

Micronutrients Table

Nutrient		Sources	Effects	Deficiency/Toxicity
Fat-Soluble Vitamins	Vitamin A	Liver, Meats, Carrots, Kale, Broccoli	Important for vision (cis-11-retinol) and for development, reproduction, energy efficiency, epithelial formation, and immune function. Binds via a TF protein RBP + TTR → RAR. Stored in liver	<i>Deficiency:</i> Night blindness, corneal scarring, follicular hyperkeratosis.
	Vitamin D	Enriched milk, fortified cereal, fish (tuna, mackerel)	Important for homeostasis of the blood calcium, growth, and development. Binds via TF protein VDR + RXR. Sequestered in fat cells. Made from 7-dehydroxycholesterol → pre D3 in the body, using sunlight. Appropriate for elderly treatment of Osteoporosis	<i>Deficiency:</i> Hypocalcemia, osteoporosis, osteomalacia, stunted growth, risk of falls, decreased bone growth (in youth). Rickets. <i>Toxicity:</i> hypocalcemia, hyperemia, excess bone loss, impaired kidney function, Ca ⁺⁺ buildup in the kidneys
	Vitamin E	Nuts, seeds, vegetable oils	Stops the production of reactive oxygen species when O ₂ oxidizes. Regulates protein kinase C, Inhibits platelet aggregation	<i>Deficiency:</i> spinocerebellar ataxia, myopathies, peripheral neuropathy, ataxia, skeletal neuropathy, impairment of immune response
	Vitamin K	Green leafy vegetables, Kale, Spinach	Produces blood clotting proteins	<i>Deficiency:</i> Liver damage, bowel diseases, osteoporosis, heart disease.
Water-Soluble Vitamins	Thiamine (B1)	Fortified cereals, oatmeal, grains, large intestine microbiota	Release energy from carbs during metabolism. Growth, and muscle tone. Pentose phosphate metabolism. Regenerate NADPH from NADP ⁺ . Transported via THTR-1/2 into the gut.	<i>Deficiency:</i> Beriberi (peripheral neuropathy, congestive heart failure), Wernicke's (ataxia, bleeding around ventricles, confusion) and Korsakov syndromes. Common after bariatric surgery (50%)
	Niacin (B3)	Meat, poultry, nuts, dairy, eggs, cereal	Involved in carb, protein, and fat metabolism. Coenzyme source (NAD ⁺ and NADPH).	<i>Deficiency:</i> Pellagra (dermatitis, diarrhea, dementia, mucosal atrophy and inflammation of digestive tracts, neurological disorders, death)
	Vitamin B6	Fish, poultry, lean meats, bananas	Build body tissue, and aids in protein metabolism. Glycogenolysis. Heme synthesis. Levodopa → dopa, Glutamate → GABA	<i>Deficiency:</i> Dermatitis, neurological disorders, convulsions, anemia with ringed sideroblasts, elevated plasma homocysteine.
	Folate (B9)	Green, leafy Vegetables, organ meats, beans	Aids in genetic material development, involved in rbc production. Transported via an H ⁺ -coupled folate transporter.	<i>Deficiency:</i> Megaloblastic anemia, neural tube and other birth defects (spina bifida), Heart Disease, stroke, impaired cognitive function, depression
	Vitamin B12	Meats, milk products, seafood	Aids cell development, nervous system functioning, and metabolism of protein and fat	<i>Deficiency:</i> Megaloblastic anemia, atrophic glossitis, Neurological changes (myelination defect), elevated homocysteine concentrations
	Vitamin C	Citrus, berries, vegetables	Essential for bone structure, cartilage, muscles, and blood vessels. Maintains capillaries and gums. Iron absorption	<i>Deficiency:</i> Scurvy (fatigue, hemorrhages, low resistance to infection, corkscrew hair)
Trace Metals	Copper	Oysters and shellfish, whole grains, nuts, beans, dark greens	Used for Redox reactions for many enzymes: CT building, Electron Transport chain, melanin, keratin. ATP7B – copper transporter to bile (dys = Wilson D). ATP7A – intestine copper transporter (dys = Menke's D.)	<i>Deficiency:</i> Menkes disease (unusual hair, mental retardation, arterial tortuosity) from deficiency in copper-dependent enzymes; Wilson Disease (liver swelling, dysjunction, jaundice, neurologic effects)
	Iron	Spinach, nuts, meats, Heme iron more bioavailable.	Allows proper oxygen transport, less fatigue, Electron transfer, O ₂ and peroxide metabolism, Redox enzymes and non-redox enzymes. DMT1 – key transporter from duodenum. <i>Weissherbst</i> mutation in Ferroportin 1 block transport. HFE protein: uptake iron in gut, metabolism	<i>Deficiency:</i> Most common micronutrient deficiency. 2bil suffer from deficiency. Causes fatigue, reduces work capacity, and weakens the immune system. Higher risk of women dying during childbirth. Higher risk of child development issues, Hemochromatosis (pigmentation, cirrhosis, diabetes.
	Calcium	Dairy, fish, broccoli	For bone growth and maintenance. Transported from kidneys via TRPV5/6, Calcibindin D, and PMCA1b	<i>Deficiency:</i> Decreased bone mineralization, rickets, osteoporosis
	Zinc	Oysters, Beef, Pork, Yogurt, Milk, Eggs	Heal wounds, grow tissues, properly blood clot, sound fetal development, DNA/RNA synthesis. ZnT4 (lethal milk), Zip4 (AE) – important transporters for Zn	<i>Deficiency:</i> Persistent diarrhea/respiratory problems. Poor pregnancy outcomes. Stunting in children. Acrodermatitis enteropathica (dermatitis, diarrhea, immune dysfunction, metabolic disorders, cognitive impairment), Lethal Milk
Other Nutrients	Iodine	Iodized salt	Allows the normal function of the thyroid in releasing TH and Calcitonin, Allowing for better control of Ca ⁺⁺ reabsorption and metabolism	<i>Deficiency:</i> 2 billion at risk. Hypothyroidism (decreased energy, decreased body temperature, decreased muscle function. Goiter. Cognitive dysfunction. Increased chance of miscarriage
	Flouride	Water, toothpaste	Reinforces teeth enamel	<i>Deficiency:</i> increased dental decay, affects bone health