Effects of zinc, copper, oregano oil and ractopamine as antibiotic alternatives on bacterial resistance and growth performance in swine

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Abstract
- Feedgrade antibiotics have been used in food animals since 1950s for growth promotion and prophylaxis.
- A worldwide increase in antibiotic resistance has prompted the exploration of alternatives to such uses in the form of heavy metals, essential oils and β-adrenergic agonists, among others.
- Our first trial on weaned piglets was arranged in a 2x2x2 complete factorial design, factors being copper (Cu), zinc (Zn), and oregano oil (OREG), and included reference diets of chlortetracycline (CTC: 22mg/kg prophylactic dose and 4mg/kg sub-therapeutic dose) for comparison purposes.
- A 2nd trial in finisher pigs was arranged in a 2x2x2 complete factorial design: Cu, Zn, & ractopamine (RAC).
- Fecal samples were collected every seven days during each study period. Quantitative and qualitative microbiological assays were performed (see methods section) on E. coli and Enterococcus spp (in progress).
- Standard growth performance and feed efficiency parameters also were recorded.
- The results of the first study did not show any significant associations between antibiotic alternatives (Cu, Zn and OREG) and bacterial resistance, with the exception of copper, which showed a strong negative association with multi-drug resistant phenotypes (including to 3rd generation cephalosporins).
- CTC and Cu added separately to the piglets’ diet each showed reduction in ceftriaxone resistance, possibly tied to associations of chromosomal pOsb and tet(B) genes versus plasmid borne tet(A) and blaCMY.
- No beneficial production effects in weaned pigs were observed for essential oils; however, other alternatives including Cu, Zn and ractopamine as well as CTC (antibiotic) improved the growth rate of nursery piglets. Carcass yield effects on subsequent nursery growth performance were minimal.
- The second study demonstrated that copper or zinc, alone or in combination with ractopamine, did not improve average daily gain in pigs; however, inclusion of ractopamine alone improved carcass leaniness as well as feed efficiency while not measurably affecting antimicrobial resistance among E. coli.
- Generally speaking, alternatives to antibiotics that we assessed in two swine production stages did not demonstrably increase the risk of antibiotic resistance among coliform bacteria.
- Statistical power was limited for observing differences in any health or disease outcomes; none were noted.

Objectives
- We investigated the effects of zinc, copper, oregano oil and ractopamine in different swine production stages (as appropriate), as alternatives to growth promotion and prophylactic in-feed antibiotics.
- These two trials involved nursery and grower pigs, respectively, in full factorial experimental study designs.

Methods

Nursery Pig Trial 1
Trial design
- N=350 21 day old commercially derived nursery piglets.
- 5 piglets were randomly assigned to a pen; each pen was randomly assigned a basal swine diet with one of the 10 N=7 replicate pens per treatment.
- 49 day trial with 7 day acclimation period; feces collected weekly; analyzed at day 0 and day 28.
- Statistical power was limited for observing differences in any health or disease outcomes; none were noted.

Results

Nursery Pig Trial 1
Bar graph that shows the phenomenon of a drop in median resistance count as the pigs age.

Discussion

Nursery Pig Trial 1
- The alternatives (copper, zinc, oregano oil) did not show a significant association with drug resistance (P>0.05), with a few notable exceptions involving copper (see Graphs 3-4).
- 5.7% of E. coli were resistant or exhibited reduced susceptibility to ciprofloxacin, which is an important broad spectrum antibiotic for humans.
- 99% of E. coli were resistant to tetracycline, which shows the saturation of this resistance in the swine industry. The widely reported phenomenon of multi-drug resistance decreasing with age was confirmed.
- Addition of CTC and copper separately to the piglet’s diet each showed a paradoxical reduction of ceftriaxone resistance likely tied to associations of pOsb and tet(B) genes versus tet(A) and blaCMY.
- The role of the pco operon in conferring E. coli resistance to copper is questionable based on our results.

Finisher Pig Trial 2
Supplementation of 125 mg/kg Cu or 150 mg/kg Zn in diets containing RAC did not improve finishing pig growth performance of pigs with high feed intake levels as observed in this study.

Future Work
- Fully explore the MDR genotypes in depth and examine Cu and Zn with regards to antibiotic r-gene presence; thus, more fully understanding the interplay of molecular biology and microbial ecology of metal and antibiotic resistance genes in pig production environments. An unexplained effect of ractopamine on MDR counts exists.

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