Fluoride Content of Foods Made with Mechanically Separated Chicken

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The goal of the present study was to determine the extent to which foods made with mechanically separated chicken can contribute to total fluoride intake. Fluoride content of each blended sample was determined with a fluoride combination electrode following perchloric-acid-facilitated diffusion of hydrogen fluoride. Infant foods had the highest fluoride content followed by chicken sticks, luncheon meats, and canned meats. A single serving of chicken sticks alone would provide about half of a child's upper limit of safety for fluoride. Fluoride content of foods made with mechanically separated chicken was significantly correlated with calcium content, which is consistent with the possibility that the mechanical separation process was the source of the extra fluoride. Foods made with mechanically separated turkey were not a major source of fluoride.

Keywords: *Fluoride; mechanically separated chicken; poultry; fluorosis*

INTRODUCTION

Fluoride is recognized as a beneficial trace element for human health based upon its role in the prevention and repair of dental decay (*1*). Epidemiological studies indicate that community water fluoridation, where the natural fluoride level has been adjusted to about 1 ppm, led to a 50−60% reduction in dental decay in the United States as well as in other developed nations (*2*). The prevalence of dental decay among 9-year-old children, for example, decreased from 71% in 1971−1974 to 34% in 1985−1986 (*3*). There is, however, a narrow range between beneficial and undesirable effects of fluoride intake. Dental fluorosis, also known as mottled tooth enamel, is a condition that occurs in children less than 8 years of age who ingest 2−3 times the recommended amount of fluoride (*4*). This non-life-threatening condition is characterized in its mild form by white horizontal lines across the tooth surface. Although the effect has been associated with dental decay (caries) resistance, it can be cosmetically unappealing with regard to the teeth that are visible with a smile.

Recent observations suggest that the prevalence of dental fluorosis is increasing in the United States, Canada, and other industrialized nations because of multiple fluoride exposures, including those from non-food sources such as the swallowing of fluoridated toothpaste (*5, 6*). Although most foods are very low in fluoride content (*7*), foods made with mechanically separated chicken have the potential to be a major contributor to total fluoride intake. The mechanical separation process removes attached meat from bone producing a product that contains meat, other soft tissue, and a small fraction of finely powdered bone. This latter fraction is likely to add bone-seeking elements such as calcium and fluoride to the food product. Several investigators have, in fact, reported higher fluoride levels in infant foods made with mechanically separated chicken compared to those in foods containing chicken not processed by this method (*8*−*11*). These studies, however, did not determine the fluoride content of foods containing mechanically separated chicken, such as chicken sticks, canned meats, and luncheon meats, that are likely to be consumed by toddlers and young children.

In the present study, we report the fluoride content of foods that were specifically labeled as containing mechanically separated chicken. Our intent was to determine the extent to which such foods can contribute to total fluoride intake that has been reported to be associated with an increased risk of mild dental fluorosis in children. Other observations were made by brand name and by poultry type (chicken compared to turkey). Fluoride and calcium contents of foods were also correlated to determine whether the additional fluoride found could originate from bone.

MATERIALS AND METHODS

Sample Collection and Preparation. Foods labeled as containing mechanically separated chicken and turkey were obtained from six local supermarkets over a period of nearly 1.5 years. Brand names were coded within each food category. A total of 10 samples with different identifying codes were selected for every food analyzed. Food categories included infant foods, toddler foods, canned meats, and luncheon meats. Because it was hypothesized that fluoride in foods containing mechanically separated poultry would originate from bone, we also collected chicken and turkey bones from poultry sold in grocery stores to analyze them for fluoride.

Pureed infant food was sampled without further modification. For toddler foods, canned meats, and luncheon meats, a randomly selected portion was removed and ground in a Waring blender fitted with a 75-g-capacity stainless steel mini-container. A ground sample was then pureed by homogenizing and sonicating in an equal volume of deionized water (Polytron, Brinkmann Instruments). Bone samples were autoclaved to remove meat, cut lengthwise with a Dremel tool to remove marrow, fat-extracted using a Soxhlet apparatus, and dry ashed in an electric furnace.

Chemical Analyses. Fluoride was determined with a fluoride combination electrode (ThermoOrion model 96-09, Beverly MA) within the electrode's linear range, after isolating

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Table 1. Fluoride Content of Foods Made with Mechanically Separated Chicken (μg fluoride/gram)[a]

food	mean ± SD[b]	range
pureed chicken		
brand A	5.58 ± 1.73	3.22−8.63
brand B	2.82 ± 0.90	1.89−4.63
pureed chicken plus pear	1.61 ± 0.57	0.08−2.01
chicken sticks	3.61 ± 1.29	1.61−6.00
Vienna sausage		
brand A	2.18 ± 0.45	1.35−3.26
brand B	1.45 ± 0.27	1.20−1.89
luncheon meat		
brand A	2.35 ± 0.67	1.53−3.65
brand B	1.60 ± 0.50	1.01−2.64

[a] $n = 10$ samples; duplicate analyses were within 5% of the mean. [b] Differences between means must exceed 0.70 to be $P < 0.05$.

fluoride from the sample by perchloric-acid-facilitated diffusion of hydrogen fluoride (*12*). For food samples, about 1 g of the pureed food was loaded into the outer elevated ring of a Conway diffusion plate (Bel-Art Plastics) to which 1 mL of deionized water and 2 mL of ice-cold fumed 70% perchloric acid were added. Plates were sealed with silicone grease and a disposable polystyrene cover and heated at 50−55 °C for 22 h. Hydrogen fluoride was collected in the center well of the diffusion plate containing 0.2 mL of 1.25 M NaOH. Center well contents were rehydrated with 2.3 mL of deionized water plus 0.2 mL of 1 M HCl and transferred to a disposable plastic beaker containing 2.5 mL of total ionic strength buffer, pH 5.2 (ThermoOrion catalog no. 940909). Unknowns were compared to 1 and 10 μg/mL fluoride standards (as NaF). A fluoride standard (5 μg) was also run through the diffusion step to verify recovery (usually 98−100%). For bone samples, the ash was dissolved in 3 mL of 3 M HCl and transferred to a 50-mL polymethylpentene flask to which 25 mL of total ionic strength buffer (pH 5.5) plus 1 mL of 5 M NaOH was added. The flask was vigorously shaken, and the contents were diluted to 50 mL with deionized water. Plastic ware was used for all fluoride analyses because fluoride ions adsorb to glass.

To determine calcium content, pureed food was wet-ashed in concentrated nitric acid, followed by 30% hydrogen peroxide, on a temperature-controlled hot plate in a fume hood. The white ash was dissolved in 3 M HCl and diluted to an appropriate volume for atomic absorption spectrophotometry analysis (Perkin-Elmer model 2380). The final solution analyzed contained 0.5% lanthanum in 0.1 M HCl to prevent interference by phosphate. A sample of known calcium content (nonfat milk powder, National Institute of Standards and Technology) was run with every set of digestions for quality control. Agreement with the certified value had to be at least 95% for the digestion to be accepted. Digestion glassware was made of borosilicate glass that had been previously made metal-free in an acid bath of 5% nitric acid.

Statistical Analysis. Results for the 10 samples for each food were averaged and reported as a mean ± SD. Differences between means of planned comparisons were tested by Fisher's protected least significant difference if a significant F value was found by one-way analysis of variance for all foods. The relationship between fluoride and calcium content of foods was determined using the Pearson correlation coefficient and linear regression analysis. Data were analyzed using SPSS for windows (version 7.5). All differences were considered to be significant at $P \leq 0.05$.

RESULTS AND DISCUSSION

Significance of Fluoride from Chicken. Results shown in Table 1 demonstrate that foods labeled as containing mechanically separated chicken contain high concentrations of fluoride in contrast to foods in general which usually contain less than 0.3 μg fluoride/gram (*7, 13*). Although fluoride contributed by foods made with mechanically separated chicken might be viewed as an unexpected benefit to dental health, fluoride has a rather narrow range of safety to prevent mild dental fluorosis (*1*). Thus, the current guideline for intake of fluoride, referred to as an adequate intake (AI) to promote resistance to dental caries (*14*), is accompanied by an upper limit of safety (UL) to indicate an intake obtained from food, water, and supplements that is likely to pose no risk of adverse health. A single serving (71 g) of infant food made with chicken would provide as much as 0.6 mg of fluoride, which is twice the AI and 87% of the UL for fluoride for a 6-month-old infant. For a one-year-old toddler, a single serving (71 g) of chicken sticks could provide 0.4 mg of fluoride, which would nearly match the AI and provide about half of the UL for fluoride. One serving (71 g) of luncheon meat containing mechanically separated chicken could provide as much as 0.45 mg of fluoride for a child. A desirable level of fluoride intake could therefore be exceeded on a recurring basis when combined with other sources of fluoride intake such as fluoridated water, foods made with fluoridated water, and swallowing of fluoridated toothpaste (*5, 6*). Although the fluoride contributed by bone would be less absorbable than that from water fluoridation (*1*), determination of an AI and UL for fluoride did not take into account the concept of bioavailability (*14*).

Table 2. Correlation between Fluoride and Calcium Content of Foods Made with Mechanically Separated Chicken

food	r	*P* value
pureed chicken	0.91	<0.001
pureed chicken plus pear	0.68	<0.05
chicken sticks	0.75	<0.05
potted meat	0.86	<0.01
Vienna sausage	0.83	<0.01
luncheon meat	0.83	<0.01

Table 3. Fluoride Content of Foods Made with Mechanically Separated Chicken Compared to that of Foods Made with Mechanically Separated Turkey (μg fluoride/gram)[a]

food	chicken	turkey	*P* value
pureed type	5.58 ± 1.73	0.78 ± 0.14	<0.001
meat sticks	3.61 ± 1.29	1.37 ± 0.13	<0.001
luncheon meat	2.35 ± 0.67	1.07 ± 0.31	<0.001

[a] Values are mean ± SD, $n = 10$; duplicate analyses were within 5% of the mean; comparisons made are for the same brand.

Correlation of Calcium and Fluoride. The highly significant correlation between calcium and fluoride content of foods made with mechanically separated chicken (Table 2) is consistent with the hypothesis that the extra fluoride could come from the mechanical separation process. Calcium and fluoride content were unrelated if a food was labeled as containing chicken rather than mechanically separated chicken. Calcium and fluoride were poorly correlated for foods made with mechanically separated turkey, with r values at least half of those shown in Table 2.

Chicken versus Turkey. Foods made with mechanically separated turkey contained significantly less fluoride than their chicken counterparts (Table 3), even though turkey bones apparently can contain more fluoride than chicken bones (340 μg fluoride/gram ash versus 275 μg fluoride/gram ash, $P < 0.05$, for our analyses). Although the fluoride content of bone is likely to be highly variable, it has been shown that turkey bones are more difficult to crush and powder in the mechanical separation process than are chicken bones (*15*).

Concluding Statement. Fluoride contributed by foods made with mechanically separated chicken could increase the risk of mild dental fluorosis for children less than eight years of age when combined with other sources of fluoride exposure. The most realistic way to minimize potentially undesirable fluoride exposure from foods made with mechanically separated chicken is by consumer choice. Variety in the foods selected, including brand name (Table 1) and type of poultry (Table 3), and moderation in the serving size could significantly reduce the level of fluoride contributed by foods made with mechanically separated chicken.

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