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EFFECT OF DIETARY COPPER SULFATE CONCENTRATION ON DIGESTION, GROWTH RATE AND SOME BLOOD PARAMETERS OF BROILER RABBITS

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Introduction

During the last decades, in many countries, copper has been recognised as an efficient and inexpensive feed additive for enhancing the performance of growing pigs (Braude, 1981). There are some indications concerning the beneficial effect of copper sulfate supplementation of chick's and rabbit's diet (Underwood, 1981 ; Omole, 1980). Nevertheless, the studies, conducted with rabbits, gave conflicting results (for review see Cheeke, 1987). Being the fact that there can be an interaction between copper supply, nutrient's digestibility and blood constituent's concentration, we complemented our fattening trial with the determination of the diet's digestibility and serum level of some important blood parameters.

Material and method

On the basis of earlier results (Fekete and Gippert, 1985) feed mixture of 18% crude protein content has been considered as ideal for growing rabbits. Pellets containing 22% less protein were also formulated. The composition of the two basal diets is given in Table 1.

At each protein level (signs: 14. and 18.) low (4 ppm), medium (25 ppm), high (50 ppm) and very high (100 ppm) copper supplementation were made using $CuSO_4 \times 5 H_2O$ (signs: 1., 2., 3. and 4.). The low copper dose corresponds to the Hungarian feed regulations (MÉM-ÁTMI, 1984).

In the feeding trials 8 x 24, 38 ± 3 day-old New Zealand White, weaned rabbits of about the same body weight (1.16 ± 0.04 kg) were used. Both origin (fullblood brother and sister groups) and sex were taken into account when forming the groups. The experiment lasted until the animals reached the 10th weeks of age. The rabbits were allocated individually. Ad libitum feeding and drinking were practiced. Feed consumption and live weight were recorded every week and losses daily. At the and of the experiment from 3 animals per treatment blood samples were taken.

Digestibility trial: 6 x 4 femal rabbits (3-4 months old, 2.7 ± 0.13 kg of body weight) of NZW were housed in individual metabolic cages, four rabbits per treatement (14.1., 14.2., 14.3., 14.4., 18.1., 18.2., 18.3. and 18.4.). The so-called self control's, total collection method was used. The duration of the experimental

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periods and treatment of feces were made according to Fekete and Gippert (1986).

Analyses of diets and feces were performed according to A.O.A.C. (1970). The serum parameters were measured by means of an Eppendorf-Photometer 1101 M, using the commercialized test collections and prescribed kinetic (optimalized) methods of Boehringer and Sons Co. Diet and water were offered ad libitum. The dimension of the pellets was 5 x 12 mm.

The digestible energy was calculated using the regression equation of Jentsch et al. (1963). Statistical analyses were performed as described by Pearce (1965).

Results

The most important parameters of the feeding trial are summarized in Table 2. It can be seen from these data that, on the low protein level, practically there was not any difference between the groups concerning the mortality, average daily gain (ADG), feed conversion ratio (FCR) and protein efficiency ratio (PER). On the high protein level, during the first 2 weeks, the copper sulfate supplementation improved somewhat both ADG (by 2-3 grams) and the FCR (by 0.1), but the differences of FCR disappeared to the end of the 5-week-period.

Losses, owing to enteral diseases were significantly lower at the groups, feeding the copper supplemented diets (18.2., 18.3. and 18.4.) than at the low copper- high protein (18.1). It is true both for the first two (mortality 4.2 vs 20.8 %) and for the total five weeks: 12.5 vs 25%.

The ADG of low protein groups was smaller (30 $\pm$ 0.8 vs 36 $\pm$ 0.8 grams), the PER value better (1.9 vs 1.5) than those of the high-protein animals; the FCR did not differ in that comparison (3.8 $\pm$ 0.1).

Data of the digestibility trial are shown in Table 3. Copper supplementation practically did not modify the nutrients' digestibility either on low or on high protein level (even at the 14.2. animals there was some decrease of the digestibility coefficients.). The protein digestibility of high protein groups was significantly ($p < 0.05$) than at the low protein animals.

The measured blood parameters are summerized in Table 4. It can be observed that the copper supplementation increased the concentration of gluthathion-peroxidase, measured either on organic or anorganic substrate, and that of gamma-glutamil-transferase. The later changement is significative (p 0.01)

Discussion

In the described experiment, on the low protein level (14 % CP) practically there was no difference between the groups concerning the ADG and FCR. On the higher protein level (18 % CP), especially during the first 2 weeks, the copper sulfate supplementation improved somewhat both ADG (by 2-3 grams) and FCR (by 0.1) but the differences of FCR disappeared to the end of the 5-week-period (Table 2). It's worth mentioning the better protein economy (PER value) of the 14 % CP groups (2.1 vs 1.7). These results contradict some previous trials (Omole, 1977; Patton et al., 1982) but correspond to those of King (1975) and Grobner et al. (1986a). The contradiction must be apparent, knowing the fact that the effect of copper supplementation is highly variable and appear to be affected by the nature of basal diet (Underwood, 1981).

The copper sulfate supplementation of the 18 % CP diet, according to the results of Patton et al. (1982), reduced the mortality both in the first two (20.8 vs 4.2 %) and in the total five week's period (25 vs 12.5 %). On the 14 % CP level there was no difference between the treatments. It seems that the enterotoxemia preventing action of copper sulfate (Grobner et al., 1986b) is more important on a higher protein diet.

The 100 ppm added copper sulfate (1 gram Cu equals to 4 grams Cu-sulfate) somewhat decreased the nutrients' digestibility of 14 % CP diet. The 200 and 400 ppm supplementation slightly (by 2 %) increased the digestibility coefficient of organic matter at both CP level. The protein digestibility improved (by 2 %) only on the low protein diet, with 200 and 400 ppm added copper sulfate (Table 3). These results indicate an interaction between copper response, dose and protein supply.

According to the earlier statements (Fekete and Gippert, 1985) there is a significant positive correlation between the protein content of the feed and the CP digestibility: 76.5 ± 1.0 vs 81.3 ± 0.4 at the 14 and 18 % CP groups respectively.

The analysed blood parameters were chosen according the fact that the liver plays a central role in the metabolism of copper (Bremner, 1987) and in the scavanger mechanisms (Fehér and Vereckei, 1985). The concentration of total cholesterol, AST, ALT, trigliceride, cholinesterase and lipase did not change owing to the copper treatment, only the level of gluthathion-peroxidase ($GSHP_x$) and gamma-glutamil-transferase (γ-GT) was changed (Table 4) by the treatment. The γ-GT concentrations are in the physiological range (Magdus et al., 1988) but may indicate a slight liver injury. The enhancement of $GSHP_x$ activity can be treated as a physiological one (Mézes and Pusztai, 1986), however it might improve the protection of organism against the so-called "free radical".

On the basis of these results the, in Hungary permitted (MÉM-ÁTMI, 1984) 16 ppm copper sulfate supplementation of growing rabbit's diet -- when one disregards the potentional enteritis-preventing effect of the compound -- is sufficient.

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Table 1.: Composition and nutritive value of experimental diets X)

Ingredients, %	Diets "14 % CP"	"18 % CP"
Wheat	25	25
Barley	15.4	8.7
Sunflower meal, solv. extd.	9.7	15
Wheat bran	15	15
Alfalfa meal, dehy, 19% CP	5	26.2
Corn stalk meal	27.9	8.1
Mineral-vitamin supplement	2.0	2.0
	100.0	100.0
DE, MJ/kg	11.68	12.08
Crude protein, %	14.10	18.07
Digestible CP, %	10.78	14.59
CRude fiber, %	11.72	11.48
Copper, mg/kg	9.2	11.2
Lysine, g/kg	4.7	7.1
Met + Cys, g/kg	4.4	5.9

X) without the 100, 200 and 400 ppm copper sulfate supplementation

Table 2: Performance parameters of rabbits in the fattening trial (n = 24/group; mean ± SEM)

Groups		5 to 7th weeks of age ADG	FCR	PER	Losses[x]	5 to 10th weeks of age ADG	FCR	PER	Losses
14.1.		32	3.5	2.07	3/0	30	3.8	1.88	4/2
	±	1.1	0.07			0.9	0.07		
14.2.		30	3.7	1.97	2/0	31	3.8	1.88	5/5
	±	0.9	0.13			0.9	0.10		
14.3.		33	3.4	2.15	2/0	30	3.8	1.88	4/0
	±	1.3	0.12			0.9	0.10		
14.4.		32	3.3	2.19	4/0	29	3.8	1.90	6/2
	±	1.3	0.1			0.9	0.10		
18.1.		37	3.5	1.63	4/1	35	3.7	1.52	6/0
	±	1.9	0.14			1.1	0.12		
18.2.		40	3.4	1.66	0/0	37	3.9	1.42	1/2
	±	1.2	0.1			0.6	0.08		
18.3.		39	3.4	1.68	2/0	35	3.8	1.47	3/0
	±	1.7	0.10			1.1	0.13		
18.4.		39	3.4	1.66	1/0	38	3.8	1.54	2/0
	±	1.6	0.12			0.7	0.07		

x) Total losses : death/ill

ADG = average daily gain, gram. FCR = feed conversion ratio, kg/kg. PER= protein efficiency ratio

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Table 3: The apparent digestibility coefficients (aDC) of nutrients'
(n = 4/group; mean ± SEM)

Groups	OM	CP	EE	CF	NFE
14.1.	71 ± 0.7	76 ± 1.1	81 ± 1.5	35 ± 1.4	78 ± 0.5
14.2.	67 ± 0.7	74 ± 1.1	72 ± 0.4	39 ± 1.4	74 ± 0.5
14.3.	73 ± 1.3	78 ± 0.9	78 ± 1.3	40 ± 2.8	78 ± 1.2
14.4.	73 ± 1.1	78 ± 0.9	82 ± 0.8	43 ± 2.4	78 ± 1.0
18.1.	69 ± 0.5	81 ± 0.3	80 ± 1.0	28 ± 2.7	76 ± 0.4
18.2.	71 ± 0.5	81 ± 0.5	82 ± 0.3	28 ± 1.5	76 ± 0.5
18.3.	71 ± 1.1	81 ± 0.3	81 ± 0.7	21 ± 3.5	77 ± 1.0
18.4.	71 ± 1.1	82 ± 0.5	85 ± 0.7	30 ± 3.5	75 ± 1.0

OM = organic matter, CP = crude protein, EE = ether extract, NFE = N-free extractives

Table 4.: Value of some blood parameters (n = 6/Cu level, mean ± SEM

Copper sulfate supplementation	TCh[x]	AST	ALT	LIP	TRIG[x]	$GSHP_x$-I.	$GSHP_x$-II.	CHE	γ-GT
	Parameters, U/1								
16 ppm	2.58	32	45	619	0.94	317	372	762	2.15
	0.88	8	12	55	0.10	70	47	35	1.18
100 ppm	1.87	30	40	642	0.90	388	392	694	8.0
	0.50	7	9	73	0.11	53	51	50	1.2
200 ppm	2.05	28	37	643	1.15	422	412	702	5.6
	0.39	4	3	65	0.11	45	46	51	1.2
400 ppm	2.71	35	38	673	0.85	522	487	689	6.5
	0.46	7	5	87	0.09	123	53	68	1.1

x) mmol/l

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In order to furnish data from the effect of different dietary copper sulfate supplementation (16, 100, 200 and 400 ppm) on the digestibility of nutrients and fattening performances at low (14 %) and high (18 %) crude protein level, the authors carried out two experiments. The protein digestibility improved (by 2 %) only on the low protein diet, with 200 and 400 ppm added copper sulfate. In the 35-day-long fattening trial, on the high protein level, especially during the first 2 weeks, the $CuSO_4$ supplementation improved somewhat both average daily gain (by 2-3 g) and the feed conversion ratio (by 0.1). The mortality was reduced only on the higher protein diet by the copper sulfate addition. Among the analysed blood parameters the level of gluthation-peroxidase and gamma-glutamil-transferase was elevated.

L'EFFET DE LA SUPPLÉMENTATION DE LA RATION DU LAPIN AVEC DU SULFATE DE CUIVRE SUR LA DIGESTION, PERFORMANCE D'ENGRAISSEMENT ET QUELQUE IMPORTANTS PARAMETRES DU SANG

Les auteurs ont complémenté de l'aliment de 14 et 18 % de protéine brute (MAT) du lapin avec 16, 100, 200 et 400 ppm $CuSO_4$. La digestibilité de la protéine n'a été améliorée (2%) qu'avec la 200 et 400 ppm de supplémentation, sur le niveau protéique de 14 %. Sur le niveau de 18 % protéine, particulièrement pendant les deux premières semaines, la supplémentation avec du sulfate de cuivre a augmenté le gain moyen quotidien (2-3 g) et l'indice de consommation (0.1). Parmi des paramètres analysés la concentration sanguine de gluthation-peroxidase et gamma-glutamile transferase a été élevée. La mortalité a été réduit par le traitement avec du sulfate de cuivre chez les animaux des groupes de 18 % protéines.