Performance and thyroid hormone status of growing pigs fed a diet with copper sulphate solution treated or untreated rapeseed meal and supplements of iodine, copper or a chinoxaline derivative

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The in vitro inactivation of goitrogenic factors in high glucosinolate rapeseed meal (RSM) by Cu was demonstrated by Bell et al. (1967) and Lüdke et al. (1985). The objectives of the following experiments were to investigate the efficacy of Zn, Fe and Ni in reducing glucosinolate content in RSM and to demonstrate the effect of Cu-treated RSM in an experiment with pigs. In a recent study supplements of Cu in connection with I improved performance (Lüdke et al.,1985) and thyroid hormone state of pigs (Schöne et al.,1986). By including the growth promotor (or ergotropic, Hennig,1982) , bisergon (a chinoxaline derivative) in the feeding trial we wanted to find out if the Cu-effect in a RSM diet is only an ergotropic one.

Material and methods

In vitro investigations

One part of RSM was infiltrated with two parts of H_2O or a Cu-, Fe-, Ni- or Zn-sulphate solution (250 - 500 mg of metal/l). After 24-hour influence of differently concentrated solutions, RSM was dried to weight constancy at 60°C. The isothiocyanate (ITC) and oxazolidinethione (OT) content of treated and untreated RSM was analysed according to the method of Youngs and Wetter (1967) in

the modification of Ohff et al. (1978).

Feeding trial

Pigs were fed a wheat barley soybean meal diet (control groups, 1 and 2) adequately fortified with minerals (without I) and vitamins and calculated to provide 16 % protein. The diet of the RSM-groups (3-8) contained 8 % RSM. It's content of ITC and OT was 0.38 and 1.19 % respectively. I was analyzed with 30 µg/kg in the basal diet according to the method described by Groppel et al. (1981). The design of the trial is to be seen in table 2.

The treatment of RSM with $CuSO_4$ in groups 6 and 7 based on the idea that the total amount of Cu is to take effect on the 8 % RSM share (1 and 12.5 g $CuSO_4 \times 5H_2O$ per kg RSM respectively).

The feeding trialwas carried out with 50 pigs with an initial live weight of 15 kg. Pigs were housed in individual pens. Duration of experiment was 140 days.

At the beginning and the end of the experiment blood was sampled from the vena cava cranialis for determination of T_3 and T_4 in the serum (Radioimmunoassay). Weights of thyroidea and liver were determined after slaughtering.

Results

In vitro investigation

Table 1 shows only for $CuSO_4$ a significant decrease of ITC and OT. Compared to the treatment with water, there was a slight influence of $NiSO_4$ and $FeSO_4$ on the ITC, but not on the OT content of RSM. $ZnSO_4$ had no effect on the concentration of both goitrogens.

Table 1: Content of isothiocyanates and oxazolidine-thione in two rapeseed meals after treatment with water or solutions of Cu-, Ni-, Fe and Zn-sulphate (100 g RSM + 200 g solution)

Metal per 100 g RSM	RSM sample 1 ITC	RSM sample 1 OT	RSM sample 2 ITC	RSM sample 2 OT
	% of dry matter		% of dry matter	
Untreated	0.38	1.19	0.11	0.78
200 ml water	0.28	1.10	0.08	0.50
Cu (mg) as $CuSO_4 x 5H_2O$				
25	non detectable		non detectable	
312	non detectable		-	
500	-		non detectable	
Zn (mg) as $ZnSO_4 x 7H_2O$				
15	-		0.15	0.65
300	-		0.20	0.61
Ni (mg) as $NiSO_4 x 7H_2O$				
25	0.22	1.12	-	
100	0.19	0.96	-	
400	0.23	1.04	-	
Fe (mg) as $FeSO_4 x 7H_2O$				
25	0.26	1.20	-	
100	0.23	1.23	-	
400	0.19	1.11	-	

Feeding trial

Copper or bisergon supplementation but especially the treatment of RSM with $CuSO_4$-solution increased feed intake and live weight gain (table 2).
Because of the small number of pigs the difference of 14 % between pigs with untreated RSM and those treated with 250 mg Cu was only near the limit of significance. The effect of the growth promotor bisergon remained below that of Cu. In the groups with SBM Cu showed no promoting effects.

Table 2: Feed intake, live weight gain and feed efficiency

		Soybean meal			Rapeseed meal				
Group		1	2	3	4	5	6	7	8
Supplements per kg diet (mg)	I	0.125	0.125	0.5	0.5	0.5	0.5	0.5	0.5
	Cu	-	250	-	250	-[1]	20[1]	250[1]	[2]
No of pigs (end of the trial)		6	5	6	6	6	5	6	8
Feed intake kg/d	$\bar{x}$[4]	2.62	2.62	2.34	2.41	2.42	2.52	2.56	2.38
	s	0.12	0.13	0.07	0.11	0.07	0.10	0.14	0.15
Live weight gain g/d	$\bar{x}$[3]	766	756	644	681	681	713	731	669
	s	68	60	54	30	46	29	58	64
Feed:gain kg	$\bar{x}$[4]	3.43	3.43	3.64	3.55	3.56	3.49	3.52	3.58
	s	0.16	0.18	0.22	0.22	0.17	0.07	0.16	0.16

1) 1 part RSM infiltrated with 0.5 parts H_2O (group 5) resp. solution of $CuSO_4 \times 5H_2O$ (groups 6 and 7)
2) 50 mg bisergon/kg diet
3) significant difference 116 ($p < 0,05$)
4) no significant difference

In spite of the I-supplementation of 0.5 mg/kg diet the thyroid weight of pigs which received untreated RSM (group 3) was quadrupled and the liver weight was increased by 40 % relatet to pigs with Cu-treated RSM (group 7) ($p < 0.05$, table 3). The treatment of RSM with water or the bisergon supplementation decreased the weight of thyroidea and liver only slightly. The weight of these organs was only normalized by Cu-supplementation and especially by the treatment of RSM with $CuSO_4$ ($p < 0.05$). The T_3 and T_4 content of the serum differed within and between the groups ($p > 0.05$). Apart from the bisergon group there was the tendency of a higher thyroid hormone level in the serum when treated RSM was fed.

Table 3: Weights of pigs, thyroids and livers as well as thyroid hormon state in trial 2

		Soybean meal								Significant
Group		1	2	3	4	5	6	7	8	difference
Supplements per	I	0.125	0.125	0.5	0.5	0.5	0.5	0.5	0.5	$p < 0.05$
kg diet (mg)	Cu	-	250	-	250	-[1]	20[1]	250[1]	[2]	
Final weight	$\bar{x}$	123	123	106	111	111	116	118	109	17
(kg)	s	9	10	8	6	5	4	9	9	
Thyroid (mg per	$\bar{x}$	92	66	345	138	254	156	88	208	205
kg body weight)	s	28	20	228	33	96	35	12	59	
Liver (g per kg	$\bar{x}$	13.9	14.0	19.4	15.4	17.9	15.7	13.9	19.1	2.9
body weight)	s	0.3	1.5	2.1	1.1	1.5	0.8	1.4	1.3	
per l serum										
T_4 nmol	$\bar{x}$	53	52	42	79	67	79	92	91	>
	s	32	6	19	37	33	29	26	36	
T_3 nmol	$\bar{x}$	1.28	1.22	0.96	1.09	1.06	1.27	1.72	1.48	>
	s	0.52	0.20	0.27	0.29	0.28	0.38	0.57	0.44	

1) RSM treated with water or $CuSO_4$ solution

2) 50 mg biseргon/kg diet

Discussion

As in the experiments of Anke et al. (1980) and Kracht et al. (1983) I deficient pigs consumed about one third less feed and gained almost 50 % less weight than animals fed the rations supplemented with I. In accordance with few findings in fattening pigs (Jahreis et al., 1985) and sows (Gürtler et al., 1984) we could demonstrate hypothyroidism by the reduced thyroid hormon level of the serum.

The inclusion of Cu into the RSM diet delayed the I deficiency (Lüdke et al., 1985) and in connection with I alleviated hypertrophy and hyperplasie of the thyroid gland. The Cu-effect exceeded that of bisergon. Contrary to the growth promotor, which acts indirectly via inhibition of bacterial thioglucosidases in the gut flora (Youngs et al., 1973 and Fenwick, 1984) Cu directly diminishes glucosinolates and their goitrogenic breakdown products. In agreement with findings of Bell et al. (1967) and Youngs et al. (1971) our investigations demonstrate the inactivation of ITC and OT due to $CuSO_4$. Contrary to the data of the Canadian investigations, $FeSO_4$ was slightly efficient. The positive effect of $ZnSO_4$ (Anke et al., 1980) in pig diets rich in RSM cannot be seen in an inactivation of ITC or OT. Searle et al. (1984) tested the influence of Cu^{2+}, Fe^{2+} and Mn^{2+} on the depression of 3-indolylmethylglucosinolates from leaves of Brassica napus in the presence of myrosinase. Cu^{2+} was more efficient than Fe^{2+} and Mn^{2+}. The prerequisite, however, was the inactivation of myrosinase in pH 4. The improvement of performance and thyroid hormone level after feeding RSM treated with $CuSO_4$-solution compared to untreated RSM proves that Cu^{2+} really exhausts goitrogenic and toxic compounds. Drying of the treated RSM seems to be necessary, because some toxical breakdown products are possibly volatile. In a test (unpublished) pigs consumed less of the diet with wet RSM than with dried one.

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