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Director's Digest

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THE EFFECT OF COPPER ON THE FAT UTILIZATION OF NURSERY PIGS

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INTRODUCTION

The addition of dietary fat to swine diets has received a considerable amount of attention the past few years. Some studies have shown that the addition of fat to the diets of nursery pigs decreased performance, primarily due to a decreased feed intake during the first 14 days postweaning (Howard et al., 1990; Lawrence and Maxwell, 1983). Other studies have shown that the addition of fat had no effect on performance during the first 14 days postweaning and improved pig performance throughout the nursery period (Cera et al., 1990). Dietary fat digestibility is low in the weaned pig and appears to be related to decreases in intestinal lipase activity shortly after weaning (Lindemann et al., 1986). Fat digestibility increases as intestinal lipase activity increases with age. Diet composition does not appear to affect changes in intestinal lipase activity. However, a fat source by age relationship has been observed for fat digestibility. Vegetable fats, higher in unsaturated fatty acids, have a higher digestibility the first week postweaning than do animal fats. However, by four weeks postweaning there is little difference in the digestibility of vegetable fat versus animal fat (Cera et al., 1988a, 1989, 1990).

added copper influences phospho-lipase & lipase activation in young pig.
$CuSO_4$ - 15 to 20% available

Growth stimulating levels of copper (>100 ppm) are routinely added to swine diets and were present in 94% of the starter diets, 43% of the grower diets and 11% of the finishing diets analyzed in Iowa in 1985 (Ewan, 1986). Braude (1975) summarized the data from 205 trials and found that the addition of 250 ppm copper improved growth rate 5 to 10.5% and feed efficiency 3.9 to 8.1%. A review by Wallace (1967) of 154 trials conducted in the USA showed that copper improved the growth rate of nursery pigs 22.1%, growing pigs 6.5% and growing/finishing pigs 3.6%. Feed efficiency was improved due to the addition of copper by 8.1, 2.3 and 1.1% for the nursery, growing and growing/finishing pigs, respectively.

The addition of growth stimulating levels of copper to the diets of growing-finishing pigs increased the weight percentage of unsaturated fatty acids, primarily C16:1 and C18:1, and decreased the weight percentage of saturated fatty acids, primarily C16:0 and C18:0 in depot fat (Elliot and Bowland, 1968; Amer and Elliot, 1973a,b). Changes in backfat composition due to the addition of copper may have also been affected by protein source, sex and the weight of the pig (Elliot and Bowland, 1970). Amer and Elliot (1973b) found that the addition of copper altered the triglyceride composition of backfat, with the migration of C18:1 and C18:2 to the 2-position of the triglyceride molecule and speculated that the alteration in triglyceride composition was a result of changes in the biosynthetic pathway.

A series of experiments have been conducted at the University of Georgia, Coastal Plain Experiment Station to determine if copper plays a role in the utilization and/or metabolism of dietary fat in the nursery pigs. The first study was conducted to determine if the addition of copper to diets containing added dietary animal fat affected the weanling pig's response to fat (Dove and Haydon, 1992). In this study the addition of 250 ppm copper to diets containing increasing levels of fat increased average daily gain, while pigs fed increasing levels of fat in diets containing 5 ppm copper showed no improvement in daily gain (Table 1). The addition of 250 ppm copper improved growth rate 5.3% in the 0% fat diet and 15.5% in the 5% added fat diet.

The increase in average daily gain is reflected in an increase in daily feed intake by those pigs fed 250 ppm copper. The addition of 250 ppm copper increased feed intake 6.9% in the diets containing no added fat and 15.2% in diets containing 5% added animal fat (Table 1). Overall, the addition of fat had no significant effect on feed intake, although the addition of 5% fat in the diets containing 5 ppm copper numerically decreased intake 5.7%, compared to the diet containing no added fat. The effect of added dietary fat on the feed intake of young pigs is variable and appears to be associated with other dietary components.

Gain:feed ratios were not affected by the addition of growth stimulating levels of copper, but were improved by the addition of increasing levels of animal fat (Table 1). Improvements in feed efficiency associated with added fat have been reported previously (Cera et al., 1988b; Fraley et al., 1988; Howard et al., 1990). Failure of the growth stimulating levels of copper to improve feed efficiency is contrary to the summaries of Braude (1975) and Wallace (1967). Any improvement in feed efficiency due to the addition of copper may have been masked by the improvement due to the addition of dietary fat.

The copper by fat interaction observed during the first 14 days of this study indicates that the addition of 250 ppm copper to the diets of nursery pigs enhances the pig's ability to use dietary animal fat. This may indicate that pigs require additional energy for maximal growth when 250 ppm copper are added to the diet, or it may indicate that under these experimental conditions additional copper was required for the efficient utilization of dietary nutrients (fat and protein) by the weanling pig. The effects of adjusting the lysine calorie ratio, the absence of an antibiotic in these diets, or the levels of other nutrients in these diets on the copper by fat interaction are unknown.

A second nursery study was conducted to determine the effect of the addition of 5, 125 or 250 ppm copper on the growth performance of pigs fed diets containing no added fat (NO FAT) or 5% added soybean oil (SBO), animal fat (ANI), or medium chain triglycerides (MCT). In this study, the addition of 5% SBO, MCT or ANI to the diet increased average daily gain over the 28 day trial (table 2). Average daily gain increased 7.7, 13.6 and 5.3% due to the addition of 5% SBO, MCT and ANI, respectively, when compared to the NO FAT control. During the first 14 days post weaning it appeared that pigs fed the NO FAT or 5% added MCT diets only needed 125 ppm copper to support growth, while pigs fed 5% added SBO or ANI appeared to need 250 ppm copper for maximal growth. During days 14 to 28 of the experiment the addition of 250 ppm copper appears to depress the growth rate of pigs fed 5% added MCT or ANI, while it increases the growth rate of pigs fed NO FAT or SBO when compared to the diets containing 125 ppm.

The addition of the various fat sources had no significant effect on feed intake, although feed intake was numerically decreased by all of the fat sources tested in this experiment. Feed intakes for the first 14 days were 89, 98 and 94% of the intake of the NO FAT diet for the SBO, MCT and ANI diets, respectively. The addition of copper increased feed intake over the 28 day experiment in all diets, however, pigs fed 5% added SBO, MCT or ANI had the highest feed intakes when 125 ppm copper was included in the diet. Decreased feed intake is often cited as the reason that nursery diets should not contain added fat, however the data from our trials indicates that any reduction in feed intake associated with the inclusion of 5% added fat to the diet can be negated by the inclusion of 125 to 250 ppm copper.

The addition of 5% SBO, MCT or ANI increased the gain:feed ratios 9.8, 13.2 and 7.6%, respectively. However the addition of varying copper levels affected the gain:feed ratio of the pigs fed the various fat diets differently. Increasing levels of copper had little effect on the feed efficiency of pigs fed NO FAT or ANI. However, gain:feed ratios were increased in pigs fed 250 ppm copper in the SBO diets and decreased in pigs fed 250 ppm copper in the MCT diets.

The copper by fat interactions and the differences in the response to copper due to the addition of various fat sources indicate that copper may play a very important role in the metabolism of dietary fat in the nursery pig. The mechanisms by which increased levels of copper stimulate the growth of pigs, particularly weanling pigs, are not well understood. A recently completed study with growing pigs indicates that the addition of growth stimulating levels of copper to growing pig diets containing up to 6% added animal fat tended to decrease probed backfat. This indicates that the effects of copper on fat metabolism may be at the cellular level. The identification of dietary components that influence the pig's response to copper and the determination of the metabolic mode of action of copper will help to explain these mechanisms and will lead to improved feeding regimes in the future.

The variable response of pigs to the inclusion of growth stimulating levels of copper indicates that the response to copper is dependent on a number of factors. These may include diet composition, stress, environment, and possibly genetics. Increased levels of iron and zinc and, possibly, manganese and selenium, as well as increased levels of several vitamins may be needed by the pig when growth stimulating levels of copper are included in the diet.

The inclusion of added dietary fat and growth stimulating levels of copper to the diets of nursery pigs will continue to be a hot topic for several years. Our data indicates that up to 5% added dietary fat may be included in the nursery diet, if growth stimulating levels of copper are included in the diet, without having an adverse effect on performance. Our data also indicates that the utilization of animal fat by the nursery pig is equivalent to the utilization of soybean oil.

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TABLE 1. EFFECT OF COPPER AND FAT ADDITION ON THE GROWTH PERFORMANCE OF WEANLING PIGS[a].

Added Cu, ppm	5			250				P-value		
Animal fat, %	0	2.5	5.0	0	2.5	5.0	SEM	Cu	Fat	Fat
Average daily gain, g/d										
d 1-14	186	170	168	191	212	215	10	.001	NS[b]	.07
d 14-28[c]	490	490	511	523	562	587	16	.001	.05	NS
d 1-28	338	330	339	357	387	401	13	.001	NS	.05
Average daily feed intake, g/d										
d 1-14	298	286	271	303	323	334	13	.01	NS	.09
d 14-28	782	733	748	857	867	866	22	.001	NS	NS
d 1-28	540	510	509	580	595	600	16	.001	NS	NS
Gain:feed										
d 1-14	.624	.594	.620	.630	.656	.644	.019	.08	NS	NS
d 14-28[c]	.626	.668	.683	.610	.648	.678	.018	NS	.01	NS
d 1-28[c]	.626	.647	.666	.616	.651	.668	.013	NS	.01	NS

[a] Least square means representing 14 replications per treatment.

[b] Not significant (P > .10).

[c] Quadratic fat effect (P < .05).

TABLE 2. EFFECT OF COPPER AND FAT SOURCE ON THE PERFORMANCE OF WEANLING PIGS.

	FAT SOURCE													P-value		
	NO FAT			Soybean Oil			MCT			Animal Fat						
	PPM, Cu			PPM, Cu			PPM, Cu			PPM, Cu					Fat	Cu X
Item	5	125	250	5	125	250	5	125	250	5	125	250	SEM	Cu	Source	Fat
ADG, g																
d 1-14[a]	160	193	199	168	180	197	216	223	226	169	184	206	14	.05	.010	NS[b]
d 14-28	443	496	533	518	554	576	562	577	538	489	557	532	17	.001	.001	.05
d 1-28[a]	301	344	366	343	367	389	389	400	382	329	370	369	13	.001	.001	NS
ADFI, g																
d 1-14[a]	314	359	368	300	310	314	330	345	354	284	315	373	18	.01	.05	NS
d 14-28[c]	790	923	934	854	925	903	879	939	883	785	961	866	33	.001	NS	NS
d 1-28[c]	551	653	651	573	617	608	604	635	619	533	641	615	22	.001	NS	NS
Gain:feed ratio																
d 1-14	.516	.548	.544	.564	.575	.627	.670	.640	.643	.576	.516	.576	.025	NS	.001	NS
d 14-28[c]	.575	.540	.575	.610	.602	.643	.644	.619	.614	.624	.583	.617	.017	.05	.001	NS
d 1-28[d]	.557	.532	.564	.601	.597	.639	.650	.634	.619	.612	.580	.606	.015	.08	.001	NS

[a] Linear copper P <.01.

[b] NS = Not significant

[c] Quadratic copper P < .01.

[d] Quadratic copper P < .05.