Dietary Zinc and Protein Utilization by Growing Chickens

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SUMMARY

Seventy birds made up of pullets and cockrels of both the RIR and WPR breeds were selected at four weeks of age and fed either a basal ration or the basal ration supplemented with 30, 60 or 90ppm zinc respectively. Breed as well as sex of growers influenced feed consumption. Dietary levels of zinc affected the feed gain ratio regardless of the breed or sex of the growers. Protein digestion was significantly higher in younger birds than in older ones as a result of zinc supplementation, similar differences were observed as a result of breed and sex. Younger birds retained more zinc than the older ones and the possible variations in the activities of enzymes having zinc as co-factor was discussed.

INTRODUCTION

THE possible function of zinc in the normal growth processes of animals was suspected early this century and Stirn, Elvehjem and Hart (1935) produced further evidence that zinc is of profound importance in the growth of both rats and mice. Direct evidence on the need for the mineral in the nutrition of all species of animals came from the observations of Keilin and Mann (1939) that zinc is present in the prosthetic group of the enzyme carbonic anhydrase; Cloetens (1941) also showed that highly purified uricase and kidney phosphatase contain zinc. Bogert (1960) noted the importance of zinc in the pancreatic hormone, insulin. These studies led to research into establishing the functions of zinc within the body.

Several results showed that zinc, like iron, probably exists within the animals in combination with protein. Thus Hove, Elvehjem and Hart (1940) showed the zinc-protein combination present in the red blood cells, Bowness and his co-

workers (1952) found zinc in the melanin-protein fractions, Tupper, Walts and Wormal (1954) found zinc associated with lipovitellin in the avian egg yolk, while Gurd and Goodman (1952) observed that zinc apparently combines stoichiometrically with specific protein groups. It is evident that utilisation of protein and zinc are related. The levels of dietary zinc that give good results in promoting growth and protein utilisation by growing chickens is being reported in this paper.

MATERIALS AND METHODS

Thirty-five RIR (Rhode Island Red) and thirty-five WPR (White Plymouth Rock) birds were selected, at about one month of age, from the Poultry Unit at the Teaching and Research Farm of the University of Ibadan. These birds were allocated to four rations made up of a basal ration and three supplemental levels of zinc (30, 60 and 90 p.p.m.). The composition of the rations are shown in table 1. Zinc was supplied as zinc oxide in rations 2, 3 and 4. The birds were housed in a floor brooder for first six weeks and they were fed *ad libitum* using the communal feeding system. During the next six weeks the birds were kept in battery cages equipped with individual feeding troughs and communal drinkers. Throughout the experimental period, records of feed intakes and weight gains were kept. The proximate and zinc analysis of the fed samples were done.

TABLE 1

Composition of Experimental Rations ^{a/} (in percentages)

Ingredients	1 (Basal)	2	3	4
Maize	66.0	66.0	66.0	66.0
Fish meal	6.0	6.0	6.0	6.0
Groundnut cake	15.5	15.5	15.5	15.5
Blood meal	4.0	4.0	4.0	4.0
Rice bran	3.0	3.0	3.0	3.0
Oyster shell	5.0	5.0	5.0	5.0
Salt	0.4	0.4	0.4	0.4
Zinc	—	30ppm	60ppm	90ppm

^{a/} The rations were supplemented with 1,600 IU of Vitamin A, and 250 ICU of Vitamin D3 per kg. of feed, together with water-soluble antibiotic sprinkled in water.

The estimation of zinc retention and digestibility of protein by the birds were studied at two different times during the experimental period. When the birds were 6 weeks old and at 12 weeks droppings of individual birds were collected in polythene sheets fitted below metabolism cages. The droppings were collected on alternate days for a week; the droppings were sprayed with one per cent boric acid to reduce bacterial decomposition of the protein as well as to fix the nitrogen so that losses as ammonia would be reduced to the minimum. Analyses done

on the faeces samples include moisture, zinc determination by an atomic absorption spectrophotometer after wet digestion and estimation of protein digestibility by a combination of Ekman (1949) and the A.O.A.C. (1960) methods for true faecal proteins and nitrogen respectively.

RESULTS AND DISCUSSION

The mean feed consumption reported in table 2 revealed the effects of dietary zinc in growers. At low levels of dietary zinc both the pullets and the cockrels of

TABLE 2

Feed Consumption (gm) by Growing Chickens (6 weeks period)

Breed	Sex	Basal diet	Basal + 30ppm Zn	Basal + 60ppm. Zn	Basal + 90ppm. Zn
RIR	pullets	2372.2	2170.8	1940.9	1943.7
	Cockrels	1785.7	1841.6	1805.2	1816.1
WPR	Pullets	2092.1	1952.2	1987.3	2031.7
	Cockrels	2382.8	1917.0	1818.2	1787.7

Analysis of variance for feed consumption

Sources of variation	d.f.	S.S.	M.S.	F (calculated)	F(P < 0.05) (tabulated)
Dietary zinc level	3	1.5	0.5	3.57	3.59
Breed	1	8.69	8.69	62.07**	4.84
Breed x zinc level	3	1.83	0.61	4.36*	3.59
Sex	1	6.28	6.28	44.86**	4.84
Sex x zinc level	3	12.55	4.18	29.86**	3.59
Error	11	1.52	0.14		

the two breeds of birds consumed more feed than when the rations were supplemented with zinc. The breed as well as the sex of the birds influenced feed consumption. Generally, the pullets tended to ingest more feed than the cockrels and the RIR pullets ate more of both the basal and the 30 ppm zinc-supplemented rations than the WPR pullets. However WPR cockrels ate slightly more feed than the RIR. The significant differences in feed consumption as a result of breed,

sex and the interactions of these two with the rations are shown by the analysis of variance for feed consumption.

In poultry production, the cost of feeds is about 60 % of the production costs and these must be matched by comparable returns in terms of live-weight gain by growers and egg production by the layers. In this study live-weight gains were recorded and the feed: gain ratio was calculated as a measure of the usefulness of the respective rations in maintaining growth. The

TABLE 3
Feed Utilisation by the Experimental Birds

Breed	Sex	Basal diet		Basal diet and 30 ppm		Basal diet and 60 ppm		Basal diet and 90 ppm	
		Wt. gain (gm)	Feed/gain	Wt. gain (g)	Feed/gain	Wt. gain (g)	Feed/gain	Wt. gain (g)	Feed/gain
RIP	Pullets	644.62	3.68	709.41	3.06	743.57	2.72	806.51	2.41
	Cockrels	496.03	3.60	588.37	3.13	656.44	2.75	763.07	2.38
	Pullets	550.55	3.80	570.82	3.42	602.21	3.30	626.48	3.35
	Cockrels	637.11	3.74	654.77	3.02	697.05	2.81	763.97	2.34

results are shown in table 3. In both the RIR and WPR growers increasing levels of dietary zinc improved the utilisation of feed for growth. However WPR pullets did not respond as remarkably as the cockrels to zinc supplementation. The analysis of variance revealed significant differences in feed gain ratio as a result of the rations, but differences due to breed and sex were not significant thus showing that regardless of the breed and sex, zinc supplementation improves feed utilisation by the birds used in the experiment. This reasoning arose from the results of analysis of the respective experimental rations. It was observed that the protein content of the rations varied from 24.10 to 24.41 %, the variations being attributed to sampling error; the zinc

content was analysed to be 12.5, 19.0, 25.8 and 32.5 mg per 100 g of the respective rations. A synoptic look at tables 2 and 3 showed that dietary zinc did not remarkably affect total feed intake by the RIR cockrels but it improved the utilisation of feed for increasing body weight.

The nutritional interest in zinc utilisation has been encouraged by the findings of Valee (1962) who related the element to protein metabolism. Our results (table 4) also show the effect of this element on the digestibility of proteins. In both pullets and cockrels of the two breeds of growers, zinc supplementation increased the digestibility of the protein. In almost all the groups of birds, the RIR growers digested the dietary protein better than the WPR. Differences also exist

TABLE 4
Protein Digestibility-a/ by Growing Chickens fed graded levels of Zinc

Breed	Sex	Basal diet		Basal diet + 30 ppm Zn		Basal diet + 60 ppm Zn		Basal diet + 90 ppm Zn	
RIR	Pullets	92.25	(90.10)	92.0	(86.51)	94.2	(84.2)	94.55	(82.73)
	Cockrels	90.32	(82.8)	93.0	(86.3)	93.54	(86.69)	95.10	(84.8)
WPR	Pullets	90.70	(84.10)	91.1	(86.4)	91.8	(90.4)	92.0	(89.6)
	Cockrels	90.6	(84.3)	90.8	(88.6)	91.2	(88.5)	92.0	(89.3)

Analysis of variance for protein digestibility.

Sources of variation	d.f.	S.S.	M.S.	F. (Calculated)	F(P<0.05) (tabulated)
Dietary zinc level	3	2.1	0.70	35**	3.24
Breed	1	0.12	0.12	6*	4.49
Breed x zinc level	3	1.74	0.58	29**	3.24
Sex	1	0.20	0.20	10**	4.49
Sex x zinc level	3	1.65	0.55	27.5**	3.24
Age	1	0.90	0.90	45**	4.49
Age x zinc level	3	0.96	0.32	16**	3.24
Error	16	0.34	0.02		

* Significant differences ($P < 0.05$)** Highly significant differences ($P < 0.01$)

-a/ Figures in brackets were obtained when the birds were 16 weeks old.

in the responses of the pullets and cockrels to protein digestion when graded levels of zinc were added to their diets. This is particularly so for the WPR in which pullets tended to digest the protein better than the cockrels. The differences between the RIR pullets and cockrels were not clear. The differences in protein digestibilities as a result of age were significant. All the birds digested the protein better at 10 weeks of age than at 16 weeks. Thus it is clear (tables 3 and 4) that zinc supplementation of rations compounded from Nigerian local feedstuffs is essential for the digestibility of protein as well as for obtaining economic feed : gain ratios for growers. These observations were supported by the analysis of variance reported in the tables. The observations become important when it is realized that carbonic anhydrase (0.3% zinc) functions in the neutralization of excess acid in the gastric mucosa, thereby influencing digestion.

Zinc retention in relation to dietary levels of the mineral, the breed, sex and age of the growers were studied and the results are presented in table 5. Zinc retention was higher when the birds were fed the basal ration without supplementation. This observation was similar to that of Zeigler and his co-workers (1964) and confirms the need for zinc supplementation above the levels present in natural feed ingredients for optimum production performances by growers. The analysis of variance showed no breed and sex differences in zinc retention by growers but differences due to age were statistically significant. In all groups of the experimental birds, zinc retention was higher when the birds were 10 weeks old than when they were 16 weeks old. The variation of zinc retention with age is partly due to its function in bone formation and in maintenance of the gonads but it could also be due to the fact that zinc

TABLE 5

Mean Zinc Retention by Growers given Different Dietary Levels of the Mineral (mg/100g body wt.)

Breed	Sex	Age	Basal diet	Basal diet + 30 ppm Zn	Basal diet + 60 ppm Zn	Basal diet + 90 ppm Zn
RIR	Pullets	10 weeks	81.0	48.2	28.0	27.0
		16 weeks	19.0	11.2	15.0	15.2
	Cockrels	10 weeks	101.9	78.2	30.0	25.4
		16 weeks	41.8	63.8	15.9	15.1
	Pullets	10 weeks	71.4	27.8	14.9	22.0
		16 weeks	11.2	10.4	13.8	14.5
	Cockrels	10 weeks	60.1	23.4	15.1	14.5
		16 weeks	13.0	9.0	11.8	11.2

Analysis of variance for zinc retention

Sources of variation	d.f.	S.S.	M.S.	F (calculated)	F(P<0.05) (tabulated)
Dietary zinc levels	3	7,860.19	2,620.06	3.91*	3.24
Breed	1	2,202.89	2,202.89	3.29	4.49
Breed x zinc levels	3	703.64	234.55	0.55	3.24
Sex	1	180.81	180.81	0.27	4.49
Sex x zinc level	3	2,725	908.33	1.36	3.24
Age	1	4,320.40	4,320.40	6.45*	4.49
Age x zinc level	3	1,413.87	471.29	0.70	2.34
Error	16	10,711.50	669.47		

is a constituent of several NAD — dependent dehydrogenases such as glutamic acid and alcohol dehydrogenases and the study of variations in the activities of these enzymes with age of growers as well as layers may throw more light on the exact physiological and biochemical functions of zinc and related micro-elements in nutrition.

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