***TEA, HYDRATION AND FLUORIDE***

**Executive summary**

* Tea is the most widely consumed beverage in the world after water.
* 83% of UK adults drink tea with average consumption of just over two servings daily (542ml).
* Tea contains approximately 99% water. It is an important source of fluid and can count towards the daily intake of 8 cups of fluid.
* Both the Food Standards Agency and the British Dietetic Association advise that tea can help to meeting daily fluid requirements.
* The idea that tea contains as much caffeine as coffee is erroneous. A cup of tea contains about a third of the caffeine in an average cup of filtered coffee and proportionately much less compared to an espresso.
* Tea is a source of polyphenolic compounds which are linked with a range of health benefits.
* Media concerns about caffeine and fluoride in tea have led to questions about the suitability of tea as a source of fluid and its role in hydration.
* Studies evaluating the effect of tea on markers of hydration suggest no impact of tea on hydration even at higher levels of intake than average UK intakes.
* Studies suggesting that caffeine can impact on hydration markers have used caffeine pills and sometimes in people who do not normally consume caffeine.
* Overall the data on caffeine and hydration suggest that high doses of caffeine in people who do not normally consume caffeine may increase urine output, but this does not occur with acute doses of low to moderate doses of caffeine nor with chronic caffeine consumption.
* Fluoride is mineral that has beneficial effects on both teeth and bone. With regards to teeth the most common benefit is prevention of dental caries. In small to moderate doses, fluoride may help to strengthen bone.
* Tea is a source of fluoride and could in theory make a dental health claim.
* The UK typical intake of tea of 2-3 servings a day is likely to contribute fluoride levels below the RDA and AI for fluoride.
* Among higher consumers of tea (up to 5 cups daily) fluoride intakes are likely to exceed the RDA and AI but remain below the upper level.
* In children aged 4-10 years an appropriate intake would be 1-2 servings and in older children up to 4 servings daily could be consumed.

**Introduction**

Tea (*Camellia sinensis*) is the most widely consumed beverage in the world after water.(1) Black tea is the most popular type representing 78% of the tea consumed worldwide, 20% is green tea and

2% oolong. (2) Up to 83% of UK adults drink tea with older adults (> 65 years) drinking more than those aged 19-64 years.(3) Tea consumption in the UK has decreased during the last 30 years from seven servings[[1]](#footnote-1) to just over two servings daily.(3)

Tea contains an array of compounds including amino acids, organic acids, methylxanthines, flavonoids and related polyphenols, as well as small quantities of micronutrients, including B vitamins, manganese, zinc and fluorine, and also caffeine and L-theanine. Tea polyphenols are of great interest because of their antioxidant and anti-inflammatory properties and their links with reduced mortality,(4) cardiovascular health,(5) improved cognitive function, (6)protection against diabetes,(7) bone health(8) and weight management.(9)

Media concerns about caffeine and fluoride have led to questions about the suitability of tea as a source of fluid and its role in hydration. However, studies on caffeine commensurate with the amounts found in tea as well as studies on tea itself, suggesting that tea contributes to normal hydration in contrast to lay beliefs that caffeine is dehydrating.(3) Tea contains approximately 99% water. It is an important source of fluid and can count towards the daily intake of 8 cups of fluid. Both the Food Standards Agency and the British Dietetic Association advise that tea can help to meeting daily fluid requirements. Moreover, the idea that tea contains as much caffeine as coffee is erroneous. A cup of tea contains about a third of the caffeine in an average cup of filtered coffee and proportionately much less compared to an espresso.  
Similarly, concerns about fluoride in tea are not born out by evidence which suggests that estimated fluoride intakes from tea are well within tolerable upper limits and that tea can contribute to both dental and bone health benefits.(10)

**Tea and hydration**

**Hydration and health**

The human body is up to 75% water by weight and water is essential for life. Water has a number of functions in the body, participating in almost every metabolic process, as well as lubricating the joints, helping to control body temperature through sweating and also helping to flush waste. Water is a major component of body fluids, including blood, urine and saliva. The amount of water in the body is controlled by anti-diuretic hormone such that if the volume of fluid increases and the concentration of salts in the blood falls, more urine will be excreted while if the blood concentration of salts increases and the volume of fluid in the blood falls, urinary excretion will fall. However, it is still possible to become dehydrated and severe dehydration is fatal. Even mild dehydration leads to headaches, fatigue and reduced mental and physical performance while chronic mild dehydration has been associated with constipation, urinary tract infections and cardiovascular disease.(11)

**How much fluid do we need?**

Individuals vary considerably in their fluid requirements. Research has shown daily requirements ranging from 0.415litres up to 4.315 litres in a study in French adults(12) while a systematic review of studies suggested a daily requirement across children and adults ranging from 0.6 litres to 3.5 litres.(13) A review of 24-hour beverage requirements in British adults aged up to 64 years reported mean total daily water intakes of 2.53 litres in men and 2.03 litres in women.(14)

Several official bodies provide guidelines on fluid consumption. In Europe, EFSA has set Dietary Reference Values for water which in healthy adults are 2.5 litres daily for men and 2 litres daily for women with smaller amounts for children (see Table 1). These guidelines do not make specific recommendations on which drinks should be included but recognize that water is consumed from different drinks and food, and they state that regular and moderate consumption of caffeinated drinks does not impair hydration.(15)

**Table 1: Dietary Reference Values for Water**

**Source EFSA (2010)(15)**

|  |  |
| --- | --- |
| **Age** | **Adequate fluid intakes (food and beverages)** |
| Infants < 6 months | 100-190ml/kg/day |
| Infants 6-12 months | 800-1000ml/day |
| Children 1-2 years | 1100-1200ml/day |
| Children 2-3 years | 1.3 litres/day |
| Children 4-8 years | 1.6 litres/day |
| Boys 9-13 years | 2.1 litres/day |
| Girls 9-13 years | 1.9 litres/day |
| Adults (age 14+) (Male) | 2.1 litres/day |
| Adults (age 14+) (Female) | 2.0 litres/day |
| Adults (age 14+) (Female) pregnant | 2.3 litres/day |
| Adults (age 14+) (Female) breastfeeding | 2.7 litres/day |

**What impact does tea have on hydration?**

Two studies have evaluated the influence of tea on hydration. One was a study in 13 members of an expedition at high altitude which found no significant differences in urine colour, urine sodium and potassium and urine specific gravity following ad libitum tea versus water consumption.(16) Although the study was non-randomised and the number of study participants was small, the study did test the impact of tea consumption in an environment where the risk of dehydration is high.

The other, more recent study, was a randomized crossover trial in 21 healthy men who abstained from caffeine, alcohol and exercise in the 24 hours before the study. The test group of men consumed 4 or 6 cups (240ml per cup) of black tea, providing a total of 168 and 252mg caffeine respectively, while the placebo group consumed the same volume of water. No differences were observed in any of the markers of hydration in blood or urine, nor were there any differences in mean 24-hour urine output.(17) The amounts of tea consumed in this study (960 or 1440ml) are higher than mean daily tea intakes in UK adults aged 19-64 years (which are 542ml) and adults > 65 years ( which are 648ml). This suggests that current average tea intakes of two to three cups each day are unlikely to cause diuresis and impair hydration.

**Caffeine and hydration**

Tea contains caffeine, and media reports have often stated that caffeinated drinks are dehydrating. Theoretically, caffeine can stimulate urine output because it increases blood flow to the kidneys and inhibits the reabsorption of sodium, potassium and magnesium thus causing water loss. However, such evidence as it exists for a diuretic effect of caffeine has largely come from trials involving caffeine pills at moderate to high doses and often in people who do not normally consume caffeine. Two studies reported moderate diuresis with caffeine pills in doses of 370-612 mg daily (18, 19) while another study showed no effect of caffeine in doses of 3-6mg/kg bodyweight on markers of hydration.(20) A review of evidence from 41 studies on caffeine which included an examination of the impact on hydration of caffeinated drinks concluded there was no significant impact on hydration with a caffeine intake of 1.4-6mg per kg bodyweight.(21)

A more recent study in 50 male moderate coffee drinkers found that compared with drinking 4 cups of water each day over 3 days the same amount of coffee had no significant impact on markers of hydration. (22)

Overall the data on caffeine and hydration suggest that high doses of caffeine in people who do not normally consume caffeine may increase urine output, but this does not occur with acute doses of low to moderate doses of caffeine nor with chronic caffeine consumption.(22)

The amount of caffeine in tea is largely dependent on brewing time and varies between 1 and 90mg per 100ml, although the average is 17mg per 100ml of brewed tea. Given that the average daily intake of tea in UK adults <65 years is 542ml, mean daily intake of caffeine from tea is approximately 92 mg.(10) EFSA has produced draft guidelines on safe intakes of caffeine recommending that for adults aged 18-65 years 400mg of caffeine daily, including single doses of up to 200mg are safe. For pregnant women, 200mg per day is considered safe while 3mg per kg bodyweight per day is considered appropriate for children and

adolescents. (15)

**Tea and fluoride**

**What is fluoride?**

Fluoride is a naturally occurring mineral that can be obtained from foods and fluids originating from soils containing fluoride, as well as by drinking water that has been fluoridated. In the UK, 10% of the population receives fluoridated water at a level of 1mg/litre.(23)

Fluoride plays a major role in the mineralization of bones and teeth, (24) and hence has a protective effect on bone and dental health. A chronically high intake exceeding the safe upper levels for fluoride intake can lead to dental and skeletal fluorosis. Mild to moderate dental fluorosis causes white mottling of the tooth enamel and despite being considered unsightly actually has the effect of increasing resistance of the teeth to dental caries. Moderate to severe dental fluorosis affecting 3-6% of people in fluoridated areas can result in yellow marks and pits on tooth enamel but does not cause a danger to the tooth.(25) A recent review that included an evaluation of the effect of fluoride on bone and dental health found from the balance of evidence that while adverse effects on bone can occur at chronically high levels of fluoride intake, bone density and strength can be improved at recommended levels of fluoride intake there are few negative implications for people living in the UK apart from mild to moderate dental fluorosis.(26)

Tea is a major contributor to fluoride in the UK. Other sources include fish and milk as well as artificially fluoridated sources such as tablets, drops or chewing gum. (15) Among adults, tea has been found to provide 70% of the average daily fluoride intake, (27) although this depends on the type of tea consumed and whether fluoridated tap water was used (28) In children, a 2006 study showed that tap water, squashes and cordials were the main sources of fluoride whether tap water was fluoridated or not. (29)

**Fluoride guidelines**

Guidelines for fluoride intake have been set by official bodies including in Europe and the UK (see Table 2). In Europe, fluoride is considered to have a beneficial effect on dental health and an adequate intake of 0.05mg/kg/body weight has been set for adults, children and pregnant women. This reflects the chronic intake that would be expected to meet the body’s requirement for fluoride.(15) The UK set a safe and adequate intake level of 0.05mg/kg/body weight/day to reflect the ‘no observed adverse effect’ level for dental fluorosis, which is a condition causing mottling of the teeth arising from excessive fluoride consumption. Safe upper levels have been set in Europe at 0.1mg/kg/body weight/day for children aged 1-8 years, 5mg daily for children aged 9-14 years and 7mg daily for adults, including pregnant and breastfeeding women.

**Table 2: UK and European Guidelines for Fluoride**

|  |  |
| --- | --- |
| **Official body** | **Guideline** |
| British Dental Association (1997) | Fluoride is unnecessary for infants < 6 months  Fluoride should not be given where the drinking water contains >700 microgram fluoride/litre |
| Department of Health (199!) | Safe intakes of fluoride for adults are 0.05mg/kg body weight/day |
| European Food Safety Authority (EFSA) (2013) | Adequate Intake (AI) of 0.05mg/kg/body weight/day for children, adult, pregnant and breastfeeding women |
| EFSA (2006) | Upper levels of fluoride:  Children aged 1-8 years: 0.1mg/kg/bodyweight/day (equivalent to 1.5mg/day for children 1-3 years; 2.5mg/day for children 4-8 years)  5mg/day for children aged 9-14 years  7mg/day for those > 15 years including pregnant and breastfeeding women |

**Fluoride intakes**

Fluoride intakes vary quite widely. In Europe generally, fluoride intakes vary broadly from 0.13 to 8.40 mg daily.(30) In the UK, a 2000 COT analysis(31) found fluoride exposure in children aged 18 months to 10 years to range from 0.023 to 0.031 mg/kg/body weight/day and in youngsters aged 11-18 years, the range was 0.015 to 0.017 mg/kg body weight/day, while in adults intake averaged 0.016mg/kg/body weight/day.

High consumers of fluoride had intakes ranging from 0.06mg/kg in children aged 4-6 years to 0.033mg/kg/body weight/day in adults. Urinary excretion data from the NDNS for 2002-2003 have been used to estimate fluoride intakes and it was concluded that only 1% of men and 3% of women had fluoride intakes above the adequate intake (AI) of 0.05mg/kg/body weight/day.(32)

**Benefits of fluoride**

Fluoride has beneficial effects on both teeth and bone. With regards to teeth the most common benefit is prevention of dental caries. Fluoride helps to prevent caries when provided systemically in the diet or in supplements, or topically as toothpastes or mouthwashes. When given systemically, fluoride works only at the pre-eruptive stage of tooth development, before the second teeth appear, i.e. at the ages of 2-8 years.(31) In contrast, topical fluoride does not have an age limit which is why toothpastes and other dental products contain it. In areas of water fluoridation, 28% fewer 5 year olds and 21% fewer 12-year olds present with decay.(25)

Fluoride also has benefits on bone, since at low doses, it can embed in the bone matrix protecting against erosion, (33)resulting in increased density and hardness. A meta-analysis of 25 studies found that 20mg/day fluoride equivalents was associated with a significant reduction in fracture risk.(34) However, a randomised controlled trial in 180 post-menopausal women using fluoride supplements providing 2.5mg, 5mg or 10mg/day found no significant effect on bone mineral density after a year.(35)

**Fluoride health claims**

Dental health claims for fluoride have been approved by the European Food Safety Authority (EFSA). A ‘source’ claim can be made for foods and beverages that provide at least 15% of the EU RDA (3.5mg) per 100g. Claims could therefore be made for products containing at least 0.5mg/100g or 100ml as sold.

**Approved health claims for fluoride(15)**

|  |  |
| --- | --- |
| Proposed health claim | Condition of use |
| Fluoride strengthens the teeth/enamel:  Fluoride helps protect the teeth  Fluoride helps the teeth to recover after meals | Must be at least a ‘source’ of fluoride for example 0.5mg/100g or 100ml as sold |
| Fluoride contributes to the maintenance of healthy teeth or tooth mineralization | As above. Applicable to both children and adults. |

One example of a beverage that could make fluoride-related dental health claims in future is tea since the amount of fluoride per 100g dry weight meets the criteria for a ‘source’ claim. Interestingly, the dental health benefits of tea have been highlighted previously since tea polyphenol compounds have antibacterial actions, (36) and can regulate acid production in dental plaque (37)while tea consumption has been associated with reduced tooth loss.(38)

**What level of fluoride is found in tea?**

Tea accumulates fluoride from soil and water during its growth and estimates of fluoride content of retail tea leaves vary considerably depending on the grade of tea, country of origin and level of fermentation (i.e. whether the tea is black, green, white or oolong)(39).

An analysis of fluoride in retail tea bags published in 2013 suggested that consuming typical amounts of tea from economy brands could lead to excessive fluoride exposure.(28) This publication led to media coverage about the potential dangers of tea consumption.(40) However, there were several drawbacks to the study including the creation of a standard brew using 2g of tea in 100ml whereas 3.1g of tea in 180-200ml is more common. Long brewing times of 2, 10 and 30 minutes were also used in the study. In addition, the authors determined fluoride intake from tea based on a daily intake of 1 litre whereas typical tea intakes in the UK are 500-600ml.(40) They also compared estimated fluoride intake with the US male adequate intake (AI) level of 4mg daily rather than the tolerable upper intake level which in Europe is 7mg daily. Different methods were used to measure fluoride in dry tea and tea infusions. All of these issues could have served to overestimate the potential exposure of fluoride exposure from tea.

A more recent study of the fluoride content of typical UK black-blended retail tea bags, specialty tea and decaffeinated tea used more robust and more realistic methodology in that a single validated analytic method was used for fluoride measurement together with a standardized brew typically consumed by the UK consumer.(10) Based on the analysed content of fluoride in the teas and typical intakes of tea in the UK, daily intakes of fluoride were less than the EU RDA and AI in this study except for those with very high tea consumption (>95th percentile) and were also within age appropriate tolerable upper intake levels at both mean and very high tea intakes. When non-consumers were excluded from the data, intakes of fluoride remained less than the UL for all groups except those aged 1.5-3 years and those > 65 years with very high intakes.

The authors concluded that their findings suggest that tea can safely be consumed from the age of 4 years. Some of the brands they examined contained sufficient fluoride for an EU health claim relating to strengthening and maintaining tooth enamel.

Overall, tea can be considered to be an important source of fluoride in the UK diet and in typical amounts of tea consumed in the UK of 2-3 servings a day is likely to contribute fluoride levels below the RDA and AI for fluoride. Among higher consumers of tea (up to 5 cups daily) fluoride intakes are likely to exceed the RDA and AI but remain below the UL. In children aged 4-10 an appropriate intake would be 1-2 servings and in older children up to 4 servings daily could be consumed.(10)

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1. A typical serving of tea in the UK contains 240g of water added to 3.1g of tea. [↑](#footnote-ref-1)