Copper provides good cost-to-benefit ratio

At current copper costs, production improvements and additional benefits continue to justify copper's inclusion in broiler chicken feeds.

By DANNY HOOGE*

The cost for copper used in broiler chicken feeds has increased considerably in the past few years, causing many nutritionists to re-evaluate its benefits.

Broiler research has demonstrated that copper can improve intestinal health, reduce breast muscle cholesterol, increase polyunsaturated fatty proportion, provide protection of enzymes and vitamins from microbial degradation and improve bodyweight and feed conversion ratio.

This article will examine published research pertaining to several of these factors, followed by an economic analysis based on live weight and feed conversion ratio improvements.

The recent rise in copper metal prices has driven both metal and copper feed ingredient costs to historic highs. While many commodity costs are up by a factor of two, copper has increased by five.

In Fig. 1, commodity costs are up by a factor of two, copper has increased by five.

Economic analysis based on live weight and feed conversion ratio.

Live performance

Smith (1969) reviewed copper supplementation for chicks and found that levels of 76-225 parts per million of dietary copper (190-560 ppm copper sulfate; typically 25.2% copper in copper sulfate) promoted growth, whereas levels in excess of 300 ppm copper inhibited growth.

Fisher et al. (1971) reviewed broiler trials with 75-225 ppm added copper from copper sulfate and found that 24 trials had positive responses, and nine had equal or no responses in feed conversion ratio. Regression lines obtained in the analysis of 48 comparisons showed a maximum improvement in live weight at 169 ppm of added copper and in feed conversion ratio at 140 ppm.

Fisher (1973) analyzed nine more estimates of responses in three trials in 1969-71 with broiler chickens and calculated improvements of +1.24% in bodyweight and -0.63% in feed conversion.

He concluded that “the addition of 150-200 mg of copper per kilogram of diet … will improve feed conversion about 2% and live weight 1%.”

Doerr et al. (1980) conducted four successive broiler litter pen trials with control or 125 ppm of added dietary copper from copper sulfate and found approximately equal results in the first two trials but significant improvements in bodyweight in the third and fourth trials (+1.29% and +1.38%) and in feed conversion ratio (-1.66%) in the fourth trial. Overall, bodyweight improved +0.79% and feed conversion ratio was reduced 0.40% with the addition of 125 ppm copper.

Aoyagi and Baker (1995) observed that duodenal lamina propria and intraepithelial lymphocytes (number per villus) were decreased in broilers fed diets with copper sulfate, TBCC or bacitracin methylene disalicylate at 55 ppm plus roxarsone at 25 ppm compared to the basal diet group.

Intestinal health

King (1972) discovered that the thickness of the intestinal wall of chickens was reduced by feeding extra copper sulfate in the diet, a finding reminiscent of that with antibiotics and sometimes attributed to a reduction in bacterial toxin production (Fisher, 1973).

Arias and Koutsos (2006) found that duodenal lamina propria and intraepithelial lymphocytes (number per villus) were decreased in broilers fed diets with copper sulfate, TBCC or bacitracin methylene disalicylate at 55 ppm plus roxarsone at 25 ppm compared to the basal diet group.

Cholesterol, fatty acids

Pesti and Bakalli (1996) determined that feeding 125 or 250 ppm of dietary copper from copper sulfate or citrate improved broiler weight and feed conversion ratio and lowered breast muscle cholesterol.

Copper citrate marketing has been discontinued; responses to copper sulfate are presented in Table 1.

Skrivan et al. (2000) reported that 200 ppm of dietary copper from copper sulfate increased bodyweight 4.3%, reduced breast muscle cholesterol 25% and, in abdominal fat, reduced saturated fatty acid proportion and increased the polyunsaturated:saturated fatty acid ratio.

Skrivan et al. (2002) added 126 ppm of dietary copper from copper sulfate to 41 days of age and determined that breast meat long-chain polyunsaturated fatty acids increased in male Ross 208 broilers.

Micronutrients; 58% copper) restored 125 of the 197 g of bodyweight loss and 15 of the 19 points feed conversion ratio due to 1 ppm aflatoxin in the diets of broiler chickens grown to 42 days of age.

Arias and Koutsos (2006) found the 45-day carcass weight of straight-run broilers on used litter to be increased by 188 ppm added copper from either copper sulfate or TBCC compared to a basal diet group.

Protection of enzymes

Hooge et al. (2000) demonstrated improved stabilities of vitamins A, D₃, E and riboflavin with TBCC compared to copper sulfate in crumbled broiler feed. Higher levels of vitamin E were detected in serum and liver of chicks fed diets with TBCC versus none. Steam pelleting of feed appeared to initiate vitamin losses, and TBCC was clearly more effective than copper sulfate at reducing these losses. Copper sources probably reduced microbial (bacterial, mold or both) oxidation to conserve vitamins.

Liu et al. (2004) reported that phytase retention in feed samples stored at 40°C (104°F) for 21 days and sampled weekly was greater (P < 0.10) with either 195 or 390 ppm added copper from copper sulfate or TBCC. Phytase retention was greater for TBCC compared to copper sulfate.

Pang and Applegate (2004) reported an interaction between copper source and the capacity of phytase to hydrolyze phosphorus from phytin-phosphorus in vitro. The highest capacity for hydrolysis to release phosphorus at pH 5.5 or 6.5 was for TBCC and copper lysinate, whereas the least was for copper sulfate or copper chloride at either pH.

Copper bioavailability

Organic copper sources or TBCC [Cu₂(OH)₃Cl] generally have higher bioavailability of copper than copper sulfate. Miles et al. (1998) reported that copper from TBCC was 106 and 112% bioavailable as copper from copper sulfate in a battery brooder and a litter pen trial, respectively. In two 21-day chick trials, Hooge et al. (2000) found relative copper bioavailability of TBCC to be 113% in a used litter and Candida albicans inoculation trial and 122% in a battery brooder trial compared to copper sulfate.

Liu et al. (2004) fed incremental levels of copper from copper sulfate or TBCC to 21-week-old laying hens for 16 weeks and calculated copper bioavailability to be 134% for TBCC.

2. Economic evaluation of copper in broiler diets

<table>
<thead>
<tr>
<th>Valuation</th>
<th>Control</th>
<th>+Copper 150 ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed consumed, lb. (11.00 vs. 11.05 lb. per bird)</td>
<td>11,000,000</td>
<td>11,049,293</td>
</tr>
<tr>
<td>Feed expense, $ ($160.00 vs. $161.44 per ton)</td>
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<td>891,899</td>
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<tr>
<td>Income–feed expense, $</td>
<td>880,000</td>
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<tr>
<td>Difference, $ (additional net income)</td>
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<td>+55,941</td>
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<tr>
<td>Cost of extra copper, $</td>
<td>—</td>
<td>7,955</td>
</tr>
<tr>
<td>Benefit:cost</td>
<td>—</td>
<td>7.01</td>
</tr>
</tbody>
</table>

1Assume 5.5 lb. broiler live weight and 2.00 feed conversion ratio at about 50 days of age; for other assumptions, see economic evaluation section.
2For Fisher (1973), assume +1% in bodyweight and -2% in feed conversion ratio at 150-200 ppm added copper.
3For Pesti and Bakalli (1996), assume +4.24% in bodyweight and -3.28% in feed conversion ratio at 125-250 ppm added copper in seven trials.
relative to copper sulfate. Higher copper bioavailability of organic copper sources or TBCC may reduce fecal copper residues and pollution of the environment.

Economic evaluation

Fisher (1973) proposed in his review article that +1% bodyweight and -2% feed conversion ratio improvements using 150-200 mg copper per kilogram of feed would be appropriate for an economic analysis. More recently, Pesti and Bakalli (1996) conducted seven broiler trials, and results for 125-250 ppm supplemental copper shown in Table 1 indicate improvements of +4.24% in bodyweight and -3.28% in feed conversion ratio.

Therefore, an economic analysis has been conducted for a complex processing 1 million broilers per week using each of these scenarios (Table 2). For the purpose of the calculations, a copper sulfate cost of $1.20/lb. has been used. This equates to an extra cost of $1.44 per ton to add 150 ppm extra copper to broiler feed. An average feed cost of $160 per ton has been used, and this figure includes feed ingredients, manufacturing and delivery costs.

Broiler live weight of 5.500 lb. and feed conversion ratio of 2.000 at about 50 days have been used. On the basis of current production economics alone (using bodyweight and feed conversion improvements), extra copper supplementation to broiler feeds appears to remain a worthwhile practice with 2.4:1 or 7.0:1 benefit:cost ratios, depending on improvements assumed.

More consistent flock health with reduced antibiotics and higher meat quality (lower cholesterol and higher residential antioxidant vitamins) are benefits that may ultimately be as important as the relatively easily quantified improvement in production economics.

Conclusions

At current feed additive copper costs, production improvements and additional benefits continue to justify its inclusion in broiler chicken feeds. Copper could go considerably higher in price, and 150 ppm supplemental copper would still provide return on investment (favorable benefit:cost ratio) to broiler producers.

References

The complete list of references can be obtained at www.feedstuffs.com or by e-mailing tlundeen@feedstuffs.com