Chromium

Two oxidation states of chromium are considered to be biologically and environmentally relevant based on their stability in the presence of water and oxygen. Compounds containing chromium(6 +) are mutagenic and carcinogenic when inhaled and potentially when ingested orally in large quantity as well. Chromium as the trivalent will be the focus of this work as it was proposed to be an essential element for mammals ~60 y ago; however, in the last 2 decades its status has been questioned. Chromium has been postulated to be involved in regulating carbohydrate and lipid (and potentially also protein) metabolism by enhancing insulin's efficacy (1). However, in 2014, the European Food Safety Authority found no convincing evidence that chromium is an essential element (2). Dietary chromium apparently is absorbed via passive diffusion and the extent of absorption is low (~1%). Chromium is maintained in the bloodstream bound to the protein transferrin. It is generally believed to be delivered to tissues by transferrin via endocytosis (1). No unambiguous animal model of chromium deficiency has been established (2). One limitation in characterizing chromium deficiency in humans is the lack of an accepted biomarker of chromium nutritional status. Attempts to identify a glucose tolerance factor have not provided a chemically defined functional compound that conforms with the proposed physiologic role of chromium as a facilitator of insulin action in vivo.

Deficiencies

Currently, no definitive symptoms of chromium deficiency have been established (2). Case studies of chromium supplementation of patients who developed insulin resistance and received total parenteral nutrition (TPN) have been cited as evidence for chromium being an essential trace element although <10 case studies with beneficial effects have been reported. Only one study attempting to apply similar conditions to multiple adult trauma subjects receiving TPN has appeared and observed no statistically significant effects of chromium supplementation on serum glucose or insulin concentrations. Subjects on TPN with known chromium content (~5–16 μg Cr/d) received oral equivalent quantities of chromium in excess of the Adequate Intake before the TPN solutions were supplemented with chromium. Thus, no relationship can be established between the results of these case studies and chromium deficiency (3).

Diet Recommendations

In 2001, the Institute of Medicine determined that insufficient evidence existed to set an Estimated Average Requirement for chromium. Consequently, Adequate Intakes of 35 and 25 μg/d for young men and women, respectively, were set based on estimated mean intakes (4). More recently, in 2014 the Panel on Dietetic Products, Nutrition and Allergies of the European Food Safety Authority determined that "there is no evidence of beneficial effects associated with chromium intake in healthy subjects" and that "the setting of an Adequate Intake for chromium is also not appropriate" (2).

Food Sources

Chromium is ubiquitous in foods at very low concentrations. Most dietary chromium apparently is derived from processing of food with stainless steel equipment; thus, humans probably evolved on a diet containing significantly less chromium than the current diets of people of developed nations.

Clinical Uses

No consistent dose-response relationships between chromium and a beneficial health outcome in humans have been established. Recent case studies examining intravenous infusions of chromium (generally 3 μg/h) as a treatment for glucose intolerance have found that chromium reduced insulin requirements for subjects with hyperglycemia. These studies are suggestive of a pharmacologic effect of chromium as supranutritional quantities of chromium were utilized, but only a small number of subjects have been examined to date (3).

Toxicity and Adverse Outcomes

As no adverse effects have been convincingly associated with excess intake of chromium from food or supplements, no Upper Tolerable Limit has been established for chromium as the trivalent ion (4). This does not mean that no toxic effects might be associated with high intakes of trivalent chromium.

Recent Research

Recent rodent studies have indicated that the effects of chromium supplementation are a pharmacologic effect and not nutritionally relevant. For example, healthy rats fed a purified diet with the lowest chromium content examined (<20 μg/kg diet) to date for 6 mo displayed no ill health effects; however, their insulin sensitivity was increased in a dose-dependent manner by the addition of chromium to the diet (1). This could potentially explain the lack of effects of chromium in clinical trials as the daily doses of chromium utilized when adjusted for body mass (normally 200–1000 μg or ~3–15 μg/kg) have not approached those utilized to generate beneficial effects in the rodent studies (generally ≥80–1000 μg/kg). However, clinical trials observing beneficial effects and using ≥10 mg Cr/d would be required before any definitive conclusions regarding beneficial effects of pharmacologic doses of chromium in humans could be reached.

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References

1. Vincent JB. The bioinorganic chemistry of chromium. Chichester: John Wiley & Sons; 2013.
2. European Food Safety Authority. Scientific opinion on dietary reference values for chromium. EFSA J 2014;12: 3845.
3. Vincent JB. New evidence against chromium as an essential trace element. J Nutr 2017;147:2212–19.
4. Institute of Medicine. Dietary reference intakes for vitamin A, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc. Washington, D.C.: National Academies Press; 2001.