

GREENPEACE

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VITAMIN A : NATURAL SOURCES vs "GOLDEN RICE"

1) HOW MUCH VITAMIN A DO PEOPLE NEED TO PREVENT DEFICIENCY ?

The FAO/WHO recommend a daily intake of 500 to 850 micrograms of vitamin A for adults (500 micrograms for females, 600 micrograms for males, 800 micrograms during pregnancy, and 850 micrograms during breast feeding), and a daily intake of 400 micrograms for a child between 1 to 3 years of age¹. This level of intake is set to prevent clinical signs of deficiency and to allow normal growth. Higher levels of vitamin A are needed during breast feeding, as the milk is the source of vitamin A for the baby.

2) NATURAL SOURCES OF VITAMIN A, BETA-CAROTENE AND BIOAVAILABILITY

Examples of natural sources of vitamin A include butter, fatty fish liver oil and sheep's liver. Provitamin A compounds such as beta (β)-carotene are found in dark green vegetables, fruits and tubers. This beta-carotene needs to be transformed into vitamin A by the body before it can be utilised. The availability of beta-carotene and the efficiency of its conversion to vitamin A are here together termed bioavailability².

There are several factors affecting the bioavailability of provitamin A compounds. The pro-vitamin A in ripe coloured fruits and cooked yellow tubers is converted to vitamin A more efficiently than from green leafy vegetables³. Nutritional deficiencies such as of zinc, protein and fat/oil can limit the bioavailability.⁴ Hence, a balanced and diverse diet is of importance in maintaining the human body's capability to absorb provitamin A and convert it to vitamin A.

Until recently, 6 micrograms of beta-carotene was assumed to equate to 1 microgram of vitamin A⁵ when converted in the human body. However, this ratio is now thought to be an overestimate of the production of vitamin A from provitamin A. The Institute of Medicine of the US National Academy of Sciences concluded in January 2001 that the amount of provitamin A required to create one unit of vitamin A is twice the amount thought previously⁶. According to this new recommendation, 12 micrograms of ingested beta-carotene are required to produce 1 microgram of vitamin A. It has even been suggested that an even lower conversion rate of 21 micrograms beta-carotene to 1 microgram of vitamin A may be more appropriate⁷.

3) EXAMPLES OF NATURAL BETA-CAROTENE RICH SOURCES

Many natural food sources are rich in beta-carotene. The following list provides some examples:

Food source	β -carotene concentration (micrograms per gram fresh weight) ⁸
Refined red palm oil*	92,8
Carrot, raw	46-125
Leafy vegetables (32 types)	10-444
Sweet potato, orange variety	11,4
Cassava, yellowish	up to 7,9
Mango	up to 6,15
Papaya, watermelon	2,28-3,24

* as used as vitamin A supplement.

4) HOW MUCH PROVITAMIN A (BETA-CAROTENE) DOES THE "GOLDEN RICE" PRODUCE?

The 'best' line (called z11b) of the genetically engineered (GE) "Golden Rice", produces 1,6 microgram beta-carotene per gram of (uncooked) rice⁹. The scientists point out that reliable quantification must await homozygous line with uniformly coloured grains. As long as there are no homozygous lines, the 'z11b' GE rice does not transmit the provitamin A traits to all its progeny in a stable fashion. The scientists aim to get a homozygous line that contains 2 micrograms provitamin A per gram of rice¹⁰.

5) COULD THE HUMAN BODY UTILIZE THE BETA-CAROTENE OF THE GE RICE?

The bioavailability of the beta-carotene in the GE rice remains an unanswered issue. There is no study yet published about the bioavailability of the beta-carotene in the GE rice. One of the scientists involved in the development of the 'Golden Rice' has stated: "[...] we have no data yet on the bioavailability and the stability during storage"¹¹.

6) HOW MUCH VITAMIN A COULD HUMANS GET FROM THE GE RICE?

The recommended daily nutritional intake of vitamin A for an adult female is 500 micrograms and for a woman who is breast feeding, 850 micrograms¹². This translates into 6000 and 10200 micrograms of beta-carotene respectively, according to the new recommendation of the US National Academy of Sciences Institute of Medicine (12:1 beta-carotene to vitamin A).

The GE rice currently produces 1,6 microgram of beta-carotene per gram of rice.

Assuming that the bioavailability of the beta-carotene in the GE rice would be as high as in vegetables and fruits, then (in accordance with the new US National Academy of Sciences Institute of Medicine recommendation):

A woman would need to consume 3750 grams (3,75 kilos) of GE rice per day i.e. around 9 kilograms of cooked rice, or 6375 grams (6,375 kilos) per day when breast feeding, in order to get sufficient vitamin A if the GE rice is the only source of vitamin A and provitamin A. A two year old child would need to eat 3 kilograms of GE rice a day i.e. around 7 kilograms of cooked rice.

So, if a female would consume 300 grams of (uncooked) GE rice per day (three servings of 100 grams), and no other vitamin A -rich food she would only obtain 8 % of the recommended daily intake of vitamin A. If she is breast feeding she would obtain only 4.7 % of the recommended daily intake. A two year old child would one get 10% of the recommended daily intake when eating 300 grams of rice.

Even if the scientists' current goal of 2 micrograms per gram of rice was achieved and confirmed, 300 gram of GE rice per day would provide only 10% for an adult female (5.9% for a female who is breast feeding) of the recommended daily intake of Vitamin A.

¹ Joint FAO/WHO Expert Consultation on Human Vitamin and Mineral Requirements, FAO, Bangkok, Thailand, September 21-30, 1998. Preliminary Report on Recommended Nutrient Intakes, Revised July 13, 2000. Also, Joint FAO/WHO Expert Consultation (1988) Requirements of vitamin A, iron, folate and vitamin B12. Food and Nutrition Series, no. 23, FAO, Rome.

² Bioavailability: In general, the terms refers to the degree to which any substance in the diet is available after ingestion for utilization by the body. In the present context, bioavailability refers to the degree to which dietary provitamin A carotenoids are utilized after ingestion. From McLaren, D.S. & Frigg, M. (2001) Sight and Life Manual on Vitamin A Deficiency Disorders (VADD), Second Edition, Basel, p.145.

<http://www.sightandlife.org/info/manunal2ed/>

³ <http://www4.nationalacademies.org/IOM/IOMhome.nsf>

⁴ Kuhnlein, H.V. & Pelto, G.H. (eds.) (1997) Culture, environment, and food to prevent vitamin A deficiency. International Nutrition Foundation for Developing Countries (INFDC) & International Nutrition Foundation for Developing Countries (INFDC). <http://www.unu.edu/unupress/food2/UIN07E/uin07e00.htm>

⁵ Joint FAO/WHO Expert Group (1976) Vitamin A deficiency and xerophthalmia. Tech. Rep. Ser. no. 590, WHO, Geneva.

⁶ National Academies of Sciences, Institute of Medicine (2001) Fruits and Vegetables Yield Less Vitamin A than Previously Thought; Upper Limits Set for Daily Intake of Vitamin A and Nine Other Nutrients, Press release Jan 9, 2001. <http://www4.nationalacademies.org/IOM/IOMhome.nsf>

⁷ West, C.E. (2000) Meeting requirements for vitamin A. Nutrition Reviews, 58, 341-345.

⁸ Ong, A.S.H. & Tee, E.S. Methods Enzymol. 213:142-167. From: McLaren, D.S. & Frigg, M. (2001) Sight and Life Manual on Vitamin A Deficiency Disorders (VADD), Second Edition, Basel, p.12.

<http://www.sightandlife.org/info/manunal2ed/>. Except for palm oil data which is from Lietz G., Mulokozi G., Mugyabuso J.K.L., Ndossi G.D., Lorri W., Henry C.J.K. & Tomkins A. (2000) Use of red palm oil for the promotion of maternal vitamin A status, Food and Nutrition Bulletin, 21, 215-218 and Lietz, G., Henry, C.J.K., Mulokozi, G., Mugyabuso, J.K.L., Ballart, A., Ndossi, G.D., Lorri, W. & Tomkins, A. (2001) Comparison of effects of red palm oil and sunflower oil as dietary supplementation on maternal vitamin A status. American Journal of Chemical Nutrition (in press).

⁹ Ye, X., Al-Babili, S., Klöti, A., Zhang, J., Lucca, P., Beyer, P. & Potrykus, I. (2000) Engineering the Provitamin A (β -Carotene) Biosynthetic Pathway into (Carotenoid-Free) Rice Endosperm, Science, 287, 303-305.

¹⁰ Same as 9

¹¹ Potrykus, I. The reality of Golden Rice, Dec 19, 2000. AgBioView Home Page: <http://agbioview.listbot.com> - Archive: Message #932.

¹² Joint FAO/WHO Expert Consultation on Human Vitamin and Mineral Requirements, FAO, Bangkok, Thailand, September 21-30, 1998. Preliminary Report on Recommended Nutrient Intakes, Revised July 13, 2000. Also, Joint FAO/WHO Expert Consultation (1988) Requirements of vitamin A, iron, folate and vitamin B12. Food and Nutrition Series, no. 23, FAO, Rome.