Vol. X (1-4) 1973.

EFFECTS OF HIGH DIETARY MANGANESE ON THE GROWTH OF CHICKS IN THE ABSENCE AND PRESENCE OF SUPPLEMENTAL VITAMIN D

BAKHT BAIDAR KHAN*

The effects of high dietary manganese in the presence and absence of supplemental vitamin D on the growth of White Leghorn baby chicks were studied. Eight dietary treatments containing 40, 200, 1000, and 5000 p.p.m. of manganese with and without supplemental vitamin D_3 were used. Data for feed consumption, body weight gain and efficiency of feed utilization were collected. Per cent bone ash and bone manganese were also determined. No symptoms indicating the development of perosis or presence of vitamin D deficiency could be detected in chicks on any of the dietary treatments used. The birds fed on diets containing as high concentrations of manganese as 200 and 1000 p.p.m showed improvement in growth in the presence of supplemental vitamin D, whereas in the absence of the latter, the reverse was true. The concentration of dietary manganese when raised to 5000 p.p.m., resulted in evident growth depression in either case. With increasing amounts of manganese in diet, the efficiency of feed utilization was found to be depressed with some of the dietary treatments.

INTRODUCTION

In several species of animals, differences in the manganese content of diet have been related to various responses, including gains in body weight, concentration of manganese in blood and serum, activity of phosphates of blood serum and of bone, development of bone, composition of soft tissues and metabolism of calcium and phosphorus (Hawkins *et al.*, 1955). Wilgus *et al.* (1936) and Miller *et al.* (1940) observed that excessively high intakes of calcium and phosphorus in poultry accentuated the dietary needs for manganese, thus indicating metabolic inter-relationships. During the last four decades growing number of functions in different species have been assigned to manganese (Comar and Bronner, 1962).

* Department of Livestock Management, University of Agriculture, Lyallpur.

Reports in literature on the effects of high levels of manganese with and without supplemental vitamin D_3 (hereafter vitamin D) on the growth of chicks are limited. This fact, along with the expanding usage of mineral mixtures of increasing complexity in animal feeding and the increasing recognition of metabolic disturbances from mineral imbalances incited the initiation of this study to ascertain the effects of high dietary manganese in the absence and presence of supplemental vitamin D on the growth of baby chicks.

MATERIALS AND METHODS

In this study 144 male White Leghorn 4–day old chicks were used. They were wing-banded, weighed and randomly grouped in 16 lots (experimental units) of nine chicks each. They were randomly placed in sixteen pens of a thermostatically controlled battery brooder. Eight experimental rations given in table 1 were carefully mixed and were randomly allotted such that there were two groups (replicate) on each ration. These rations were offered *ad libitum* during the experimental period of four weeks. The records of weight gain, feed consumption were kept on weekly basis. The birds were constantly watched for detection of symptoms of deficiency diseases or any other abnormality. At the end of four weeks experimental period, three birds from each pen were randomly picked up and slaughtered. The femur bone from each bird was removed and saved for the determination of bone ash percentage. The bone ash was further analysed for manganese content by atomic absorption spectrometer.

RESULTS AND DISCUSSION

The results obtained in this study have been summarized in table 2. It is evident that the birds on diets supplemented with vitamin D gained on an average 253.8 gms while those on unsupplemented diets gained 245.9 gms during the experimental period of four weeks. The birds on diet containing 40, 200, 1000 and 5000 ppm of manganese gained 258.6, 256.0, 253.8 and 231.0 gms respectively. The differences between mean weight gains on supplemented and unsupplemented diets or on diets having various levels of manganese were non significant. On critically looking at the data, it was revealed that the birds on diets having varying levels of manganese with and without vitamin D supplementation showed the same trend in growth rate. Apparently it seems that growth rate was depressed by increasing levels of manganese in diet. The favourable effect of vitamin D observed in this study on the growth of chicks receiving 200 and 1000 ppm of manganese was in agreement with the findings of Chornock *et al.* (1942). This improvement

effected by supplemental vitamin D may be explained on the basis of its general effect in increasing calcium and phosphorus retention and raising serum phosphorus level. Depressed growth in case of birds fed such high levels of manganese as 5000 ppm appeared to be due to toxic effect of this element. Confirmation of similar effects had earlier been done by Hawkins *et al.* (1955) who indicated that feeding high levels of manganese to the calves affected concentration of serum manganese and interfered with calcium and phosphorus metabolism. Hartman *et al.* (1955) found that excessive dietary manganese retarded haemoglobin formation. Thus depressed growth of chicks fed 5000 ppm manganese as noticed in this study may be explained in the following ways: the high dietary manganese may interfere with (i) the absorption of iron, (ii) the formation of haemoglobin (iii) the combination of (i) and (ii) and (iv) interference with calcium-phosphorus-magnesium metabolism.

The experimental birds on diets having no vitamin D supplementation consumed 424.3 gms of feed per bird while the birds on diets with added vitamin D on an average consumed 440.5 gms of feed. The feed consumption of diets with 40, 200, 1000, and 5000 ppm manganese was 426.9, 460.6, 428.2 and 413.9 gms per bird. Although these differences were non significant yet feed consumption was higher in diets supplemented with vitamin D as compared to unsupplemented diets. The feed consumption was also higher on ration containing 200 and 1000 ppm manganese. This comparison affords evidence of the favourable effect of manganese on feed consumption when used along with vitamin D at 200 and 1000 ppm levels. No consistent trend could be traced from the data for efficiency of feed utilization. However, in general, the efficiency tended to be depressed by the high concentration of dietary manganese.

The average bone ash of the femurs of chicks fed diets containing supplemental vitamin D was 49.88, 50.35, 51.58 and 51.91 per cent with the corresponding levels of 40, 200, 1000, and 5000 ppm of manganese. Although non significant but a gradual increase in bone ash percentage was noticeable with increasing levels of dietary manganese. Comparing this with the values obtained from vitamin D supplemented birds, no accordant uniformity could be noticed since the corresponding bone ash figures for the levels of manganese were 49.66, 48.97, 49.72 and 49.66 per cent. No explanation was readily available for these results, however, the percentage bone ash observed in this study was within the range as quoted by Ewing (1963) for normal chicks. Average bone manganese values in birds fed the vitamin D unsupplemented and supplemented diets were 2, 11, 29, and 74 ppm and 3, 15, 38 and 92 ppm,

TABLE 1. *Composition of Experimental Diets*

Dietary Treatments Ingredients		1	2	3	4	5	6	7	8
Vitamin D_3 (I.U./lb)		—	—	—	—	1000	1000	1000	1000
Manganese (ppm)		40	200	1000	5000	40	200	1000	5000
Yellow maize	(lb)	63.81	63.81	63.81	63.81	63.81	63.81	63.81	63.81
Meat and bone meal	(lb)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Soybean meal	(lb)	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Corn oil	(lb)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Dicalcium phosphate	(lb)	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Limestone	(lb)	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Salt (Iodized)	(lb)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Mineral and vitamin mixture	(lb)	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

TABLE 2. *Summary of Results*

		DIETS							
		1	2	3	4	5	6	7	8
Average weight gain/bird	(gms)	258.40	249.90	242.80	232.50	258.80	262.20	264.90	229.50
Average feed consumption/ bird	(gms)	433.60	445.70	395.40	422.60	420.30	475.60	461.00	405.20
Feed efficiency		1.67	1.78	1.62	1.81	1.62	1.81	1.74	1.76
Bone ash	(%)	49.88	50.35	51.58	51.91	49.66	48.97	49.72	49.66
Manganese in bone ash	(ppm)	2	11	29	74	3	15	38	92

respectively, for the manganese levels of 40, 200, 1000 and 5000 ppm used in the experimental diets. In contrast to the bone ash, the values for bone manganese showed a gradual and persistent increase as the concentration of manganese was enhanced in various dietary treatments. This observation seemed to be in partial agreement with the findings of Smith and Ellis (1947) who, by supplementing the manganese deficient diet with 1, 2, and 4 mg manganese (chloride), could raise the bone manganese of dry, fat-free femurs from the level of 0.5 to 3, 6, and 13 ppm, respectively.

No symptoms indicating the development of *perosis* or presence of vitamin D deficieney could be detected in chicks on any of the dietary treatments used. The absence of *perosis* in birds used for the present study was supported by the findings of Gallup and Norris (1939) who observed that chicks of the White Leghorn breed had a low-manganese requirement. Complete prevention of *perosis* among the chicks of this breed was readily accomplished by feeding them with a level of manganese equivalent to 30 ppm of diet.

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