FLUOROSIS RISK INCREASES WITH TEA CONSUMPTION WORLDWIDE

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INTRODUCTION

Camellia sinensis, has two varieties, *v. sinensis* (native to southeast China and the variety to be discovered, recorded, and used to produce tea dating back to 3,000 years ago) and *v. assamica*, which are the varieties grown today. All types of tea, which include white, yellow, green, oolong, dark, black, and pu-erh, come from these two varieties.

Tea is the second most commonly consumed drink in the world after water. The age of the tea leaves, along with the fermenting process, differ for each type of tea. Tea plants are known as fluoride hyperaccumulators, which means they absorb higher concentrations of fluoride and heavy metals such as nickel and chromium and other toxic substances from the soil. Older tea leaves (black and pu-erh teas) absorb the highest concentration of fluoride, and thus, longer brewing time and higher temperatures produce much higher fluoride content in the infused tea. Other fluoride hyperaccumulators include certain fruits, crab, shrimp, fish, and rice.

Studies have shown that skeletal fluorosis is a major endemic problem in countries in the Middle East and Africa as well as in Tibet, China, Japan, Mexico, Argentina, Ireland, Australia and England. This condition is generally related to drinking well water with elevated fluoride content and high consumption of tea. In the United States, skeletal fluorosis is uncommon and reported cases have been associated with excessive consumption of instant tea.

TEA AND FLUORIDE

The daily consumption of tea infusions may contribute to the dietary requirements of several essential elements such as potassium, magnesium and manganese. The contents of aluminum and fluoride in tea leaves are relatively higher than those in other plants (Dambiec et al., 2013).

Fluoride is selectively absorbed from the soil into the tea plant and exists in the tea leaf as an anion. Specifically, acidic soils are conducive to the increased amount of fluoride uptake by tea plants (Cai et al., 2016). It has been known that fluoride levels in leaves and stems increase linearly with the age of the plant (Cai et al., 2016; Fung et al., 1999). The tea plant in Tibet is known as the most fluoride-contaminated plant in the world (Fan et al., 2016).

TEA FLUORIDE CONCENTRATION AND BREWING TIME

According to the Tea Association of the USA, more than half of the population of the United States consumes tea on any given day, and the millennial generation is the largest group of consumers. A recent study noted that the greatest fluoride concentration was found in tea made from Matcha Love powder. Matcha is a finely ground powder of green tea leaves, and it is possible that tea made from Matcha Love powder has higher fluoride content because brewing required less water and all the powder was left to dissolve in the beverage (fluoride content 3.3-4.3 mg/l). However, tea brewed for two minutes from tea bags, exhibited lower fluoride levels (Regelson et al., 2021).

The fluoride gets released with tea infusion and becomes available for full absorption through the GI tract. Instant tea mixes can have up to 200% fluoride concentration above the safe level (USDA National Fluoride Database of Selected Beverages and Foods, 2005).

Malinowska and colleagues reported that longer brewing times (tested at 5, 10 and 30 min) increased the fluoride content of black, green, oolong, pu-erh, white and herbal tea infusions. Additionally, after 5 minutes of brewing, infusions of black tea were found to have higher fluoride concentrations than other types of tea, with the fluoride content ranging between 0.32 and 4.54 mg/l for black teas to 0.37–0.54 mg/l for white teas and 0.02–0.09 mg/l for herbal teas (Malinowska et al., 2021).

Food item	Mean ppm
Carrots, raw	0.03
Peanut butter, creamy	0.03
Macaroni and spaghetti, cooked	0.07
Yogurt, low-fat, plain	0.12
Chicken, cooked	0.15
Bread (white or whole wheat)	0.49
Shrimp, fried	1.66
Crab, canned	2.10

Beverage	Mean ppm
Low-fat or skim milk	0.03
Regular or light beer	0.45
Diet Coke	0.60
Cranberry juice cocktail	0.71
Coffee, brewed, decaffeinated	0.52
Coffee, brewed	0.91
Red wine	1.05
White wine	2.02

Tea	Mean ppm
Chamomile herb tea, brewed	0.13
Peppermint herb tea, brewed	0.90
Cool Nestea natural lemon, iced	0.90
Green tea, brewed	1.15
Black tea, brewed, decaffeinated	2.69
Black tea, brewed	3.73
Instant tea, tap water	3.35
Instant tea powder, dry	897.72

Tables showing fluoride content in various foods and beverages using data from the USDA National Fluoride Database of Selected Beverages and Foods, 2005.

TEA AND FLUOROSIS

Tea is supposed to be good for us. It has flavonoids, a mild amount of caffeine, and has been shown to reduce risk for cardiovascular disease, hypertension, and type 2 diabetes. It is also anti-inflammatory and has antioxidants.

Fluorosis, caused by chronic excessive consumption of fluoride, can be a crippling condition in which bones become weak and joints are stiff and painful. Deformities are seen in severe cases. There can also be neurological complications. A 2011 study in the *Journal of Clinical Endocrinology and Metabolism* concluded that skeletal fluorosis "can result from chronic consumption of large volumes of brewed tea" and that "daily consumption of 1-2 gallons of instant tea can lead to skeletal fluorosis" (Izuora et al., 2011).

The tea plant in Tibet has been shown to have a very high concentration of fluoride. The fluoride content in tea from the main Brick tea producing districts, has been shown to have a concentration from 261.7mg/kg to 875.8 mg/kg. Due to the customs, habits and a very high volume of tea consumption in this area, skeletal fluorosis is a problem for this ethnic minority (Fan et al., 2016).

Clinical and Radiographic Manifestations of Skeletal Fluorosis:
Prominent interosseous membrane ossification, extensive coarse trabecular fusion, ossification of elbow flexors, joint enlargement and fish wing-like fusion appearance of interosseous membranes. Other pathologies include: ligament and tendon attachment pathologies, indicating degenerative hyperplasia and ossification changes of the fibrous tissues.

CONCLUSION

The optimal fluoride concentration in drinking water for prevention of dental caries in the United States has been reduced to 0.7 mg/L, from the previous range of 0.7–1.2 mg/L (1 ppm is equal to 1 mg/L), with 10 mg per day of fluoride ingestion being considered toxic (US Department of Health and Human Services). The American Dental Association, American Academy of Pediatric Dentistry, and the American Academy of Pediatrics jointly recommend guidelines that range from zero for infants up to 1 mg/day for adults, depending on availability of fluoridated water.

Most teas contain a higher fluoride concentration than optimally fluoridated water (0.7 mg/L). Dental healthcare professionals should consider this information when advising caries prevention regimens for patients and determining the potential for dental or skeletal fluorosis in at-risk patients. It is advisable to review patients' tea drinking habits and inform them of the possibility of fluorosis related to higher fluoride concentrations found in different types of teas.

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