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Serum Fluoride in the Chick.* (28974)

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The blood fluoride content of most species consuming normal diets is usually under 0.2 ppm(9) and at least in the case of humans has been reported to show little increase with, or correlation to increased levels of fluoride in the water supply(8). In other species, some increase in blood fluoride has been obtained upon fluoride administration(9). In our laboratory, some elevation of the fluoride content of bovine blood with increased dietary exposure has been observed which would suggest that the efficiency of serum fluoride homeostasis may be species dependent. In investigating reports(2,3) of a Mg-F antagonism in young chicks, it was observed that chicks fed high levels of fluoride in the diet had up to 5.0 ppm of F in the blood serum. This report will present the results of studies designed to extend these observations.

Methods. Day old White Leghorn X New Hampshire hybrids were obtained unsexed from the University Poultry Science Department and fed either a practical chick starter ration or a synthetic diet which has previously been shown to be adequate for the chick(4). Indicated levels of fluoride were added to these diets as NaF. Blood was collected by cardiac puncture, and the serum obtained was analyzed for fluoride by the method of Singer and Armstrong(7).

Results. It has previously been demonstrated that the chick is one of the species most resistant to fluorine intoxication(5,6,10), and will maintain a nearly normal increase

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TABLE I. Effect of Dietary Fluoride Level on Tissue Fluoride Concentrations of Chicks Fed a Natural Diet.

Diet	Wt at 2 weeks	Serum F μg F/ml $\pm \sigma$	Femur ash F ppm F $\pm \sigma$
	(g)		
Basal	121	.23 $\pm$ .05	1,210 $\pm$ 30
300 ppm F added	125	2.1 $\pm$ .7	10,800 $\pm$ 820
600 ppm F added	116	3.1 $\pm$ .8	17,400 $\pm$ 1370
900 ppm F added	100	5.2 $\pm$ 2.3	23,500 $\pm$ 2080

The basal ration fed was composed of: 210 lb ground corn, 50 lb ground oats, 50 lb wheat middlings, 25 lb alfalfa meal, 25 lb meat scraps, 100 lb soybean oil meal, 2.5 lb iodized salt, 25 lb fish meal, 5 lb oyster shells (chick), 5 lb granite grit, 1 lb feeding oil (800 units vit A and 300 units vit D/g), 2 lb riboflavin conc (500 γ/g), 0.25 lb antibiotic, B_{12} conc (2 g penicillin and 3 mg vit B_{12}/lb), and 50 g $MnSO_4 \cdot H_2O$. The chicks were placed on experiment at one day of age and killed after 2 weeks. There were 5 chicks in each experimental group.

TABLE II. Effect of Dietary Fluoride Level on Tissue Fluoride Concentrations of Chicks Fed a Purified Diet.

Diet	Wt at 2 weeks	Serum F μg F/ml $\pm \sigma$	Femur ash F ppm F $\pm \sigma$
	(g)		
Basal	125	$<$ .1	811 $\pm$ 150
300 ppm F added	110	.5 $\pm$ .3	9,500 $\pm$ 400
600 ppm F added	125	1.4 $\pm$ .2	18,100 $\pm$ 600
900 ppm F added	101	2.5 $\pm$ .3	21,800 $\pm$ 750

Basal diet employed was a standard purified diet (4), and chicks were on experiment for 2 weeks, starting at one day of age. 5 chicks in each experimental group.

in body weight when more than 0.05% fluoride is incorporated into the diet. An experiment was therefore set up to determine the influence of various dietary fluoride levels on serum fluoride content of chicks fed a fluoride containing chick starter ration for 2 weeks. These data are presented in Table I, along with the growth response and data on the femur fluoride retention in each group. The results of this experiment confirmed the original observations on the existence of high serum F levels in young chicks and indicated that the response was to some extent dependent on the dietary fluoride level.

Analyses of the natural chick starter ration used as the basal diet indicated that it contained about 25 ppm F. To obtain a lower control fluoride level, and to check on any influence of the diet on serum fluoride response, the experiment was repeated using a purified diet which contained by analysis only 6 ppm F. The results (Table II) demonstrated that although there was again a definite increase in serum fluoride with each increase in dietary fluoride, serum fluoride levels at each dietary level were lower than in the previous experiment.

As both of the previous experiments were for 14-day periods, a study of the effect of length of exposure to the diet was initiated using chicks on the control natural starter ration, and this diet to which 900 ppm F had been added. The data in Table III indicate that by the end of one week on the 900 ppm F diet, serum fluoride level had risen to above 4 ppm and did not significantly increase thereafter.

Discussion. The serum fluoride values reported here are significantly higher than those recently reported for other species, and much higher than obtained for other species in our laboratory. It would appear from the high level of fluoride found in both femur and serum of these chicks that the marked resistance of the chick to fluoride intoxication is not the result of poor absorption from its relatively short digestive tract, but rather

TABLE III. Effect of Time on Levels of Fluoride in Serum and Femur of the Young Chick.

Weeks on diet	Serum F, μg/ml $\pm \sigma$		Femur ash F, ppm $\pm \sigma$	
	Basal	900 ppm F	Basal	900 ppm F
1	$<$.1	4.4 $\pm$ .8	662 $\pm$ 26	18,800 $\pm$ 1,670
2	$<$.1	4.2 $\pm$ .9	625 $\pm$ 15	21,400 $\pm$ 1,490
3	.12 $\pm$ .04	5.2 $\pm$ .9	693 $\pm$ 92	22,600 $\pm$ 1,610
4	.60 $\pm$ .3	3.8 $\pm$ 1.4	716 $\pm$ 18	20,200 $\pm$ 710

Basal diet fed was that indicated in Table I. Four chicks from each group were killed at each time period.

some altered mechanism for metabolizing fluoride ion.

It would also seem that the differences in serum fluoride level observed in chicks fed fluoride in the natural or purified diet are not due to a simple effect on absorption as the femur retention values are very similar on both diets. A time curve of retention on the synthetic diet, would, however, be needed to clarify this point.

As intracellular soluble fluoride concentrations of this magnitude would undoubtedly be inhibitory to a number of enzyme systems, it points to the possible existence of an efficient barrier to fluoride entry into the cell, or a complexing of fluoride in an inactive form in the cell. Although Carlson *et al*(1) have obtained a measure of the relative intracellular distribution of fluoride in the soft tissues of the rat, no such information is presently available for the chick.

The relatively high standard deviations reported in the Tables indicate a considerable variation in serum fluoride response between chicks on the same diet. The response is more variable than has been observed in the human (8) or in bovine serum in our laboratory. This might also point to some peculiar features of fluoride metabolism in the chick.

Preliminary analyses indicate that many of the soft tissues of fluoride fed chicks are high in fluoride content, and that in contrast to the serum data, the fluoride content of soft tissues from chicks fed low fluoride diets is elevated relative to other species. The data presented here would indicate that the homeostatic mechanisms for regulating fluoride levels are either much different or operate less efficiently in the chick than in certain other species.

Summary. The serum fluoride level of the young chick has been shown to be elevated from a normal range of under 0.2 ppm F to over 4.0 ppm F when 900 ppm F is added to the diet. The response is related to the amount of fluoride in the diet, and is dependent upon the composition of the diet. This large increase in serum fluoride in the chick is in sharp contrast to the efficient homeostatic fluoride control noted in most species.

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