Vitamin B5 (Pantothenic acid)

Pantothenic acid, also called vitamin B$_5$ (a B vitamin), is a water-soluble vitamin. Pantothenic acid is an essential nutrient. Animals require pantothenic acid to synthesize coenzyme-A (CoA), as well as to synthesize and metabolize proteins, carbohydrates, and fats. The anion is called pantothenate. Pantothenic acid is the amide between pantoic acid and β-alanine. Its name derives from the Greek pantothen, meaning "from everywhere", and small quantities of pantothenic acid are found in nearly every food, with high amounts in fortified whole-grain cereals, egg yolks, liver and dried mushrooms. It is commonly found as its alcohol analog, the provitamin panthenol (pantothenol), and as calcium pantothenate. Pantothenic acid was discovered by Roger J. Williams in 1933.

Biological role

Only the dextrorotatory (D) isomer of pantothenic acid possesses biologic activity.$^{[10]}$ The levorotatory (L) form may antagonize the effects of the dextrorotatory isomer. Pantothenic acid is used in the synthesis of coenzyme A (CoA). Coenzyme A may act as an acyl group carrier to form acetyl-CoA and other related compounds; this is a way to transport carbon atoms within the cell.$^{[12]}$ CoA is important in energy metabolism for pyruvate to enter the tricarboxylic acid cycle (TCA cycle) as acetyl-CoA, and for α-ketoglutarate to be transformed to succinyl-CoA in the cycle. CoA is also important in the biosynthesis of many important compounds such as fatty acids, cholesterol, and acetylcholine. CoA is incidentally also required in the formation of ACP,$^{[14]}$ which is also required for fatty acid synthesis in addition to CoA. Pantothenic acid in the form of CoA is also required for acylation and acetylation, which, for example, are involved in signal transduction and enzyme activation and deactivation, respectively. Since pantothenic acid participates in a wide array of key biological roles, it is essential to all forms of life. As such, deficiencies in pantothenic acid may have numerous wide-ranging effects.

Sources

https://med.libretexts.org/Courses/Dominican_University/DU_Bio_1550%3A_Nutrition_(LoPresto)_OLD/07%3A_Vitamins/7.3…

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Dietary

Content of pantothenic acid varies among manufactured and natural foods, especially fortified ready-to-eat cereals, infant formulas, energy bars and dried foods. Major food sources of pantothenic acid are dried mushrooms, liver, dried egg yolks and sunflower seeds.[7] Whole grains are another good source of the vitamin, but milling removes much of the pantothenic acid, as it is found in the outer layers of whole grains.[16] In animal feeds, the most important sources are alfalfa, cereal, fish meal, peanut meal, molasses, mushrooms, rice, wheat bran, and yeasts.[17]

Supplementation

The derivative of pantothenic acid, pantothenol (panthenol), is a more stable form of the vitamin and is often used as a source of the vitamin in multivitamin supplements.[17]:347 Another common supplemental form of the vitamin is calcium pantothenate. Calcium pantothenate is often used in dietary supplements because, as a salt, it is more stable than pantothenic acid. Supplementation may improve oxygen utilization efficiency and reduce lactic acid accumulation in athletes.[17]

Dietary reference intake

The Food and Nutrition Board of the U.S. Institute of Medicine updated Estimated Average Requirements (EARs) and Recommended Dietary Allowances (RDAs) for B vitamins in 1998. At that time there was not sufficient information to establish EARs and RDAs for pantothenic acid. In instances such as this, the Board sets Adequate Intakes (AIs), with the understanding that at some later date, AIs will be replaced by more exact information. As for safety, the FNB sets Tolerable Upper Intake Levels (known as ULs) for vitamins and minerals when evidence is sufficient. In the case of pantothenic acid there is no UL, as there is insufficient human data to identify adverse effects from high doses.[18] The European Food Safety Authority reviewed the same safety question and also reached the conclusion that there was not sufficient evidence to set a UL for pantothenic acid.[19] Collectively the EARs, RDAs and ULs are referred to as Dietary Reference Intakes.

For U.S. food and dietary supplement labeling purposes the amount in a serving is expressed as a percent of Daily Value (%DV). For pantothenic acid labeling purposes 100% of the Daily Value was 10 mg, but as of May 2016 it has been revised to 5 mg. A table of the pre-change adult Daily Values is provided at Reference Daily Intake. Food and supplement companies have until July 2018 to comply with the change.

Pantothenic acid in the form of 4’phosphopantetheine is considered to be the more active form of the vitamin in the body; however, any derivative must be broken down to pantothenic acid before absorption.

<table>
<thead>
<tr>
<th>Age group</th>
<th>Age</th>
<th>Adequate intake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infants</td>
<td>0–6 months</td>
<td>1.7 mg</td>
</tr>
<tr>
<td>Infants</td>
<td>7–12 months</td>
<td>1.8 mg</td>
</tr>
<tr>
<td>Children</td>
<td>1–3 years</td>
<td>2 mg</td>
</tr>
<tr>
<td>Age group</td>
<td>Age</td>
<td>Adequate intake</td>
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<tr>
<td>Children</td>
<td>4–8 years</td>
<td>3 mg</td>
</tr>
<tr>
<td>Children</td>
<td>9–13 years</td>
<td>4 mg</td>
</tr>
<tr>
<td>Adult men and women</td>
<td>14+ years</td>
<td>5 mg</td>
</tr>
<tr>
<td>Pregnant women</td>
<td>(vs. 5)</td>
<td>6 mg</td>
</tr>
<tr>
<td>Breastfeeding women</td>
<td>(vs. 5)</td>
<td>7 mg</td>
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</tbody>
</table>

**Absorption**

When found in foods, most pantothenic acid is in the form of CoA or acyl carrier protein (ACP). For the intestinal cells to absorb this vitamin, it must be converted into free pantothenic acid. Within the lumen of the intestine, CoA and ACP are hydrolyzed into 4'-phosphopantetheine. The 4'-phosphopantetheine is then dephosphorylated into pantetheine. Pantetheinase, an intestinal enzyme, then hydrolyzes pantetheine into free pantothenic acid.

Free pantothenic acid is absorbed into intestinal cells via a saturable, sodium-dependent active transport system. At high levels of intake, when this mechanism is saturated, some pantothenic acid may also be absorbed via passive diffusion. As intake increases 10-fold, however, absorption rate decreases to 10%.

**Deficiency**

Pantothenic acid deficiency is exceptionally rare and has not been thoroughly studied. In the few cases where deficiency has been seen (victims of starvation and limited volunteer trials), nearly all symptoms can be reversed with the return of pantothenic acid.

Symptoms of deficiency are similar to other vitamin B deficiencies. There is impaired energy production, due to low CoA levels, which could cause symptoms of irritability, fatigue, and apathy. Acetylcholine synthesis is also impaired; therefore, neurological symptoms can also appear in deficiency. They include numbness, paresthesia, and muscle cramps. Deficiency in pantothenic acid can also cause hypoglycemia, or an increased sensitivity to insulin. Insulin receptors are acylated with palmitic acid when they do not want to bind with insulin. Therefore, more insulin will bind to receptors when acylation decreases, causing hypoglycemia. Additional symptoms could include restlessness, malaise, sleep disturbances, nausea, vomiting, and abdominal cramps. In a few rare circumstances, more serious (but reversible) conditions have been seen, such as adrenal insufficiency and hepatic encephalopathy.

Deficiency symptoms in other nonruminant animals include disorders of the nervous, gastrointestinal, and immune systems, reduced growth rate, decreased food intake, skin lesions and changes in hair coat, and alterations in lipid and carbohydrate metabolism.
Toxicity

Toxicity of pantothenic acid is unlikely. In fact, no Tolerable Upper Level Intake (UL) has been established for the vitamin.[20] Large doses of the vitamin, when ingested, have no reported side effects and massive doses (e.g., 10 g/day) may only yield mild intestinal distress, and diarrhea at worst. It has been suggested, however, that high doses of pantothenic acid might worsen panic attacks in those with panic disorder by prolonging the duration until adrenal exhaustion. Pantothenic acid, at a human equivalent dose within the range of common supplementation, was shown to induce adrenal hyper-responsiveness to stress stimulation.[23] There are also no adverse reactions known following parenteral (injected) or topical (skin) applications of the vitamin.[24]

Research

Although pantothenic acid supplementation is under preliminary research for a variety of human diseases, there is insufficient evidence to date that it has any effect.[10][8]

Ruminant nutrition

No dietary requirement for pantothenic acid has been established as synthesis of pantothenic acid by ruminal microorganisms appears to be 20 to 30 times more than dietary amounts. Net microbial synthesis of pantothenic acid in the rumen of steer calves has been estimated to be 2.2 mg/kg of digestible organic matter consumed per day. The degradation of dietary intake of pantothenic acid is considered to be 78 percent. Supplementation of pantothenic acid at 5 to 10 times theoretic requirements did not improve performance of feedlot cattle[25]