

Table 3. Interactions between nutrients and Hg: minerals.^a

Nutrient/nutrition factor	Proposed type of interaction	Ref.
Protective effects		
Phosphate ions (with ATP)	Decreased severity of inhibition of protein synthesis by Hg	(93,100)
Selenium	Alters GSH and GSH enzyme metabolism; forms precipitate with Hg; protective of toxic effects of MeHg and HgCl ₂ ; protects kidneys by reducing their MeHg uptake (may be mechanism for protecting survival)	(115–123)
Zinc	Activates GSH-associated enzymes that thus increase GSH level in kidney; altered superoxide dismutase activity; reduction of oxidative stress; induces metallothionein and activities of enzymes (GSH peroxidase and G-6-P dehydrogenase) that inhibit lipid peroxidation	(124–126)
Enhanced toxicity		
Iron	May increase lipid peroxidation by MeHg	(127–129)
Manganese ions	Mn exacerbated Hg damage to biogenic amines in the central nervous system; Hg altered superoxide dismutase activity	(126,127)
Other effects		
Calcium	Binding of inositol 1,4,5-triphosphate and 1,3,4,5-tetrakisphosphate to cellular membranes is inhibited by Hg	(130)
Iodine	Increases gastrointestinal absorption of Hg	(131)
Effects of Hg		
Cations	Hg alters cation metabolism; related to renal toxicity and/or the synthesis of metallothionein in kidney	(132)
Chloride ion	Action by direct effect of Hg on epithelial cells and also mediated by prostaglandins and cholinergic and noncholinergic neurons	(133,134)
Cobalt	Fluctuates due to altered vitamin B ₁ and B ₁₂ metabolism by Hg	(127)
Copper	Hg affects superoxide dismutase activity	(126,135)
Iron	Fluctuates due to lipid peroxidation by MeHg	(127–129)
Magnesium	Mg levels are altered due to alteration in GSH metabolism by Hg	(127)
Potassium ions	Hg disrupts the function of Na ⁺ ,K ⁺ -ATPase; Hg altered permeability through antiporters	(136,137)
Sodium ions	Hg disrupts the function of Na ⁺ ,K ⁺ -ATPase; Hg altered permeability through antiporters	(136,137)
Sulfur (sulfate, sulfite)	Hg reacts with sulfhydryl groups on proteins to form mercaptides; fluctuates due to altered vitamins B ₁ and B ₁₂ metabolism by Hg	(103,134,138)
Trace metals	Fluctuate due to association of Hg with various macromolecules; Hg dissociates Cu and Zn from metallothionein	(127)

Abbreviations: ATP, adenosine triphosphate; G-6-P, glucose 6-phosphate. ^aTable contains references to both inorganic and organic forms of Hg.

Table 4. Interactions between nutrients and Hg: vitamins.^a

Nutrient/nutrition factor	Proposed type of interaction	Ref.
Protective effects		
Lipoic acid	Decreases biliary excretion of MeHg and increases the biliary excretion of HgCl ₂ ; protects against toxicity	(139,140)
Vitamin B complex	Aids in recovery of glycosidases injured by Hg; protects membrane and maintains cell stability during Hg toxicity	(103,127)
Vitamin E	Alleviates MeHgCl and HgCl ₂ toxicity and neuronal degeneration; prevents lipid peroxidation due to Hg	(127,141–145)
Enhanced toxicity		
β-carotene	Alters fatty composition and hepatic GSH concentration; alters antioxidant defense mechanisms against MeHg-induced lipid peroxidation	(144,145)
Folate	Deficiency enhances the development of symptoms of Hg toxicity	(147)
Vitamin A	Increases toxicity of MeHg in rat; interaction not clear	(148)
Vitamin B ₁₂	Increases MeHg uptake in liver	(95,147)
Vitamin B ₁ (thiamine)	Deficiency enhances development of symptoms of Hg toxicity; possible ionic reaction similar to that with Cu and Cd	(30,90,134)
Vitamin C (ascorbate)	Enhances Hg absorption from intestinal tract; reducing agent of Hg ⁰	(134,149,150)
Other effects		
Vitamin D	Does not affect Hg uptake into tibia of chicks	(151)
Effects of Hg		
Biotin	Hg stimulates lipogenesis in biotin deficient state	(152)
Coenzyme A	Hg binds to CoA and interferes with CoASH function	(68)
NADPH	Hg forms a covalent complex with NADPH	(153)
Vitamin B ₁₂	Hg inhibits Met synthesis in brain	(95,147)

Abbreviations: NADPH, nicotinamide adenine dinucleotide phosphate. ^aTable contains references to both inorganic and organic forms of Hg.