Chromium

Introduction

In ionic form chromium exists in many valence states. Trivalent chromium (III) is the most stable form and the principal form of chromium found in foods and supplements. It is ubiquitous in nature, occurring in air, water, soil and biological materials. Hexavalent chromium (VI) makes chromates and dichromates, which are strongly oxidizing and transverse biological membranes. Hexavalent chromium compounds occur only rarely in the environment and are almost always man-made. They are toxic, mutagenic and environmental contaminants.

Dietary sources and intake

Analysis of chromium in foods requires special sampling procedures to avoid chromium contamination from the environment (air, stainless steel, etc.). Old data on chromium contents of foods should therefore be used with care. Fish, whole grain products, nuts, pulses and spices along with processed meats, are the good sources, while most other foods have low concentrations (< 100 μg/kg). Foods high in simple sugars, such as soft drinks and table sugar, are not only low in chromium content, but also promote chromium losses (Kozlovsky et al 1986). Analysed or estimated intakes of chromium in the diet of the Nordic countries are scarce, but are in the range 20-160 μg/day (Jorhem et al 1998). Many food supplements contain chromium in doses from 50-100 μg per serving unit.

Physiology and metabolism

The absorption of trivalent chromium from the diet is low, 0.4-2.5 % (Lukaski et al 1999). The element is mainly excreted via urine, with only small amounts being eliminated in sweat and bile. Organic chromium compounds are absorbed more efficiently but are rapidly excreted via bile. Simultaneous ascorbate administration increases chromium uptake both in humans and animals. Chromium absorption is also higher in both zinc- and iron-deficient animals.

The exact biological function of chromium has not yet been determined. Experimental chromium deficiency in animals results in reduced glucose tolerance in spite of normal insulin levels. Other deficiency signs in animals include impaired growth, elevated serum cholesterol and triglycerides, increased incidence of aortic plaques, corneal lesions and decreased fertility and sperm count.

Chromium is considered to be a cofactor for insulin, possibly through influencing membrane receptors. A low molecular weight chromium-binding substance is believed to be involved in the process (Sun et al 2000). It has also been suggested that chromium influences carbohydrate, lipid and protein metabolism via its effect on insulin action.

Three cases have been reported of possible chromium deficiency in humans after long-term, parenteral nutrition (Jeejeebhoy et al 1977, Freund et al 1979, Brown et al 1986). The symptoms observed were impaired glucose tolerance and glucose utilization, weight loss, neuropathy, elevated plasma fatty acids, depressed respiratory quotient and abnormalities in nitrogen metabolism. The symptoms improved after chromium supplementation (200 µg/day). However, the reported concentrations of chromium in blood and urine were above those considered normal even before the supplementation was initiated. As with foodstuffs, analytical data on chromium concentrations in biological specimens produced before approximately 1980 should be regarded with caution, as possible contamination in sampling and processing may have led to spuriously high values of chromium (Lukaski 1999). The lack of reliable biomarkers for chromium status combined with the absence of clear-cut chromium deficiency conditions are the main reason for the current uncertainties about the biological significance of chromium as an essential trace element (Lukaski 1999).

A number of chromium supplementation studies have been published investigating effects on insulin and blood glucose levels. (Althuis et al. 2002, Balk et al. 2007). In 20 randomized controlled trials (RCTs) included in a meta-analysis from 2002 (Altuis et al. 2002), no effect of chromium on glucose or insulin concentrations was seen in non-diabetic subjects. Although some studies suggest beneficial effects of chromium supplementation in individuals with type 2 diabetes (Balk et al. 2007), the results are yet inconclusive, and further studies are needed in order to make any claims about chromium supplementation in this group (Althuis et al. 2002, Balk et al. 2007, Mullee et al. 2012)

There are also quite a few studies looking at chromium supplementation in relation to body composition and lipid metabolism (Mullee et al. 2012) Possible benefits to total and LDL cholesterol concentrations at supplementation of 200 to 240 µg chromium/day have been suggested (Mullee et al. 2012). However, the number of studies in this area is still limited and the studies which the suggestion is based on are defined as being at high risk of bias (Mullee et al. 2012). The effects of chromium supplementation on body composition therefore remain inconclusive (Mullee et al. 2012).

Requirements and recommended intake

As described above, the role of chromium as an essential nutrient is still unclear. If chromium is an essential trace element it must have a specific role in an enzyme cofactor, and a deficiency should produce a disease or impairment of function. Methods for evaluating chromium status are missing. Furthermore, there is still uncertainty about how chromium deficiency in humans manifests itself, and the requirement for chromium is accordingly not known.

The EU SCF (1993) stated that “Since data on the essentiality and metabolism of chromium are so sparse, the Committee is unable to specify any requirements”.
The UK Committee on Medical Aspects of Food Policy (1991) calculated a theoretical requirement for adults from balance studies of 23 µg/day by using regression equations and mentioned that a safe and adequate level of intake is believed to lie above 25 µg/day for adults.

The US Food and Nutrition Board (2001) estimated Adequate Intakes (AI) for chromium for different age groups based on calculations of well-balanced diets: for men (19-50 years) 35 μg/day and for women 25 μg/day.

Authors of a scientific report submitted to EFSA in 2012 came to the conclusion that evidence was still inadequate for setting dietary reference values for chromium (Mullee et al. 2012). The conclusion was based on a systematic review including relevant publications from January 1990 to September/October 2011.

The Nordic Recommendations of 2004 did not include recommendations for chromium intake. As very few relevant new human studies have been conducted since then, requirements are also impossible to establish this time and accordingly, recommendations have not been set for any age group.Data are also lacking on the requirements during pregnancy. The US Food and Nutrition Board (1991) suggests an increase of 5 μg/day during pregnancy.

Within Europe, chromium concentration of human milk range between 0.09 to 19.8 μg/L, (Mullee et al. 2012). The chromium concentration seems to be independent of maternal chromium intake (Anderson et al 1993, Wappelhorst et al. 2002, Mohamedshah et al 1998). A study on lactating Finnish mothers found an average concentration of 0.4 μg/L (range 0.2-0.7) (Kumpulainen and Vuori 1980).

Upper intake levels and toxicity

Chromium III has low toxicity, no adverse effects were observed at intakes of 1000-2000 μg/day. Due to the lack of adequate data, the EU Scientific Committee for Food (2003) has not suggested a Tolerable Upper Intake Level (UL) for chromium (III) salts. The same conclusion was reached by the US Food and Nutrition Board (2001) and the UK Expert Group on Vitamins and Minerals (2003).

Chromium picolinate, a trivalent chromium compound popular in many food supplements, is being discussed because of possible adverse health effects. It may influence the central nervous system and thus behaviour (Reading 1996). One study has suggested kidney damage as a result of high doses of chromium supplementation (Cerulli et al 1998). Potential clasterogenicity is being discussed (Bagchi et al 2002). It is still unclear whether these effects are due to the picolinate fraction or to the higher extent of chromium absorption. The UK Food Standards Agency (2003) advises people not to take chromium picolinate and has consulted on a proposal to ban the use of this form of chromium in the manufacture of food supplements because there is a chance that it could cause cancer. A paper from 2004 (Berner et al) evaluated one particular brand of chromium picolinate and found it safe.

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