

NUTRITION NEWS

ISSUE 1/2007 Newsletter for the Dietary Supplement, Beverage and Food Industry

Vitamin D

TOPICS OF THIS ISSUE

What is Vitamin D?

Vitamin D production in humans

How much exposure to sunlight do we need?

Environmental factors

Personal factors

Vitamin D insufficiency and deficiency

Bone health

Heart health

Other health benefits

Recommended intakes

Vitamin D from BASF

Helping Make
Products More
Nutritious™



Vitamin D, the “sunshine vitamin”, is all over the media these days. The latest research findings confirm vitamin D's established health benefits and identify new ones.

Many people in the world today are not getting enough vitamin D to enable them to benefit from its healthgiving effects. There are various reasons why. Vitamin D production in the skin is the primary source of this essential nutrient for humans. Apart from individual differences in production capability, vitamin D synthesis is strongly dependent on a person's exposure to ultraviolet light. Hence, production levels vary considerably

in response to geographical, cultural and lifestyle factors. When vitamin D production in the skin is insufficient, a balanced diet or supplements are the only sources of vitamin D.

Dietary intake of vitamin D is limited to a small number of foods that are natural vitamin D suppliers. These include fatty fish, eggs and milk products. In the United States, Canada and a few other countries, some staple foods are fortified with vitamin D. In most parts of the world, however, dietary sources are limited.

Scientists say we urgently need to improve our vitamin D supply. In many countries they are seeking legislative change to allow fortification with vitamin D. Nutrition experts are calling for an increase in the dosage of vitamin D per serving to a level high enough to produce effective concentrations of the vitamin in the body. There is a strong appeal for revision and elevation of the currently recommended daily intake levels. Improvement of vitamin D status is set to become a major public health issue.

Vitamin D is linked with:

- Bone health
- Muscle function
- Heart health
- Immunity
- A lower risk of diabetes
- A lower risk of certain autoimmune diseases
- A lower risk of certain cancers
- Other health benefits

What is Vitamin D?

Vitamin D (calciferol) is a micronutrient essential for healthy body function. There are two types of vitamin D: D3 (cholecalciferol) and D2 (ergocalciferol). Both types function as vitamins in their own right and help prevent symptoms of vitamin D deficiency. Vitamin D is unique among vitamins in that humans can produce it themselves, provided they have sufficient exposure to ultraviolet light. Vitamin D3 is the form produced in humans. It is also found naturally in milk, eggs and fatty fish such as herring and mackerel. Vitamin D2 is from plant-based foods (wild mushrooms, for example). Vitamin D2 and D3 were long thought to be equivalent and interchangeable. Both forms help prevent classical vitamin D deficiency. However, scientists have now established that vitamin D2 has lower bioefficacy than vitamin D3. Furthermore, there is no convincing scientific evidence that vitamin D2 prevents bone fractures and some other diseases.

Vitamin D production in humans



Vitamin D3 is produced by humans when ultraviolet radiation (UVB) from sunlight or artificial sources reaches skin cells. Within a few hours after exposure, 7-dehydrocholesterol, the vitamin precursor present in the skin, isomerizes to pre-

subsequently to vitamin D3. Vitamin D3 is transported to the liver and converted to 25-hydroxyvitamin D3 (calcidiol). Its levels in the blood vary depending on ultraviolet exposure and dietary intake. Hence, calcidiol levels are an indicator of vitamin D status. As needed, 25-hydroxyvitamin D3 is converted in the kidney to its active hormone 1,25-dihydroxyvitamin D3 (calcitriol) in a tightly controlled process.

How much exposure to sunlight do we need?

The amount of vitamin D3 produced in skin upon exposure to sunlight depends on environmental and individual factors. As a general recommendation, regular short outdoor activities with exposure of face and arms should be practiced. Adequate vitamin D3 synthesis occurs at UVB doses that are not high enough to cause sunburn (reddening of the skin). However, only unshielded exposed skin synthesizes vitamin D3. Holick et al (2004) found that proper sunscreen use with sun protection factor 8 blocks vitamin D3 synthesis by > 95%. The feasibility of exposing unshielded skin depends on local skin protection recommendations and on cultural and religious practices, ambient temperature, fashion and other factors.

Throughout the world, large population groups are at risk of vitamin D insufficiency due to a lack of production in the body. Most modern diets are low in vitamin D, and few countries have vitamin D food fortification programs in place.

Environmental factors

The amount of ultraviolet light reaching the skin depends on the latitude, season, time of day, as well as on the weather conditions (cloudiness), amount of air pollution and surface reflection. Optimum conditions for vitamin D3 synthesis are low latitudes, summertime, solar noon, fair sky, clean air (rural) and high reflection (snow).

Personal factors

Skin type strongly determines a person's effectiveness in producing vitamin D3. The darker the skin is pigmented, the more ultraviolet radiation is absorbed by melanin and the less vitamin D3 is produced. Dark-skinned populations originally live near the equator where ultraviolet radiation is heavy, and the little non-absorbed ultraviolet radiation entering the skin is considered sufficient to produce enough vitamin D3 for health. In contrast, fair-skinned populations originally live at high latitudes where ambient ultraviolet radiation is low, and paleness maximizes the capture of radiation for vitamin D3 production (the risk of ultraviolet damage is considered low at high latitudes even for fair skinned people). Migrant populations and their descendants often have skin types that do not fit to the ambient ultraviolet environment. Age has also an influence on vitamin D3 production. The amount of 7-dehydrocholesterol in skin decreases with age, and the body's ability to produce vitamin D3 declines. At the same time, vitamin D requirements rise as people grow older. Other personal factors include clothing habits, lifestyle and workplace (e.g indoor vs. outdoor), sunscreen use, sun avoidance practices, and certain diseases (e.g. fat malabsorption).



Vitamin D content in food (Example: United States)

| | | | |
|--------------------------------|-----------|----------|-------------------------|
| Cod liver oil | 1360 IU | 34 µg | per tablespoon (13.6 g) |
| Herring, raw | 1640 IU | 41 µg | per 100 g |
| Mackerel, raw | 360 IU | 9 µg | per 100 g |
| Egg | 20 IU | 0.5 µg | per piece (50 g) |
| Fortified milk | 40 IU | 1 µg | per 100 ml |
| Fortified orange juice | 40 IU | 1 µg | per 100 ml |
| Ready-to-eat breakfast cereals | 40-140 IU | 1-3.5 µg | per 100 g |

Scientists agree that diet alone does not provide enough vitamin D.

Source: USDA National Nutrient Database for Standard Reference, Release 19 (2006), M.S. Calvo et al. (2004)

Vitamin D insufficiency and deficiency

If vitamin D production or intake is low, vitamin D insufficiency is the result. The deficit in turn increases the risk of dis-



ease. In many such cases, doctors fail to make the connection between the disease and the patient's vitamin D insufficiency. Children may be at higher risk of pneumonia and death while adults may be more likely to develop heart disease and cancer.

Classical signs of vitamin D deficiency develop as the deficit worsens. Initially, elevated blood levels of parathyroid hormone cause osteoporosis and an increased risk of fractures. Parathyroid hormone levels start rising at calcidiol cutoff levels of 75 nmol/l or lower (concentrations below 50 nmol/l or even below 25 nmol/l are commonly observed in various population groups). A calcidiol level of 75 nmol/l is usually not achievable through sun exposure alone. Through diet alone it isn't achievable either.

Severe vitamin D deficiency causes a lack of bone mineralization, which manifests as rickets in children and osteomalacia in adults. Childhood rickets is on

the increase, and is re-emerging as an important health problem in countries with strong sun avoidance policies and cultures requiring modest dress.

Dietary risk factors for vitamin D insufficiency:

- Low intake of foods containing vitamin D (e.g. fatty fish, milk)
- No vitamin D fortification
- No multivitamin or other supplement use
- Prolonged breastfeeding

Bone health

Vitamin D hormone acts on bones, intestines and kidneys to yield calcium, resulting in higher calcium levels in the blood. It enhances intestinal absorption of calcium thereby promoting bone mineralization (if sufficient amounts of calcium are available from the diet). In addition, vitamin D hormone directly stimulates bone mineralization. Sufficient vitamin D is required to build healthy bones in children and to maintain bone health in adults. Low blood levels of calcidiol and low calcium levels lead to an increase in bone turnover and calcium mobilization from bones, causing osteoporosis and subsequent fractures. Bone mineral density increases when parathyroid hormone levels are low, to an extent depending on genetic polymorphisms in the vitamin D receptor.

Heart health

Vitamin D status affects cardiovascular health. High parathyroid hormone levels due to low vitamin D increases the risk of cardiovascular disease and mortality, especially that of high blood pressure and coronary artery disease. Moreover, vitamin D levels are inversely related to blood glucose levels and insulin resistance. Insufficient vitamin D levels in the blood are therefore associated with a higher risk of type II diabetes. Supplementation with vitamin D3 helps to decrease the level of parathyroid hormone in the blood and may thus help lower the risk of cardiovascular disease and diabetes.

Other health benefits

Vitamin D hormone acts in most body tissues and cell types. Via the vitamin D receptor, calcitriol acts locally on cells, regulating cell growth and stimulating cell differentiation. This helps to prevent cancer. A lower risk of cancer in people with adequate vitamin D status has been observed for a number of cancers, including cancer of the colon, bladder, prostate and breast. Vitamin D hormone also acts on cells of the immune system, stimulating production of macrophages and increasing their activity in combating infections. Vitamin D hormone also inhibits autoimmune responses in the body, thereby lowering the risk of rheumatoid arthritis, chronic inflammatory bowel disease and multiple sclerosis.

Did you know?

- Scientists agree that about 50% of the elderly in North America do not get enough vitamin D.
- Vitamin D intakes in North America are also insufficient in other age groups despite food fortification with vitamin D.
- In the rest of the world, it is estimated that 75% of the elderly and large part of the younger people do not get enough vitamin D.
- Vitamin D deficiency is common in Southern Europe, the Middle East, India, China and Japan.
- Small children, the elderly, institutionalized people and dark-skinned immigrants to Northern countries are at particular risk of vitamin D deficiency.

Sources: A.W. Norman et al (2007), P. Lips (2007), M.A. Strand et al (2007)

Recommended intakes

The currently valid Recommended Daily Intake (RDI) for vitamin D is 200 IU or 5 µg (adults)¹. Recent research suggests that the RDI should be raised. Scientists strongly recommend that agencies reassess what daily vitamin D intakes are appropriate. Increasing the RDI for vitamin D is expected to help lower the risk of disease in a large part of the population.

(R. Vieth et al, 2007)

Mean dietary intakes of vitamin D should be at least 12.5 µg or 500 IU for fair-skinned people when additional vitamin D

is provided from skin (e.g. during summertime). Recommendations for mean vitamin D intake should increase to at least 50 µg per day for the elderly, people with little sun exposure or darkly pigmented skin.

(S.J. Whiting et al, 2007)

According to a recent risk assessment conducted by the US-based Council for Responsible Nutrition (CRN), the Tolerable Upper Intake Level (UL) could be raised from 2,000 IU or 50 µg per day (adults)² up to 10,000 IU or 250 µg per day.

(J. Hathcock et al, 2007)

¹ Recommended Dietary Allowances as published in several countries, e.g. by the Food and Nutrition Board of the U.S. Academy of Sciences, and the Council of the European Community for Nutrition Labeling

² European Food Safety Authority (2006), and the U.S. Institute of Medicine (1997)

“Current governmental guidelines in all countries with respect to how much daily vitamin D is required (...) are too low and do not reflect the many scientific advances made in vitamin D and hormone D research over the past 10 years.”

“(...) it is not advisable for individuals to prolong their exposure to sunlight to produce the needed higher concentrations of vitamin D because of the well documented effects of sunlight on skin aging and the promotion of skin cancer.”

“(...) vitamin D3 fortification of foods such as bread, milk, and orange juice or vitamin D3 supplementation in daily vitamin capsules should be very significantly improved and implemented.”

13th Workshop consensus for vitamin D nutritional guidelines. A.W. Norman et al, *Journal of Steroid Biochemistry & Molecular Biology*, Vol. 103, pp. 204-205 (2007)

Vitamin D from BASF

BASF supplies vitamin D3 in oil-based formulations and in powders. Vitamin D3 from BASF is thus suitable for use in a variety of applications such as capsules, multivitamin tablets, infant formula, milk fortification, and other food fortification programs. Manufacturers can choose from a range of formulations, including gelatin-free products which are also certified kosher and halal. All vitamin D3 products are GMO-free¹, allergen-free², gluten-free and BSE/TSE unaffected. Product examples are Dry Vitamin D3 100 GFP, Dry Vitamin D3 50 GFP and Vitamin D3 1.0 mio IU/g.

BASF's Nutrition business unit is a leading supplier of food ingredients and feed additives. The portfolio for human nutrition includes vitamins, carotenoids, omega-3s and other products. BASF supplies products of outstanding quality produced with modern, state-of-the-art technologies. BASF also combines technical services and scientific expertise to meet the highest demands and to deliver the best value to the industry. Premium formulations are a key strength that has made BASF a leader in the industry. Further information is available at www.nutrition.basf.com.

¹ No labeling requirements according to Regulations (EC) 1829 and 1830/2003. Further information upon request.

² No labeling requirements with regard to allergens according to Directive 2000/13/EC (as amended).

Recommendations:

- Adequate and safe sun exposure. Regular outdoor activities
- Regular consumption of vitamin D-rich foods and fortified foods (if available)
- Regular multivitamin use

References: A list of references is available for download at www.nutrition.basf.com. Please go to Human Nutrition / About Us / Scientific Affairs.



The Chemical Company

For further information, please contact your local representative

North America

BASF Corporation
Fine Chemicals North America
Nutrition
100 Campus Drive
Florham Park, New Jersey 07932
USA
Phone: ++1/800-527-9881
Fax: ++1/973-245-6843
e-mail: nutrition@basf.com

Europe, Africa, West Asia

BASF Aktiengesellschaft
Fine Chemicals Europe, Africa,
West Asia
Nutrition
J550
67056 Ludwigshafen
Germany
Phone: ++49/621 60-76962
Fax: ++49/621 60-76985
e-mail: nutrition-europe@basf.com

Asia, Pacific

BASF East Asia Regional Headquarters Ltd
Fine Chemicals Asia/Pacific
Nutrition
45th Floor, Jardine House
No.1 Connaught Place
Central Hong Kong
Phone: ++852/273 11-582
Fax: ++852/273 49-638
e-mail: finechem-hk@basf.com

South America

BASF S.A.
Fine Chemicals South America
Nutrition
Av. Brigadeiro Faria Lima,
3600/3624
São Paulo – SP 04538-132
Brazil
Phone: ++55/11 3043-2863
Fax: ++55/11 3043-2255
e-mail: quimica.fina@basf.com

™ = trademark BASF Aktiengesellschaft