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9 **Fluoride**

10 **Introduction**

11 Fluoride is found in food and drinking water either in an ionic form or bound in
12 complexes. Fluoride has a well-documented role in the prevention and treatment of dental
13 caries but the mechanism is attributed to local (effect on the tooth surface) rather than
14 systemic effects. The role of fluoride as an essential trace element is debated.

15

16 **Dietary sources and intake**

17 Fluoride levels in foods (except water) are generally low, with a few exceptions. Fish
18 eaten with bones, such as canned sardines, some teas and mineral waters and drinking
19 water in some areas have the highest content. There are few data on fluoride intake from
20 food but according to EFSA (6) intake for young and older children and adults is reported
21 to range from 0.042, 0.114 and 0.120 mg/day, respectively. A major proportion of
22 fluoride intake is from water sources. Estimated intake from water sources, given a water
23 content of 1 mg/L, is 1.7 mg/day in adults and 0.3 mg/day in small children (7), but since
24 fluoride concentration in drinking water varies between areas, intake also varies
25 considerably due to water source. Another source of fluoride in small children is
26 toothpaste. It is estimated that in adults <10% of the toothpaste is ingested as the spitting
27 reflex is well developed, whereas the estimated intake in children may be up to 40%. In
28 children the ingestion has been reported to be as high as 48 % in 2 to 3 year olds, 42% in
29 4 year olds and in 5 and 6 year olds 34 and 25% respectively. In children aged from 8 to
30 12 years of age the ingestion is reported to be ~10% (8).

31

32 **Physiology and metabolism**

33 Fluoride in drinking water is effectively adsorbed (>90 %), while complex-bound fluoride
34 in foods is less well absorbed. Approximately 50% of absorbed fluoride is excreted via
35 the kidneys, the rest incorporated into the bone and, in childhood, into the teeth. Thus, the
36 main proportion of fluoride in the body is complex-bound to calcium in the skeleton and
37 tooth tissues, where upon replacement of hydroxyl ions in hydroxyapatite crystals it leads
38 to less soluble crystals. This was previously considered to render fluoride its caries
39 preventive property. Today, the presence of fluoride in the mouth and subsequent
40 deposition of CaF₂ in the tooth biofilm acting as a fluoride reservoir ready to interact with
41 the balance between enamel demineralisation and remineralisation is recognized as the
42 basis for the cariostatic effect of fluoride (1). Besides this local effect, biological functions
43 of fluoride in man remain largely unclear.

44

45 **Requirement and recommended intake**

46 No recommendation for daily fluoride intake is given since it is not considered an
47 essential trace element. This agrees with the EC Scientific Committee for Foods, which
48 also did not set any recommended intake (2). The US Institute of Medicine was unable to
49 establish an RDA but has set a reference value for fluoride, which is based on the
50 observed estimated intake judged to reduce the incidence of dental caries in a group of
51 healthy adults (3). For adults this level was set to 3 mg/d and 4 mg/d for women and men,
52 respectively (3).

53

54 **Upper intake levels and toxicity**

55 An intake of 2.2 g/kg bodyweight is lethal in adults. In children 15 mg/kg bodyweight is
56 lethal and 5 mg/kg bodyweight causes acute symptoms, such as nausea, stomach pain and
57 vomiting. Chronic high intakes may affect skeletal mineralisation and kidney function (4).
58 The most common side effect of high fluoride intake is enamel fluorosis also called
59 'mottled teeth'. Fluorosed enamel is composed of hypomineralized sub-surface enamel
60 covered by well-mineralized enamel. The exact mechanisms of dental fluorosis
61 development have not been fully elucidated (5).

62

63 The EFSA NDA (6) panel considered that an intake of less than 0.1 mg F/kg BW/day in
64 children up to 8 years old corresponds to no significant occurrence of "moderate" forms
65 of fluorosis in permanent teeth.

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