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Trivalent Chromium an Essential trace Element-A Review

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ABSTRACT

Among the transition metal ions chromium shows the most controversy in terms of its toxicity and nutritional value. Severe and often deadly pathological changes are associated with excessive intake of hexavalent chromium compounds. On the other hand, the trivalent chromium is an essential nutrient that plays an important role in metabolic processes. Cr(VI) is regarded to be the best or only reagent, suitable for many important technological processes including leather tanning, electroplating, metal finishing, textile industries, chromate preparation.

KEYWORDS: Chromium, toxicity, essential nutrient, metabolic process.

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INTRODUCTION

Chromium can exist in eleven oxidation states ranging from –IV to +VI [1]. Trivalent and hexavalent chromium has major environmental significance because of their stability in natural environment. Between the two forms Cr(VI) shows several toxic effects because of its high water solubility and mobility as well as easy reduction[1,2]. Acute exposure to Cr(VI) causes nausea, diarrhea, liver and kidney damage, internal hemorrhage and respiratory problems. Inhalation causes irritation and ulceration of nasal septum and respiratory sensitization. Skin contact can produce skin allergies, dermatitis, dermal necrosis and dermal corrosion. Cr(VI) has been shown to induce a variety of DNA lesions such as strand breaks, DNA-protein cross links and base modification. The united states environmental protection agency (USEPA) has laid down the maximum contaminant level (MCL) for Cr(VI) in domestic water supplies to be 0.05 mg/L. Whereas the trivalent form of chromium has been identified as a novel micronutrient for its beneficial role in human nutrition by serving as a critical cofactor in the action of insulin as well as nutritional enhancement to energy, glucose, and lipid metabolism[3]. It also shows antioxidative properties in vivo, and it is integral in activating enzymes and maintaining the stability of proteins and nucleic acids[4]. According to the national research council (NRC), the estimated safe and adequate daily dietary intake (ESADDI) for Cr(III) is 50-200 µg/day[5].

STRUCTURAL DIFFERENCE OF CR(VI) AND CR(III):

Trivalent chromium:

Chromium concentration in foods:

Significant dietary sources of trivalent chromium are available in variuos food sources such as whole-grain products, high-bran breakfast cereals, egg yolks, coffee, nuts, green beans, broccoli, meat, Brewers' yeast and selected brands of beer and wine. Cr(III) is also found in many mineral or multivitamin supplements.

Biological roles of trivalent chromium:

Metal ions have been loosely divided into groups, according to whether they have biological activity, as being essential, beneficial, abiological or detrimental[6]. Most nutritionists regard Cr(III) as an essential micronutrient for humans[7-13]. Many people such as athletes, diabetics, pregnant women are especially at risk of chromium(III) deficiency leading to impaired insulin function, inhibition of protein synthesis and energy production, and to type 2 diabetes and heart disease[14].

Signs and symptoms of chromium(III) deficiency: Source: [15]

Function	Species
Impaired glucose tolerance	Human, rat, mouse, squirell, monkey, guinea pig
Elevated circulating insulin	Human, rat, pig
Glycosuria	Human, rat
Fasting hyperglycemia	Human, rat, mouse
Impaired growth	Human, rat, mouse, turkey
Hypoglycemia	Human
Elevated serum cholesterol and triacylglycerols	Human, rat, mouse, cattle, pig
Increased incidence of aortic plaques	Rabbit, rat, mouse
Increased aortic intimal plaque area	Rabbit
Neuropathy	Human
Encephalopathy	Human
Corneal lesion	Rat, squirell, monkey
Ocular eye pressure	Human
Decreased fertility and sperm count	Rat
Decreased longevity	Rat, mouse
Decreased insulin binding	Human
Decreased insulin receptor number	Human
Decreased lean body mass	Human, pig, rat
Elevated percentage body fat	Human, pig
Enhanced humoral immune response	Cattle
Morbidity	Cattle

(i) Glucose metabolism:

Chromium potentiates the action of insulin via the glucose tolerance factor (GTF)[16].

Transport of Cr(III) in the body:

Absorption: The dietary Cr(III) may exist as inorganic form or as organic complexes. Organic chromium(III) is suspected to be more absorbable than inorganic one[17]. The percentage of absorption for various chromium(III) compounds are given in following table.

Table- Source:[18]

Chromium(III) source	Absorption(%)	Subject
Chloride	0.9 ± 0.2 (4 hours) 0.69 (mean range 0.3-1.3) ~0.5	Rat Human Rat
Nicotinate	1.3 ± 0.3	Rat
Picolinate	1.1 ± 0.3 2.8 ± 1.14 SD	Rat Human
Dinicotinic acid-diglycine-cysteine-glutamic acid complex	0.6 ± 0.1	Rat
Chromium from food	1.8 (36.8 mg Cr/day) 2-3	Human Human
Chromium from brewer's yeast	5-105	Human

Dietary chromium is absorbed in the intestinal mucosa. The fate of dietary Cr(III) absorption can be significantly affected by many dietary and drug factors such as starch, ascorbic acid, minerals, oxalate and amino acid intake[19- 20]. Some chelating substances can combine with chromium and significantly influence the absorption of chromium in the gut tract[21]. The precipitation of chromium at the basic pH of the intestine, can be prevented by some amino acids and increases chromium absorption[23]. Some competition metals could drive chromium from its binding sites or form complexes with chromium and then modify its absorption[22]. Cr(III) absorption can also be affected by plasma proteins, such as tranferrin and albumin[23].

Transportation:

At pH 7.35, human plasma proteins were found to strongly bind with Cr (III).

CONCLUSION

In this comprehensive review, the emphasis is on outlining the good sides of trivalent chromium. Trivalent chromium is an essential nutrient that plays an important role in metabolic processes. Cr(VI) is regarded to be the best or only reagent, suitable for many important technological processes though Little toxic effect is attributed to trivalent chromium when present in very large quantities.

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