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The effect of high level copper on some meat and back fat factors of pigs

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Summary

High level copper (250 ppm) in the feed of slaughter pigs has been shown to increase significantly the iodine number of the depot fat by 1 unit with restricted feeding and by 2 units with ad lib. feeding. Gas chromatography analysis showed the differences to be due to an increase in the content of oleic acid and a corresponding reduction of stearic acid. There was a tendency for other poly-unsaturated fatty acids also to increase with Cu supplementation though not in the case of linolenic acid.

Meat colour as measured by the tristimulus value (Y) has also shown to be influenced by high level copper in the feed, the copper fed pigs having a significantly darker meat.

The experiments also showed that ad lib. feeding gave a significantly softer backfat than restricted feeding in spite of the fact that the restricted feeding gave a thinner backfat than ad lib. feeding.

Mention is also made of an indication of an increase in iodine number of the backfat due to the interaction of high level energy intake in combination with high level copper.

Zusammenfassung

Hohe Cu-Gehalte (250 ppm) im Schweinemastfutter bewirken schon bei verhaltener Fütterung eine eindeutige Erhöhung der Jodzahl des Depotfettes mit einer Einheit, während bei ad lib.-Fütterung eine Erhöhung von zwei Einheiten zu verzeichnen ist. An Hand gaschromatographischer Bestimmungen konnte gezeigt werden, dass diese Resultate auf eine Erhöhung des Ölsäuregehaltes und einen entsprechenden Abfall des Stearinsäuregehaltes zurückzuführen ist. Es trat eine Tendenz einer Erhöhung anderer poly-ungesättigter Fettsäuren bei hoher Cu-Verabreichung, jedoch nicht für die Linolsäure, hervor.

Bei Beurteilung der Fleischfarbe mit Hilfe des Helligkeitswertes (Y) nach dem CIE-System konnte für diese ein signifikanter Einfluss durch den hohen Kupfergehalt des Futters mit einer Verdunkelung der Farbe nachgewiesen werden.

Die Versuche ergaben weiterhin, dass ad lib.-Fütterung ein eindeutig weicheres Depotfett ergab als die verhaltene, obwohl die letztere eindeutig dünnere Rückenspeckmasse ergab als die erstere.

Den Versuchen ist weiterhin zu entnehmen, dass die Wirkung des Cu-Zusatzes auf die Speckqualität bei ad lib.-Fütterung stärker hervortrat als bei der verhaltenen. Diese Frage muss jedoch in weiteren Versuchen geklärt werden.

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It is already well established that the addition of copper to pig feed at the rate of 125-250 ppm increases growth rate and decreases the feed required per unit of growth in about the same degree. These and other factors have been comprehensively reviewed by Hays (1964). Different copper compounds of varying solubility have been the object of research but the greater part of the research reported in the literature has been carried out with copper sulphate. In general, the increase in growth rate reported has been between 5 and 10 %. But in spite of a large number of experiments there is still uncertainty as to the explanation of the stimulating effect of copper. It has been shown that the bacterial flora of the pig is altered with high level copper in the diet and it can be that copper works in the same way as antibiotics in the diet by reducing the number of microorganisms with give rise to sub-clinical infections in the intestines. One cannot, however, exclude the possibility that copper has a specific effect on the metabolism which in turn manifests itself in growth stimulation. Our experiments have shown definite effects on the normal composition of specific factors.

Research with copper supplementation of pig feed has shown technical and economic advantages which has resulted in ~~the~~ many European countries now including Cu in pig feed as a matter of routine. Since, as mentioned above, certain effects have been observed in connection with high level feeding of Cu it seems of interest to call attention to some effects on fat and meat quality.

In an earlier publication, Taylor & Thomke, (1964) reported the effect of high level copper on the depot fat of pigs. Since then, the research has continued and now includes a total of 185 pigs. Of these 146 have been fed ad lib., the remainder being fed on a restricted scale. The main results are presented in Table 1. Briefly, the research details are that the same feed formula was used with copper sulphate 0.1 % (250 ppm) as the only variable. The balanced mixture basically made up of barley-oats mixture, 15 % protein until the pigs were 50 kg and 13 % protein from 50 kg to slaughter at 90 kg liveweight. The mixture was supplemented with the necessary minerals and vitamins. The pigs were of the Swedish Landrace breed from the College herd. After slaughter at 90 kg a strip of the back fat 2.5 cm wide and down to the long. dorsi was taken from the mid-line of the back between the head and tail. After sampling the fat was put through a meat grinder, melted on a water bath, filtered through a thermo filter and samples taken for the various determinations. The fat was pure and free from water.

The results for growth rate and feed conversion shown in Table 1 are in agreement with results reported in the literature and illustrate the significant effect of high level Cu on these two characteristics. The result which is of more interest, however, is the effect of copper on the iodine number of the backfat. The difference, with restricted feeding is about 1 unit and 2 units with ad lib. feeding. Both results are significant at the $P = 0.01$ level.

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Table 1. Mean results for growth rate, feed conversion, backfat thickness and iodine value. (1 kg barley = 2.91 Mcal metabolizable energy for pigs).

Treatment	Control		Copper (250 ppm)	
Feeding	Restricted	ad lib.	Restricted	ad lib.
No. of pigs	19	83	70	63
Growth rate g/day	579	660	622	709
Feed conversion Mcal/kg growth	9.7	10.4	9.1	9.8
Mean backfat m.m.	28.2	30.5	29.0	30.7
Iodine no. of backfat	59.6	61.9	60.5	63.9

The fatty acid components of the backfat were determined by gas chromatography. The results are presented in Table 2, where it can be seen that there is a significant increase in C_{18} 1Δ with a corresponding reduction of stearic acid. It is interesting to note that the total of the C_{18} components is the same for all four treatments with copper apparently bringing about a redistribution of the acids of the C_{18} group.

A further point of interest in connection with Table 2 is that certain of the fatty acids show a marked difference in distribution between restricted and ad lib. feeding. This factor is already evident from the iodine numbers shown in Table 1. Ad lib. feeding has rather surprisingly given a softer backfat than restricted feeding in spite of the negative correlation r = -0.45, between backfat thickness and iodine number. According to another investigation by Thomke (1962) with 143 observations the regression of iodine number on backfat thickness was -0.32 which means that the iodine number of the restricted fed pigs should be lower by 0,6

Table 2. Distribution of the more important fatty acids in the depot fat of pigs in molarpercent. (n = 33).

	Control		Copper		Significance level	
	Restricted	ad lib.	Restricted	ad lib.	Control v copper	Restricted v ad lib.
C_{14}	1.4	1.4	1.3	1.3	--	--
C_{16}	25.3	25.0	24.9	24.4	--	--
C_{16} /Δ	3.1	3.3	3.1	3.8	--	xx
C_{18}	16.0	13.7	14.9	11.9	xxx	xxx
C_{18} 1Δ	41.9	43.9	42.8	45.5	xx	xxx
C_{18} 2Δ	10.6	10.7	10.7	11.1	--	--
C_{18} 3Δ	1.7	1.9	2.3	1.9		

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units when corrected to the backfat thickness of the ad lib. fed pigs. The regression is in good agreement with that found by Jarl (1940). From the point of view of fat quality it is thus a disadvantage to use ad lib. feeding since, for the same backfat thickness, the iodine number is raised by between 2 to 3 units. The reason for the higher iodine number is the same as pointed out for the effect of copper namely that there is an increase in the unsaturated fatty acids ($C_{18\ 1\ \Delta}$) and a decrease in the C_{18}. Table 2 is also of interest in connection with the significant difference for C_{16} between restricted and ad lib. feeding.

The colour of the meat is also of importance in quality judging. Meat colour is measured as a routine in our pig research to determine the effect of feeding on colour. Measurement is made with a remission photometer (Zeiss Elrepho) 24 hours after slaughter.

A sufficiently large sample of the long. dorsi at the 10^{th} rib is taken in connection with routine measurements for carcase quality. Before measurement, a fresh surface, at right angles to the muscle fibres, is exposed by cutting with a sharp knife. A circular shape, to fit the measuring holder of the apparatus, is obtained by stamping out with 5 cm diameter circular stamp.

Measuring is carried out using white (MgO) as standard. The results are then converted according to the CIE system. An analysis of the results showed that there was no difference between treatments for the x,y - chromaticity coordinates. On the other hand, as can be seen from Table 3, a significant effect of copper on the meat was obtained for the third dimension Y - tristimulus value. In these experiments the Cu fed pigs showed a distinctly darker meat.

The reason for this has not been fully investigated. The determination of the copper content of the muscle - a total of 24 samples-did not show any difference between copper and controls. The mean value was 0.4 ppm and the range 0.3 to 0.6 ppm.

It should be pointed out that the mean difference of 2 units for colour (Y) between controls and copper was fully apparent to the eye. There was a tendency for the restricted feeding to give a somewhat lighter colour than ad lib. feeding,

Table 3. Meat colour of the long.dorsi and copper content of livers.

Treatment	Control		Copper (250 ppm)	
Feeding	Restricted	ad lib.	Restricted	ad lib.
No. of samples	18	77	19	60
Tristimulus value (Y)	20.1	19.1	18.2	17.1
Cu, ppm in fresh liver	7.2	10.3	86.0	171.0

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Reference to Table 3 shows that the Cu content of the livers was significantly different between Cu-fed pigs, both on restricted and ad lib. feeding, 86.0 and 171.0 ppm respectively. The difference is, no doubt, accounted for in that the ad lib. fed Cu pigs consumed 8 % more feed and consequently 8 % more copper.

The level of copper in the livers does not in any way constitute a hazard for human consumption. The average level of 171 ppm and the highest value of 400 ppm are well within the tolerance level for humans.

There are indications of an interaction between energy consumption and high level Cu in the feed. Reference has already been made to the fact that ad lib. feeding results in a higher iodine value of the backfat due to the higher level of energy consumption. High level Cu supplementation in combination with high level energy consumption appears to further influence the iodine value of the backfat indicating that high level Cu in the liver influences directly, or indirectly, the deposition of backfat and the constituent fatty acids. Further investigation is necessary, however, to elucidate this point conclusively.

Literature

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