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THE EFFECT OF FLUORIDES ON THE TEETH

C. A. KEMPF AND V. E. NELSON

Mention was made, in the previous paper, of the fact that mottled enamel of the teeth results from the presence of fluorine in the water supply. The water of the city of Ankeny and surrounding territory may have a fluorine concentration to exceed eight or ten parts per million of water; mottled enamel is very prevalent in that area. Work by Smith (1) of the University of Arizona indicates that mottled enamel may result when the concentration of fluorine is as low as 0.8 to 0.9 part per million of water. The work of Schulz and Lamb (2) and McCollum, Simmonds, Becker, and Bunting (3) has demonstrated that sodium fluoride when fed to rats will produce abnormalities of the teeth of these animals similar to that generally known as mottled enamel in human beings. The work reported in this paper had as its object to ascertain if other inorganic fluorides will produce mottled enamel and also to determine if mottled enamel can be produced by organic fluorides. Furthermore, it was deemed advisable to ascertain if the administration of alum (aluminum sulphate) along with sodium fluoride would prevent the development of mottled enamel.

EXPERIMENTAL

All of the work reported in this paper was performed on rats. The animals were about four weeks of age when placed on the diet and weighed at this time between 45 and 50 grams. The diet used in all of the experiments consisted of the following: 4 volumes of yellow cornmeal, 4 volumes of oat groats (ground), 1 volume of alfalfa meal, 1 volume of wheat (ground), $\frac{1}{2}$ volume of dried buttermilk powder, $\frac{1}{2}$ volume of tankage, and $\frac{1}{2}$ volume of linseed oil meal. For every 100 lbs. of the above mixture were added 0.50 lb. of NaCl and 0.35 lb. of bone meal. All of the animals were kept on screens, and they were cared for daily. The following inorganic fluorides were tested: NaF, Al_2F_6 , $CaSiF_6$, ZnF_2 and CuF_2 . Each salt, except NaF, was fed at a level of 0.10 per cent of fluorine and thoroughly incorporated into the finely ground basal ration. Sodium fluoride was fed at 0.05 per cent of the salt. The ration without the fluorine addition served as a control.

Sodium fluoride caused distinct mottling of the enamel. Calcium silicofluoride also caused lengthening and bleaching of the teeth after 25 days. This salt proved very toxic at the level fed, apparently, so that the animals died suddenly at the end of 33 days. After 18 days the animals on cupric fluoride showed mottling of the teeth. Although the animals receiving CuF_2 were on experiment for at least 6 months, reproduction did not take place and reproduction was not restored even after they were given the growing ration. Zinc fluoride at the level fed proved toxic to the animals, which died at the end of one month without showing any evidence of mottled teeth. Al_2F_6 did not cause mottling of the teeth, and reproduction on the diet containing this salt was good. Hemoglobin determinations were performed on the animals by means of the Newcomer acid hematin method. There were no significant changes in the hemoglobin content of the animals receiving the various inorganic fluorides.

The following organic fluorides were tested: alpha-fluoronaphthalene, p-fluorobenzoic acid, p-p'difluorodiphenyl, and fluorobenzene. Alpha fluoro naphthalene was fed at levels of 0.10 and 0.05 per cent of fluorine. Para-fluorobenzoic acid and p-p'difluorodiphenyl were administered to the extent of 0.05 per cent of fluorine; whereas, fluoro benzene was given at a level of 0.10 per cent of fluorine. The animals receiving 0.10 per cent of fluorine as alpha-fluoronaphthalene died in 20 days and showed no abnormalities of the teeth. The same compound fed at a level of 0.05 per cent of fluorine produced mottled teeth. These animals are now one year old, but have not reproduced. The p-fluorobenzoic acid, p-p'difluorodiphenyl, and fluorobenzene did not produce mottled enamel at the levels used. None of the animals on the organic fluorides showed any significant variation in hemoglobin content of the blood.

Previous work from this laboratory by Keil and Nelson (4) on aluminum in nutrition, indicates that the animal can tolerate considerable quantities of aluminum salts. The toxicity of aluminum salts depends on the nature of the salt. The data recorded in this paper also show that no effect on the teeth results by the incorporation of 0.10 per cent of fluorine as Al_2F_6 in the basal diet. The animals looked well and reproduction was very good on this level of fluorine intake. It therefore seemed possible that, if aluminum sulphate were fed to animals receiving fluorine water, mottled enamel would not develop and no serious disturbance of metabolism should result. Animals receiving 0.025 per cent of

NaF all showed severely mottled teeth. The animals which received 0.025 per cent of NaF plus 0.132 per cent of $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$ showed some mottling. The animals receiving 0.025 per cent of NaF plus 0.396 per cent of alum had normal teeth. Animals receiving 0.05 per cent of NaF plus 0.792 per cent of $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$ showed very slight mottling. All of the alum-fed rats grew normally, and they all reproduced. Second generation animals on the alum diets are now on experiment. Further work is necessary in order to determine if the alum has any deleterious effect and, also, further work is required to determine whether alum will absolutely prohibit the development of mottled enamel when fluorides or fluorine-containing waters are ingested.

SUMMARY

1. Calcium silico fluoride and cupric fluoride caused mottled enamel of the teeth; whereas, ingestion of Al_2F_6 did not produce this effect.

2. Alpha-fluoronaphthalene produced mottled enamel; whereas, the ingestion of p-p'diflorodiphenyl, p-fluorobenzoic acid, and fluorobenzene had no effect on the teeth.

3. The ingestion of aluminum sulphate simultaneously along with fluorides prevents the development of mottled enamel of the teeth.

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