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MINERALS AND NITROGEN IN POULTRY MANURE

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OPSOMMING: MINERALE EN STIKSTOF IN HOENDERMIS

Hoendermismonsters soos beskikbaar as 'n voerbestanddeel vir herkouers, is verkry van verskillende bronne en verdeel in suiwer mis van batteryhoenders, mis en beddegoed vanaf braaikuikenhuise en mis en beddegoed vanaf jong-en teelhenne gehou op die vloer. Groot variasies in minerale – en stikstofinhoud is waargeneem binne sowel as tussen bronne van mis. Die gemiddelde waardes het egter goed ooreengestem met gepubliseerde resultate. Sommige van die braaikuikenmismonsters het 'n hoë koperinhoud bevat (gemiddeld 424 mg/kg Cu). Deur rantsoene met verskillende peile koper en sink aan braaikuikens te voer, is die konsentrering van koper en sink in die mis van die kuikens ondersoek. Daar is afgelei dat kopersulfaat as groeistimulant vir braaikuikens, selfs teen lae peile van byvoeging, die koperinhoud in die mis tot potensieel toksiese peile vir skape kan laat styg.

SUMMARY:

Poultry manure, potentially suitable as a ruminant feedstuff, was obtained from various sources. Samples consisted of pure excreta from birds kept in batteries, broiler excreta on deep litter systems and pullet and breeder excreta on deep litter systems. Large variations in levels of minerals and nitrogen were observed within and between the sources though the average values corresponded well with published results. Some of the broiler litter samples contained high levels of copper (average 424 mg/kg Cu). A trial was carried out to investigate the concentration of copper and zinc in manure from broilers fed rations containing various levels of these minerals. It was concluded that even low levels of copper sulphate additions to broiler rations could give rise to copper levels in the excreta which are potentially toxic to sheep.

For a number of years poultry manure has been used successfully in South Africa as a substitute for more expensive protein sources in ruminant rations (Anonymous, 1960; Bishop, Wilke, Nash, Nell, MacDonald, Compaan, Grobler & Kingman, 1971; van der Westhuizen & Hugo, 1972 a,b) though the high mineral content of manure is often neglected.

Poultry manure can be sold in South Africa as an animal food only if it complies with certain nutrient and hygienic specifications. To satisfy the hygienic requirements manure has to be processed, eg. artificial drying, which substantially increases the price of the product (Denny, 1977). Consequently poultry manure is commonly purchased as fertilizer but used as an animal feed. In order to obtain information on the nutrient content of poultry manure, particularly its mineral content, 3 types of poultry manure were obtained from various sources, viz., pure excreta from birds in batteries, broiler excreta on deep litter systems and pullet and breeder excreta on deep litter systems.

A potential problem with poultry manure as a ruminant food is the danger of chronic copper toxicity in sheep. Fontenot, Webb, Libke & Buehler (1971) and Webb, Phillips, Libke, Harmon & Fontenot (1973) reported cases of copper toxicity in sheep on rations high in poultry manure. Chronic copper toxicity in sheep can develop even at relatively low levels of copper intake (10 to 20 mg/kg Cu) depending on the molybdenum and sulphur content of the diet (Todd, 1969). Furthermore, copper sulphate is sometimes used in broiler rations as a growth stimulant and consequently high copper levels in the excreta (Fisher, Wise & Filmer, 1972).

Because of the negative interaction between copper and zinc in the body of the sheep, Bremner & Davies (1973) suggested the inclusion of high levels of zinc in the ration of sheep as a means of decreasing the danger of copper toxicity. Zinc bacitracin is often used as an unabsorbed antibiotic in poultry diets (Scott, Nesheim & Young, 1969) while levels of zinc above those normally included in poultry rations could have a protective role when copper sulphate is fed to broilers (Fisher, *et al.*, 1972). With both practices the zinc content of manure should increase substantially.

Procedure

A trial was carried out on broilers (one day to 3 weeks of age) to determine to what extent copper and zinc would accumulate in the pure excreta of broilers. The experiment was arranged as a 2 x 3 x 4 factorial design with 3 replications. Half the birds received zinc bacitracin at a rate of 40 g zinc bacitracin premix (10% active ingredient) per 1000 kg food and the remaining birds served as controls. Furthermore, the rations were supplemented with 0, 100 or 200 mg/kg Zn as $ZnCO_3$ and 0, 70, 140 or 210 mg/kg Cu as $CuSo_4$.

The flame atomic absorption spectrometry method was used in the determination of calcium, magnesium, potassium, copper, zinc, manganese and iron, while phosphorus and sodium were measured by the flame emmission method (Allan, 1970). Sulphur and molybdenum were quantitated according to the procedures described by Blancher, Rehm & Caldwell (1965) and Blamey (1971), respectively. The albuminoid nitrogen method of the AOAC (1965) was used to determine true protein. Correlation coefficients were calculated within type of manure between all minerals and nutrients and the F- and t-test for unequal numbers was used to compare mineral contents between groups (Rayner, 1967).

Results and discussion

The summarised results of the nutrient content of the survey samples are given in Table 1.

From Table 1 it is clear that the nutrient content varies tremendously amongst samples, with mineral differences being greatest when battery manure and broiler deep litter were compared. Although the means for pullet and breeder deep litter were intermediate to those obtained for layers and broilers, the range for the majority of minerals was wider than in the latter 2 sources. This inconsistency in composition of poultry manure is considered to be an important drawback in its use as an animal feed. Fontenot & Webb (1974) found that the crude protein content of broiler litter varied considerably even though samples were collected from more or less similar broiler enterprises.

The proportion of bedding material (litter) in the manure could have an important influence on the composition of the final product. The proportion of litter depends on the amount of bedding used, density of birds on the floor and their duration of stay in the houses. Wood shavings are commonly used as litter material in South Africa. Only a few of the samples in the survey contained other litter material such as bagasse, grass hay or sunflower hulls. The crude protein and ash content of different types of wood shavings are given in Table 2 and the results indicate that these litter materials contribute very little to the nitrogen and ash content of poultry manure samples and thus act rather as a diluting factor.

The high ash and mineral content of the poultry manure samples given in Table 1 clearly indicates that poultry manure can be an excellent source of minerals for livestock. The mineral content of poultry manure compares well with that of protein sources such as carcass meal and fish meal (NRC, 1969). Average positive correlations of r=0,74 and r=0,62 were observed between the ash content and calcium and between ash and iron respectively in all 3 groups of manure. Most of the other minerals showed low but positive correlations with ash.

Table 2

The nitrogen x 6,25 and ash contents of wood shavings used as litter material in poultry houses (dry matter basis)

	nitrogen x 6,25 (%)	ash (%)
Pine	0,54	0,46
Meranti	0,71	0,06
Soft Eucalyptus	0,30	0,20
Hard Eucalyptus	0,51	2,39

The calcium levels in the samples corresponded well with those obtained by other workers (Blair, 1974; Emerson, 1975). The phosphorus levels were slightly lower than the minimum values required by the Department of Agricultural Technical Services in South Africa for registration of poultry manure as a livestock food, viz. 2,0% minimum for cage birds and 1,5% minimum for broilers (Denny, 1977). Jimenez (1974) quoted calcium retentions of 88% and phosphorus retentions of 66% for poultry manure, indicating that manure would be an excellent source of these 2 minerals. However, the high Ca : P ratio in pure battery manure could be a problem in rations where wide ratios of Ca : P already exist, eg. the natural veld (van Wyk, Oosthuizen & Meyer, 1955), whereas in rations high in maize meal and consequently low in Ca, it would be an excellent supplement.

High positive correlations were observed in all 3 types of manure between each of the following minerals: Mg, K, Zn and S.

With the exception of a few samples, the sodium levels fell below the upper limits of 0,5% as required for registration of poultry manure as a livestock food (Denny, 1977). The sulphur levels of the analysed samples were high while the molybdenum (Mo) levels were very low, except for one sample with a content of 4,3 mg/kg Mo. This sample also had an Fe content of 1,7% which was considerably higher than the levels in the other samples and was therefore excluded from calculations. The iron levels in the samples compared well with levels given in the literature, eg. 630 mg/kg (Lowman & Knight, 1970) and 1660 mg/kg (Essig, 1975).

Copper and Zinc

The broiler manure samples could be divided into 2 groups, those samples with an average of 28 mg/kg Cu ranging from 5 to 52 mg/kg and the remainder with an average of 424 mg/kg Cu ranging from 296 to 570 mg/kg. These high copper levels in the latter group probably reflect the use of copper supplement as a growth stimulant in the broiler rations. With rations containing 50% broiler litter with 191 mg/kg Cu, Fontenot, *et al.*, (1971) experienced sheep mortalities due to copper toxicity. The samples with the high Cu levels (424 mg/kg) would therefore be potentially dangerous to sheep.

The marked concentration of copper and zinc in broiler excreta when additional copper and zinc were fed, can be seen from Table 3, and Figure 1.

Bremmer, Young & Mills (1976) found that high levels of zinc (220 and 420 mg/kg) in sheep rations containing 29 mg/kg Cu, resulted in decreased copper levels in the sheep livers. They concluded that the incidence of copper toxicity in sheep could be controlled by the inclusion of zinc at high levels in sheep rations. The high zinc content of poultry manure may therefore be a safeguard against copper toxicity in sheep when poultry manure contains copper levels of below 50 mg/kg, as required for registration as a livestock food in South Africa (Denny, 1977). However, to what extent zinc would be a protection at copper levels above 29 mg/kg is not clear.

Table 1

Mineral and protein content of poultry manure on a dry matter basis (Survey results)

	Pure battery manure (n = 8)			Broiler Deep Litter (n = 12)			Pullet & Breeder Deep Litter (n = 14)		
Nutrient	average	S E ±	range	average	S E ±	range	average	S E ±	range
Calcium (%)	6,26^{b}	1,76	4,14 – 8,41	1,83^{b}	0,70	0,92 – 2,97	3,66^{b}	2,11	0,94 – 7,62
Phosphorus (%)	1,84^{a}	0,35	1,11 – 2,30	1,44^{a}	0,39	0,51 – 1,89	1,62	0,22	1,25 – 2,08
Ca : P ratio (:1)	3,63	–	2,06 – 7,58	1,38	–	0,85 – 2,80	2,18	–	0,63 – 4,28
Magnesium (%)	0,75^{b}	0,24	0,34 – 1,08	0,47^{b}	0,09	0,36 – 0,70	0,60	0,18	0,34 – 0,94
Potassium (%)	1,71^{b}	0,51	1,00 – 2,62	1,10^{ba}	0,20	0,85 – 1,43	1,46^{a}	0,37	1,14 – 2,66
Sodium (%)	0,35^{a}	0,08	0,22 – 0,51	0,48^{ad}	0,15	0,31 – 0,86	0,37^{d}	0,10	0,16 – 0,55
Sulphur (%)	0,66^{a}	0,18	0,47 – 1,08	0,60^{ab}	0,08	0,55 – 0,81	0,51^{ab}	0,12	0,30 – 0,85
Copper (mg/kg)	36^{a}	9,04	23 – 53	192^{ab}	214,9	5 – 570	47^{b}	23,6	10 – 97
Zinc (mg/kg)	364^{ad}	133,0	246 – 661	261^{a}	63,4	170 – 361	264^{d}	72,9	208 – 484
Manganese (mg/kg)	533^{b}	74,8	455 – 697	418^{b}	88,9	290 – 595	469	95,2	309 – 629
Molybdenum (mg/kg)	0,73	0,50	0,36 – 1,84	1,15	1,01	0,45 – 4,30	0,89	0,20	0,41 – 1,11
Iron (mg/kg)	1576^{bc}	252	919 – 3259	700^{b}	39	506 – 17603*	962^{c}	121	45,2 – 1784
Ash (%)	30,8^{b}	4,66	20,6 – 37,0	13,7^{bd}	5,58	9,1 – 30,0	19,0^{bd}	6,99	9,3 – 33,9
Crude protein (N x 6.25) (%)	22,8^{c}	4,50	19,0 – 32,7	24,7^{b}	3,06	19,5 – 31,1	16,9^{bc}	3,77	9,9 – 26,1
True protein (%)	16,6	3,81	13,7 – 24,9	16,1	2,45	12,6 – 20,0	12,2	2,81	7,3 – 17,6
% true protein in total protein	68,6		62,2 – 71,5	60,8		45,5 – 72,8	68,8		57,3 – 76,0

* The value 17603 mg/kg Fe has been excluded from calculations.

Within the same nutrient, values with the same superscripts a or d designated difference at P = 0,05 and b or c at P = 0,01 levels of significance.

Table 3

Excretion and concentration of copper and zinc in excreta of broilers at various levels of intake

Copper				Zinc		
Intakes	Excretion	Concentration in Excreta	Concentration in Livers	Intakes	Excretion	Concentration in Excreta
(mg/kg)	(mg/kg)	%	(mg/kg)	(mg/kg)	(mg/kg)	%
8	31,8	397,5	18,8	74,0	236,5	319,6
85,7	281,5	328,5	24,6	118,8	378,0	318,2
150,3	502,6	334,4	63,7	174,2	733,0	420,8
250,7	725,1	289,2	166,8	216,4	838,5	387,5
				281,0	1235,0	439,5
				320,7	1335,0	416,3

From Table 3 it can be seen that at all levels of copper and zinc intake, these 2 minerals would concentrate in the excreta. Even at low levels of copper sulphate supplementation the copper levels in the excreta would rise to potentially toxic levels even if diluted with litter or if included in a mixed ration. The accumulation of copper in the chicken livers seemed to explain the curvilinear increase of copper in excreta at high levels.

Protein content

The results from the survey substantiated the use of poultry manure as a nitrogen source. However, wide variations amongst samples were observed especially in the case of pullets and breeders on the deep litter system where some samples had crude protein levels as low as 9,9%.

The proportion of true protein to total protein was high in the samples examined. Only one sample had a level of true protein below 50% of total protein. This is not in agreement with the generally reported results that poultry manure is mainly a NPN source (Blair, 1974), but agrees with the determination of 66,7% true protein obtained by van der Merwe, Pretorius & du Toit (1975). Ashby (1976) indicates that if poultry waste is not dried within 3 days of voiding, the uric acid starts to degrade into ammonia and other breakdown products which are eventually lost to the atmosphere. This would increase the proportion of true protein in the samples and could explain the high true protein percentages in the samples examined.

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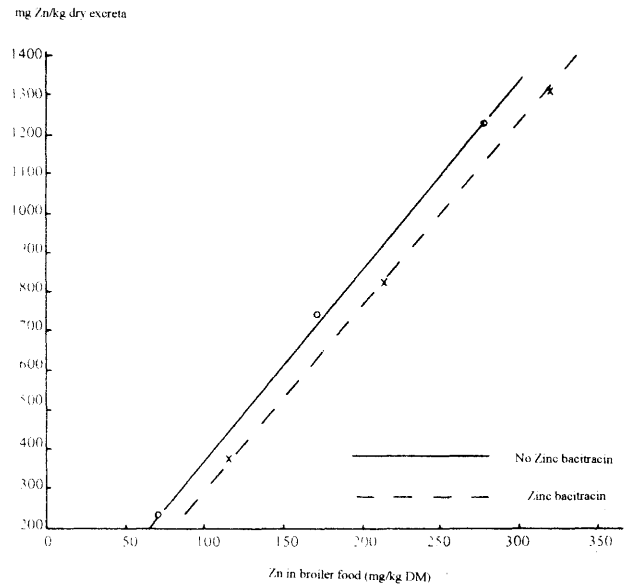

Fig. 1a Zinc levels in broiler excreta

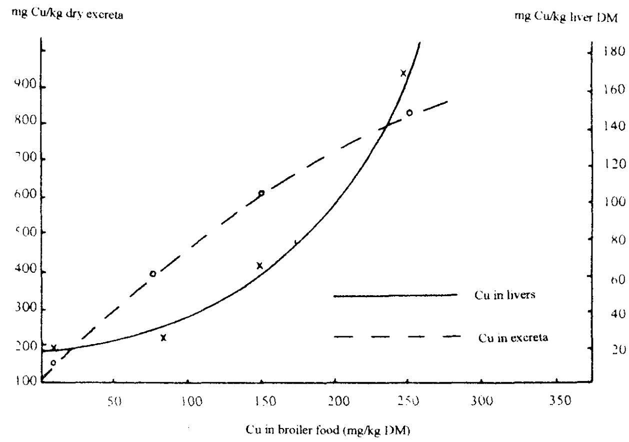

Fig. 1b Copper levels in broiler excreta and livers

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