatments, and each treatment was replicated 4 times. The treatments consisted of: 1) control, 10 ppm Cu as CuSO₄; 2) 66 ppm Cu as CuSO₄; 3) 225 ppm Cu as CuSO₄; 4) 33 ppm Cu as CuCit; 5) 66 ppm Cu as CuCit; 6) 100 ppm Cu as CuCit. The basal diets contained an antibiotic, carbadox (Mecadox®). The nursery phase lasted a total of 35 d, and animal weights and feed disappearance measurements were recorded at the termination of the nursery trial. In addition, blood samples were obtained on d 28 from 2 pigs per pen for the determination of plasma Cu concentrations, and on d 35 liver and bile samples were collected from 2 pigs per pen for the determination of Cu concentrations. Following the nursery phase, 16 pigs per treatment, with 4 replicate pens per treatment, were continued on their respective treatments through the growing and finishing phases. The entire grow-finish phase lasted for a total of 103 d. Animal weights and feed disappearance measurements were obtained at the completion of the growing and the finishing phases. Blood samples were collected at d 42 and d 84 for the determination of plasma Cu concentrations.

Experiment 2: The performance data in Exp. 1 revealed no effect (P > .10) of Cu on growth during the nursery phase. Therefore, in order to determine if the growth promoting effects of Cu
were being obscured by the growth stimulating effects of an antibiotic, one hundred ninety-two
crossbred gilts and barrows (96 gilts and 96 barrows) were weaned at 18 to 22 d of age and
allotted to 24 pens based on weaning weight, litter origin, and sex. All experimental procedures,
treatments, and diets were identical to the nursery trial in Exp. 1, except there was no addition of
an antibiotic to the basal diets.

**Results and Discussion**

*Performance:* The performance results from the nursery studies in Exp. 1 and Exp. 2 indicate
that CuCit may be as beneficial as CuSO₄. This is difficult to extrapolate upon, due to the fact
that there was no growth response to the supplementation of 225 ppm Cu as CuSO₄.
Nonetheless, CuCit (at lower concentrations) did not hinder the performance of the animals
relative to the performance of the animals consuming basal diets supplemented with CuSO₄
during the nursery phase. In the grow-finish phase, 66 ppm Cu as CuSO₄ improved \( P < .10 \)
ADG and ADFI compared to the control and the high CuSO₄ treatment.

*Copper Metabolism:* Pigs receiving 225 ppm Cu from CuSO₄ had higher \( P < .10 \) plasma Cu
concentrations than those fed the control, 66 ppm Cu as CuSO₄, 66 ppm Cu as CuCit, and 100
ppm Cu as CuCit in Exp. 1. In addition, pigs fed 225 ppm Cu as CuSO₄ had higher \( P < .05 \)
plasma Cu concentrations in Exp. 2 than pigs in other treatments. During the growing phase,
animals receiving 225 ppm Cu as CuSO₄ had increased \( P < .10 \) plasma Cu concentrations
compared with the control animals. In the finishing phase, animals receiving 225 ppm Cu as
CuSO₄ and 100 ppm Cu as CuCit had greater \( P < .10 \) plasma Cu concentrations than pigs fed
66 ppm Cu as CuSO₄ or 33 ppm Cu as CuCit. Irrespective of Cu source, there was no linear
increases in plasma Cu with increasing Cu concentrations in the diet in the nursery (Exp.1 and 2)
or grow-finish phases.

Measurements of Cu bioavailability have traditionally focused upon liver Cu concentrations.
Studies have demonstrated that liver Cu accumulation is linear when dietary Cu concentration is
greater than 250 ppm in pigs; however, at dietary concentrations below 250 ppm there is no
linear increase in liver Cu (Cromwell et al., 1989). In the present studies, liver Cu concentrations
increased \( P < .01 \) with the addition of 225 ppm Cu as CuSO₄ in Exp. 1 and 2. There was a 16-
fold and a 31-fold increase in liver Cu concentrations from 66 ppm Cu as CuSO₄ to 225 ppm Cu
as CuSO₄ in Exp. 1 and 2, respectively. There was no change \( P > .10 \) in liver Cu concentrations
in Exp. 1 or 2 with increasing dietary concentrations of CuCit up to 100 ppm or with 66 ppm Cu
as CuSO₄. Therefore, the current data suggest that liver Cu concentrations do not provide an
accurate assessment of the bioavailability of Cu sources when dietary Cu is fed below 225 mg
Cu/kg diet.

Bile Cu concentrations have been used to evaluate the bioavailability of various Cu sources in
Cu-deficient chicks fed between 0 and 2 mg Cu/kg diet (Aoyagi and Baker, 1993). Bowland et
al. (1961) reported that biliary excretion of Cu is the primary route of excreting absorbed Cu in
pigs. Therefore, biliary Cu excretion was used to assess the bioavailability of CuCit relative to
CuSO₄. Bile Cu was higher \( P < .01 \) in animals receiving diets supplemented with 225 ppm Cu
as CuSO₄ in Exp. 1 and 2. The lower concentrations of supplemental Cu did not increase \( P > .10 \)
bile Cu compared to the control treatment. According to the current data, neither liver nor
bile Cu concentrations provide an accurate means to assess bioavailability in pigs fed adequate to pharmacological concentrations of Cu.

Summary

Supplemental Cu in the form of CuCit appears to be as effective as CuSO$_4$ as a Cu source for weanling and grow-finish pigs. However, there was no effect of Cu, regardless of Cu source, on growth performance; therefore, it is difficult to make an accurate assessment on the efficacy of CuCit relative to CuSO$_4$ as a Cu supplement. In addition, liver and bile Cu concentrations were not reliable indicators of bioavailability of Cu sources in pigs when adequate to pharmacological concentrations of Cu were fed.

References


