

Vitamin A

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**BASF Nutrition –
the healthy decision**



Vitamin A deficiency (VAD) is a serious public health problem in more than half the world's countries. The prevalence is particularly high among poor populations of Africa, South America and major parts of Asia whose diet is limited to affordable staples such as flour and rice, with an associated higher risk of illness and death by malnutrition. VAD primarily affects young children and pregnant women. VAD is the number one cause of childhood blindness, promotes night blindness during pregnancy, and is associated with higher maternal mortality. Overall, vitamin and mineral deficiencies blight the economies of developing countries, causing losses equivalent to 2.5% of gross domestic product.

The Copenhagen Consensus 2008 consisting of a panel of eight of the world's most distinguished economists has recently set priorities among a series of proposals for confronting ten great global

challenges. The question: "What would be the best ways of advancing global welfare, and particularly the welfare of the developing countries, illustrated by supposing that an additional \$75 billion of resources were at their disposal over a four-year initial period?" The experts' top priority ranking was micronutrient supplements for children (vitamin A and zinc) and fortification of staple foods with micronutrients to combat malnutrition. Providing vitamin A supplements to all children at risk at least twice a year is very important to combat VAD although a major challenge for the countries' ministries of health and their partner organizations. The fortification of locally produced staples such as oil, flour, sugar and rice with vitamin A is a cost-effective, sustainable additional intervention for preventing VAD among poor people and ensuring regular intake of adequate amounts of vitamin A. BASF is committed to help combat vitamin A deficiency worldwide and develop vitamin A products designed for the fortification of staple foods in developing countries.

Vitamin A is linked with:

- Healthy vision
- Healthy lung function
- Immunity
- Preventing night blindness and eye damage
- A lower risk of certain cancers
- A lower risk of birth defects
- Other health benefits

"An estimated 250 000 to 500 000 vitamin A-deficient children become blind every year, half of them dying within 12 months of losing their sight." (WHO, 2008)

What is vitamin A?

Vitamin A is not a single nutrient. It comprises a group of compounds that have vitamin A activity, i.e. the ability to prevent manifest vitamin A deficiency in humans. The parent substance is vitamin A alcohol, called all-trans-retinol. Vitamin A is a lipid-soluble substance that is unstable to light, oxidizing agents and heat. Dietary supplements and fortified foods usually contain the more stable vitamin A esters (i.e. acetate and palmitate).

Provitamin A

Plants contain a variety of vitamin A precursors called provitamin A carotenoids. These are plant pigments which may be converted to vitamin A after ingestion. They include beta-carotene, alpha-carotene and gamma-carotene. The most common provitamin A is beta-carotene, which has the highest provitamin A activity of all carotenoids. When eaten, carotenoids are absorbed and either broken down to vitamin A, or remain intact and exert health benefits as antioxidants in the body.

Dietary sources

Vitamin A is limited to foods of animal origin such as liver, butter, egg yolk, whole milk, cheese, and fortified margarine. Being fat-soluble, vitamin A is mainly confined to fat, so skim, lean and low-fat products contain much less vitamin A than regular foods. Foods of vegetable origin merely contain vitamin A precursors, the carotenoids.

Plant foods rich in provitamin A carotenoids include

- yellow vegetables such as squash, carrots, and pumpkin
- green leafy vegetables such as broccoli
- yellow fruits such as apricots, mangoes, and peaches.

No vitamin A is contained in beans, tofu, lean meat, cereals, bread and bakery products, soft drinks, alcoholic beverages, and many other foods. Staple foods like flour, rice, sugar and oil do not contain vitamin A unless fortified with vitamin A.

Biological function

Vitamin A plays a pivotal role in numerous important body functions such as reproduction, growth, vision and immune function. See table.

Vision	Component of eye pigment. Essential for converting light energy into nerve impulses, leading to "vision". Vitamin A requirements are particularly high in dim light (night vision) and very bright light.
Resistance to infections	Helps maintain skin and mucous membrane barrier function. Essential for resistance to bacteria, viruses and parasites entering via body surface, airways, intestine and urinary system.
Immune function	Helps produce antibodies and lymphocytes, thus improving immune defense against bacteria and viruses.
Blood cells	Required for production of red blood cells (in combination with iron)
Metabolism	Required for production of protein and for fat metabolism in the liver
Brain function	Required for healthy brain and nerve functioning
Reproduction	Required for proper functioning of reproductive organs and hormone production.
Growth	Supports and regulates cell growth and development, including the building of bones, skin, eyes, hair, mucosa, lymphatic organ, teeth, and more.

Bioavailability

Absorption of vitamin A and carotenoids requires dietary fat and bile acids. Vitamin A has a bioavailability of about 45%, but the bioavailability of carotenoids, and therefore their accessibility as provitamin A may be less since is influenced by several factors: chemical structure (carotenoids differ in provitamin A potency), amount of carotenoids present in a meal (depends on crop growing conditions, storage duration & conditions), digestibility (food matrix and method of food preparation), and personal factors (health status, genetics).

Contribution of plant foods to vitamin A intake

The contribution of plant foods to vitamin A intake is limited. In the intestine, beta-carotene may in theory be split by the enzyme 15,15'-dioxygenase into two molecules of vitamin A. Conversion factors for estimating vitamin A obtained from plant foods are a subject of constant debate in the scientific community. To calculate the required amounts, provitamin A carotenoid activity is converted into Retinol Equivalents (RE) or Retinol Activity Equivalents (RAE):

1 µg Retinol Activity Equivalent (RAE, US)
 = 1 µg retinol
 = 2 µg supplemental beta-carotene
 = 12 µg dietary beta-carotene
 = 24 µg other dietary provitamin A carotenoids

1 µg Retinol Equivalent (RE, Europe)
 = 6 µg beta-carotene
 = 12 µg other provitamin A carotenoids

The conversion rates propounded by the U.S. Institute of Medicine may be lower in malnourished populations.



Vitamin A deficiency (hypovitaminosis)

Vitamin A deficiency is the most common type of vitamin deficiency in the world. Deficiency of vitamin A is found among malnourished populations, the elderly, and chronically sick individuals. Initial symptoms include increased light sensitivity, dry eyes and impaired adaptation to the dark, to the point of night blindness. In the advanced stage of this disease, yellowish horny spots appear in the conjunctiva and the production of tear fluid is severely reduced (xerophthalmia). Keratomalacia can ultimately lead to severely impaired eyesight and even complete blindness, particularly in small children.

Vitamin A deficiency may also cause reduced resistance to infection, which in turn results in higher morbidity and mortality rates due to diarrhea, respiratory infections and measles. Reproductive disorders (reduced fertility, sterility, birth defects) are common. Further symptoms include alterations in the mucous membranes of the respiratory and reproductive organs, the intestinal mucosa and the urogenital tract. These symptoms are accompanied by unpleasant transformation of the skin, which becomes dry, squamous and wrinkled, and develops an acne-like appearance. In children, vitamin A deficiency stunts their growth, is responsible for bone deformation and adversely affects dental development. Vitamin A deficiency may worsen anemia and the health status during AIDS, malaria, measles and other diseases. Vitamin A deficiency increases morbidity and mortality.

Note: Depletion of body stores of vitamin A may take place before blood levels of vitamin A decrease and clinical manifestations occur. People with protein deficiency (common in developing countries) are at higher risk of vitamin A deficiency since proteins are needed to transport and store vitamin A in the body.

“Provision of vitamin A supplements every four to six months is an inexpensive, quick, and effective way to improve vitamin A status and save children’s lives. (...) However, comprehensive control of vitamin A deficiency must include dietary improvement and food fortification in the long term.” (WHO, 2008)

Benefits of optimized vitamin A supply:

Children benefit from less infant and childhood mortality, reduced severity of disease (measles, diarrhea, malaria), improved growth and development, and improved learning ability.

Pregnant women benefit from increased survival (e.g. because of a reduced incidence of anemia) and increased resistance to infections (e.g. malaria, HIV).

The public health benefits include increased workforce productivity and less time off sick, a lower healthcare bill, and improved well-being for children, families, and whole communities.

BASF’s Nutrition Ingredients business unit is a leading global supplier of vitamins. Food fortification is a flagship corporate social responsibility initiative that offers BASF the opportunity to address a humanitarian challenge at scale in an economically sustainable way. Through its product solutions, technical assistance, scientific capacities and partnerships with academic and public-interest organizations, BASF engages in programs in over 30 developing countries assisting local producers, the public sector and civil society in the reduction of vitamin and mineral deficiencies.

Further information is available at:
www.nutrition.basf.com
www.food-fortification.com

Overdosing vitamin A (hypervitaminosis)

Too high a vitamin A intake may cause toxicity, as excess vitamin A accumulates in the liver and body fat tissues and is not excreted, unlike water-soluble vitamins. The first signs of acute vitamin A toxicity are headaches, vomiting, vertigo, and drowsiness, later progressing to toxic hepatitis, hypercalcemia, and other serious manifestations.

Effects of chronic overdosing include, but are not limited to, loss of appetite, dry skin, hair loss, bone pain, growth retardation, and cirrhosis of the liver.

Acute vitamin A toxicity occurs when children and adults consume > 20 x and > 100 x the RDA¹, respectively. In children, chronic intakes of 1500 IU vitamin A per kg body weight are considered toxic whereas in adults long-term intakes of 25000 IU - 100000 IU vitamin A per day lead to toxicity (Penniston and Tanumihardjo, American Journal of Clinical Nutrition, 2006).

The risk of overdosing with vitamin A from eating fortified staple foods is very low. Therefore, fortification of staple foods is considered a safe and reliable means of combatting vitamin A deficiency.

¹ Recommended Daily Allowance (RDA) is “average daily dietary nutrient intake level sufficient to meet the nutrient requirement of nearly all (97 to 98 percent) healthy individuals in a particular life stage and gender group”. DRI, Food and Nutrition Board of the U.S. Academy of Sciences, 2001.



Recommended intakes

The currently recommended daily vitamin A (retinol) intake from the diet (the Recommended Daily Allowance, or RDA) is 700 µg and 900 µg for adult women and men, respectively². Higher intakes are required during pregnancy (up to 770 µg) and lactation (up to 1,300 µg).

Consumption of fruits and vegetables rich in beta-carotene may contribute significantly toward meeting the RDA for vitamin A.

Adolescent girls and women of childbearing age, pregnant and lactating women should not consume liver. They should also limit their intake of preformed vitamin A to 2800 µg per day (14-18 years old) and 3000 µg per day (19-50 years old), respectively. Preformed vitamin A does not include carotenoids. (Source: U.S. Institute of Medicine, 2001)

Vitamin A requirements may be higher during infections and parasite infestations, inflammatory states, and post-surgery. Smoking, sunlight, certain drugs, and alcohol abuse are also linked with a higher vitamin A requirement. Diseases associated with insufficient fat absorption and storage also raise the dietary vitamin A requirement.

Vitamin A utilization may be impaired in the presence of protein energy malnutrition (PEM) states such as marasmus and kwashiorkor. This is due to insufficient production of vitamin A-binding proteins, which impairs vitamin A transport from the liver to target tissues in the body.



² Dietary Reference Intake (DRI) as published by the Food and Nutrition Board of the U.S. Academy of Sciences, 2001.

³ No labeling requirements according to Regulations (EC) 1829 and 1830/2003.

⁴ No labeling requirements with regard to allergens according to Directive 2000/13/EC (as amended).

Vitamin A from BASF

BASF supplies vitamin A in oil-based (i.e. liquid) and powdered (cold- and hot water soluble) formulations prepared by tailored formulation technologies. Vitamin A from BASF is suitable for administration in capsules, tablets, infant formula, and for fortifying various foodstuffs. Manufacturers can choose from a range of formulations, including gelatin-free products which are also kosher and halal. All vitamin A products are GMO-free³, allergen-free⁴, gluten-free and BSE/TSE unaffected. Product examples include Dry Vitamin A Acetate 325 GFP, Dry Vitamin A Acetate 250 DC/GFP, Vitamin A Palmitate 250 GFP BG (beverage grade), and various oily vitamin A palmitates and blends.

BASF's vitamin A for the fortification of staple foods

Fortification of staple foods such as oil, sugar, flour and rice requires special vitamin formulations. Important features include higher stability toward light, humidity and prolonged exposure to warm environments – conditions often found in developing countries. Product examples include Dry Vitamin A Acetate 250 FM CWD, Dry Vitamin A Palmitate 250 MS CWD, and various oily vitamin A products. BASF's vitamin A products for dry food fortification are uniquely encapsulated with starch, round and dense in structure. Therefore they robustly resist stress factors occurring during processing or inherent in the product itself such as moisture. BASF's vitamin A products have up to 90% higher stability than simple spray-dried products found on the marketplace. Using vitamin A from BASF is highly cost effective for manufacturers of fortified staple foods achieving performance with less amount of vitamin A.

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