Vitamins as Nutraceuticals

Recent Advances and Applications

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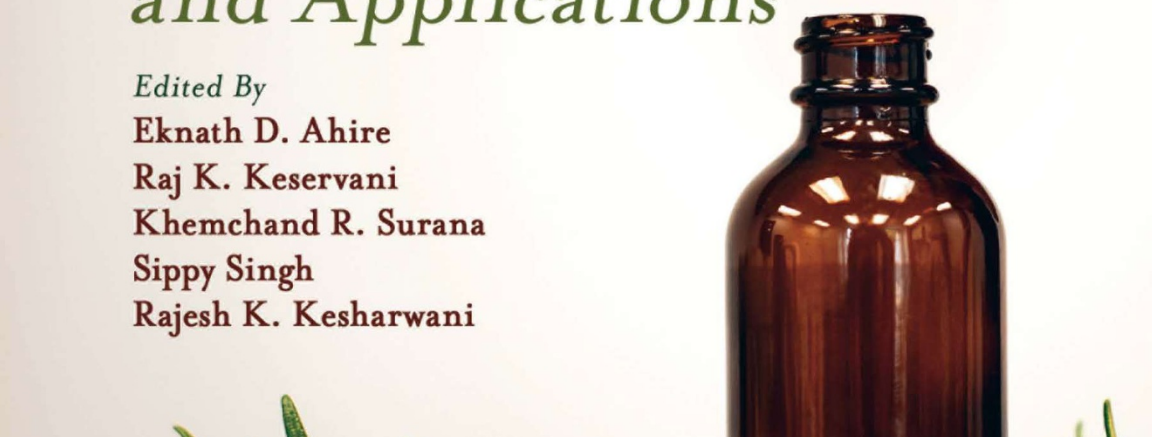

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Vitamins as Nutraceuticals

Scrivener Publishing
100 Cummings Center, Suite 541J
Beverly, MA 01915-6106

Publishers at Scrivener
Martin Scrivener (martin@scrivenerpublishing.com)
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This edition first published 2023 by John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, USA and Scrivener Publishing LLC, 100 Cummings Center, Suite 541J, Beverly, MA 01915, USA

For more information about Scrivener publications please visit www.scrivenerpublishing.com.

Wiley Global Headquarters
111 River Street, Hoboken, NJ 07030, USA

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Library of Congress Cataloging-in-Publication Data

ISBN 978-139-417470-6

Cover image: Pixabay.Com
Cover design by Russell Richardson

Set in size of 11pt and Minion Pro by Manila Typesetting Company, Makati, Philippines

Printed in the USA

10 9 8 7 6 5 4 3 2 1

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Preface

Since vitamins are widely predicted to be one of the most significant nutritional advancements over the next 25 years, the editors of this book have brought together renowned experts in the field to provide a single authoritative resource for the nutraceutical sector. This book begins by defining and classifying the field of vitamins, with a focus on legislative issues in both the United States and the European Union. The important work of vitamins as nutraceuticals in disease prevention is then summarized. Finally, a chapter on establishing vitamins as nutraceuticals is presented, which also discusses the recent advances and applications in the field.

In addition to discussing recent advances and applications, this book also includes scientific information on the importance of vitamins as nutraceuticals to human health, as well as the potential mechanisms of nutraceuticals in illness prevention, management, and control. It is being published at a time when there is a pressing need to address the rising number of cases of nutritional deficiency disorders and the high number of deaths caused by a lack of knowledge or a deviation from healthy eating habits. As such, it is intended to serve a constructive purpose as a replacement for unverifiable sources of information on the internet and within extremely outdated literature, which can be full of all kinds of promotional propaganda for profit while also leading people astray. The general population must understand what they should eat and why they should take certain nutritional supplements. This book furthers this goal by balancing the evidence in terms of the health-promoting benefits and associated hazards of vitamins as nutraceuticals. A summary of the main ideas and supporting details of the work presented in each of the 12 chapters follows:

–In Chapter 1, Introduction to Nutraceutical Vitamins, Khemchand R. Surana and his coworker present an overview of several bioactive compounds (vitamins) that operate as nutraceuticals. In addition to reviewing their health benefits, nutraceutical applications for the prevention of several diseases are also discussed.

- In Chapter 2, Structure and Functions of Vitamins, Khemchand R. Surana and his colleagues provide an extensive overview of the current evidence on the health implications of food vitamins and also include the effects of emerging technologies on vitamins.
- In Chapter 3, Vitamin Intervention in Cardiac Health, Eknath D. Ahire *et al.* analyze the pertinent research on the role of various vitamins in cardiovascular disease, taking into account both their deficiencies and their supplementation, as well as looking at a few related concerns.
- In Chapter 4, Impact of Vitamins on Immunity, Khemchand R. Surana *et al.* focus on the function of nutrients in immunity and immune-associated diseases. They present the findings of a scientific practitioner and a team of researchers, who observed the ways in which multivitamins and some micronutrients can assist in enhancing the immune system.
- In Chapter 5, Nutraceuticals Potential of Fat-Soluble Vitamins, Ashwini Mahajan *et al.* focus on fat-soluble vitamins and their potential use as nutraceuticals.
- In Chapter 6, Marine-Derived Sources of Nutritional Vitamins, Jayesh D. Kadam and his associates provide an overview of a number of recently studied beneficial compounds of marine origin that show great potential as nutraceuticals or for use in the food industry.
- In Chapter 7, Nutraceutical Properties of Seaweed Vitamins, Afsar Pathan and his coworker discuss the use of seaweeds as potential sources of seaweed-based vitamin-containing products and their potential therapeutic role in them.
- In Chapter 8, Vitamins as Nutraceuticals for Pregnancy, Tushar N. Lokhande and his colleagues discuss how vitamins aid in the development of the fetal immune system. Various herbal remedies as a source of vitamins during pregnancy are also discussed.
- In Chapter 9, Role of Vitamins in Metabolic Diseases, Eknath D. Ahire and his associates present the way in which vitamins can help avoid metabolic diseases like diabetes, obesity, cardiovascular disease, stroke, renal disease, cancer, and others, as well as how they can cause metabolic disease in some situations.
- In Chapter 10, Beneficial Effects of Water-Soluble Vitamins on Nutrition and Health Promotion, Pankaj G. Jain *et al.* discuss how vitamin deficiency causes the suffering brought on by many harsh diseases. In order to overcome this, dietary supplements are provided to maintain the proper amount of vitamins in the body for overall better body performance.
- In Chapter 11, Vitamins as Nutraceuticals for Anemia, Snehal Dilip Pawar and coworker discuss how vegetables like cabbage and cauliflower, and oil and fat like sunflower oil and soyabean oil, are rich in vitamins C and E

and various sources of folate and riboflavin that help in the prevention of anemia.

–In Chapter 12, Vitamins as Nutraceuticals for Oral Health, Snehal Dilip Pawar and his colleagues discuss the different types of vitamins which help in the prevention of oral diseases to improve oral health.

In closing, we wish to express our sincere gratitude for the outstanding efforts of the chapter contributors for their perseverance and collaboration throughout the editing process. Their dedication and hard work have greatly aided in the development of this book. Our families also deserve special recognition for their support and patience throughout the process of producing this book.

The Editors
February 2023

1

Introduction to Nutraceutical Vitamins

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Abstract

Vitamins are low-molecular weight organic compounds that are required for life activity in trace amounts for essential metabolic reactions, with deficiency causing specific disease symptoms. Vitamins do not include other essential nutrients, such as dietary minerals, essential fatty acids, or essential amino acids, nor do they include the large number of other nutrients that promote health but do not provide cellular structural material and energy. Plants and microbes provided vitamins to animals. Vitamins are divided into two categories: fat-soluble (A, D, and E) and water-soluble (B, C, and P). Natural diets, herbal items, biofortified crops, genetically modified, and processed food products are all examples of nutraceuticals. Beyond basic diet, nutraceuticals improve health, alter immunity, and/or prevent and cure certain diseases. An overview of several bioactive compounds (vitamins) that operate as nutraceuticals has been reviewed in this chapter, as well as their involvement in health benefits. Nutraceutical applications in the prevention of several diseases have also been discussed.

***Keywords*:** Nutraceuticals, vitamins, nutrition, dietary requirements, food

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Eknath D. Ahire, Raj K. Keservani, Khemchand R. Surana, Sippy Singh and Rajesh K. Kesharwani (eds.) Vitamins as Nutraceuticals: Recent Advances and Applications, (1–34) © 2023 Scrivener Publishing LLC

1.1 Introduction

Vitamins were discovered as a result of research into nutrition and their significance in the vital activities of living organisms. N. I. Lunin, a Russian physician, was the first to show in 1880 that, in addition to the recognized basic components (proteins, lipids, carbohydrates, water, and minerals), some other accessory ingredients were required for the organism's appropriate growth and maintenance [1]. While researching the causes of Beriberi in 1905, the English physician W. Fletcher noticed that eating unpolished rice instead of polished rice prevented Beriberi, and he hypothesized the existence of some specific nutrients in the rice husk. C. Funk, a Polish biochemist, coined the term "vitamin" in 1912, combining the Latin words "vita" for life and "amine" for chemicals found in the thiamine he extracted from rice bran [2]. Vitamin was eventually abbreviated to vitamin. Vitamins are chemical substances with a low molecular weight that are required in trace amounts for critical metabolic activities in the body and whose absence results in certain illness symptoms. Additional necessary nutrients, such as dietary minerals, essential fatty acids, and essential amino acids, as well as the enormous number of other nutrients that support health, are not included in the term vitamin. Vitamins, unlike other organic nutrients that give cellular structure material and energy, either engage in coenzyme formation or operate as biochemical process regulators [3]. A vitamin deficiency causes organism-specific symptoms that may or may not be alleviated by other vitamins. Plants and microbes provided vitamins to the animal world. Vitaminoids include flavonoids, inositol, carnitine, choline, lipoic acid, and essential fatty acids, which have "vitamin-like" function and are believed by some to be vitamins or to partially replace vitamins [4]. There is minimal evidence that any of these are dietary essentials, with the exception of essential fatty acids. With the exception of vitamin B6 and B12, they are easily eliminated in urine and do not store well, necessitating frequent ingestion. They are generally safe when consumed in excess of requirements, though megadoses of niacin, vitamin C, or pyridoxine may cause symptoms (B6). All of the B vitamins work as coenzymes or cofactors, helping essential enzymes in their activity and allowing energy-producing reactions to complete smoothly. Overcooking can easily destroy water-soluble vitamins. Vitamin K and several B complex vitamins are generated by bacteria in the small intestine in the human body; vitamin D is synthesized by the skin when exposed to sunshine [5].

Ascorbic acid is a vitamin for humans and guinea pigs since it is not formed in their tissues, but it is not a vitamin for rats, rabbits, or dogs because it is synthesized in their cells. Vitamins are obtained from food and gut microorganisms in humans [6].

Chronic or long-term vitamin insufficiency causes avitaminosis (beriberi, scurvy, rickets, and pellagra). Hypovitaminosis is a term used to describe a variety of disorders caused by a lack of one or more vitamins. Antivitamins are substances either degrade or inhibit a vitamin's metabolic function. Vitamin disintegrating enzymes (thiaminase and ascorbase), nonactive complexes with vitamins (avidin), and physically identical to vitamins (sulphonamides) are examples of antivitamins. Hypervitaminosis, also known as vitamin intoxication, is a disorder caused by a continuous high intake of vitamins or vitamin supplements, which can cause nausea, diarrhea, and vomiting [7]. General symptoms of hypervitaminosis, or vitamin intoxication, include lack of appetite, gastrointestinal motor function problems, severe headaches, increased nervous system excitability, hair shedding, skin desquamation, and other indicators. Hypervitaminosis has the potential to be lethal. Hypervitaminosis can be caused by consuming too much fat-soluble vitamin-rich food (for example, the liver of a polar bear or whale, which is high in vitamin A), or by taking too many vitamin pills [8].

Nutraceuticals are also said to slow the aging process, enhance life expectancy, and maintain the body's structure and function. Herbal nutraceuticals help to sustain health by fighting nutritionally induced acute and chronic diseases, as well as promoting optimal health, lifespan, and quality of life. Because of their supposed safety and possible nutritional and therapeutic advantages, nutraceuticals have sparked a lot of attention. Nutraceuticals are divided into two categories: functional foods and dietary supplements. Supplementation and the use of formulated or fortified foods can help people enhance their health [9]. Vitamin B–enriched flour helps to prevent pellagra, vitamin D-enriched milk helps to prevent rickets, and iodine-fortified salt helps to prevent goiter. Commercial nutraceuticals must pass stringent regulatory tests to ensure their quality and beneficial health effects. Functional foods are processed foods that contain nutritious elements that assist healthy body functioning and were initially developed in Japan. Beyond the fundamental nutritional content, a functional meal with novel components provides an additional function or greater benefit to human health. Medical foods and prescription medications are not the same as functional foods [10, 11].

1.1.1 Multivitamins

Multivitamins are lipid-soluble vitamins (A, D, E, and K) as well as water-soluble vitamins (thiamin (B1), riboflavin (B2), B6, B12, C, folic acid, niacin, pantothenic acid, and biotin). They are available over-the-counter (OTC) and as self-prescribed diet/nutritional supplements. Minerals such as calcium, phosphorus, iron, iodine, magnesium, manganese, copper, and zinc may be found in multivitamins [12, 13].

1.1.2 Classification of Vitamins

Vitamins are divided into two classes based on their physicochemical properties: fat-soluble vitamins and water-soluble vitamins. A letter of the Latin alphabet, as well as a chemical or physiologic name, is allocated to each vitamin in each category. Fat-soluble vitamins are absorbed and stored in bodily tissues via fat globules (chylomicrons). Excessive fat-soluble vitamin consumption can result in excessive buildup and hypervitaminosis [14, 15].

1.2 Fat-Soluble Vitamins A, D, E, F, and K

1.2.1 Vitamin A

All foods of animal origin provide vitamin A to humans. Vitamin A is abundant in fish liver particularly that of cod and banded sea perch. Pork and beef liver, egg yolk, sour cream, and whole milk are high in vitamin A. Carotenoids, which are provitamins A, are found in vegetables, such as asparagus, beet, celery, carrots, cabbage, dandelion, lettuce, endive, orange, turnip leaf, tomato, prune, parsley, spinach, and watercress. As a result, if the conversion of alimentary carotenoids to vitamin A is not impeded, vegetables give a partial supply of vitamin A to the human organism. The adult human's daily vitamin A requirement is 1.5 mg [16–18].

Chemical nature and biologically active forms

Retinol, retinal, and retinoic acid are diterpenoid alcohols (unsaturated monobasic alcohols), as are other provitamin A carotenoids such as a- and b-carotenes, b-cryptoxanthin, and others. Retinol and its derivatives are referred to as retinoids together. A typical synthetic vitamin A supplement is retinyl palmitate (vitamin A palmitate), which is an ester of retinol (vitamin A) and palmitic acid. Retinol, often known as vitamin A, is a chemical isoprenoid generated mostly from b-carotene, which has a b-ionone ring and a side chain of two isoprene residues with a main carbinol group at the end [19]. There are at least six vitamer (vitamin with similar molecular structure) substances that qualify as "vitamin A," but each has slightly different qualities (e.g., retinol, retinal, and four carotenoids: a, b, c, and d carotenes; and b-cryptoxanthin). A vitamin's vitamer is any of several chemical molecules with comparable molecular structure and physiological activity. Plant-based foods have four vitamers (three carotenes and one xanthophyll), while animal-based foods contain retinol (alcohol) and retinal (aldehyde) forms (e.g., fish). Retinoids (retinol, retinal, retinoic acid, isotretinoin, alitretinoin, and others) are vitamin A pharmaceuticals [20]. Retinol (vitamin A alcohol) is transformed to retinal (vitamin A aldehyde) and retinoic acid in the human body (vitamin A acid). Vitamin A ester derivatives such as retinyl palmitate, retinyl acetate, and retinyl are generated in the tissues of the organism. A-, b-, and c-carotenes are three precursors or provitamins A that differ in chemical structure and biological function [21]. The most active is b-carotene, which is oxidized at the central double bond in the intestinal mucosa with the help of the enzyme carotene dihydroxygenase. Two active retinal molecules are generated. The breakdown of a- and c-carotenes, which each include only one b-ionone ring, unlike b-carotene, results in only one vitamin A molecule in both cases. Only one molecule of vitamin A is present in b-cryptoxanthin (retinol). As a result, both a- and c-carotenes, as well as b-cryptoxanthin, have lower activity than b-carotene. Retinol, retinal, retinoic acid, and their esterified counterparts are all biologically active forms of vitamin A [22, 23].

Biochemical functions

Retinoids (retinol, retinoic acid, and their derivatives) are pharmaceutical forms of vitamin A that play a variety of roles in the body, including vision, cell proliferation and differentiation in developing organisms (embryos, juvenile organisms), differentiation of rapidly proliferating tissues like cartilage and bone tissue, spermatogenic epithelium and placenta, skin epithelium, and mucosae, immune function, and immune cell activation [24, 25].

Deficiency

The dark adaption condition and night blindness are the first signs of vitamin A insufficiency. Juvenile growth retardation, follicular hyperkeratosis (excessive keratinization of the skin caused by delayed epithelial renewal), mucosal dryness (also caused by delayed epithelial renewal), xerophthalmia (dryness of the conjunctiva and cornea), keratomalacia (opacification and softening of the cornea), and disordered reproductive function (failure of the spermatozoa [26, 27].

Uses

Natural vitamin A (which has a combination of biological forms) and its synthetic analogs (retinol acetate and retinol palmitate) are utilized in medicine. They are used to treat hypovitaminosis in people whose jobs demand them to be in front of a computer all day, as well as to stimulate growth and development in youngsters. Vitamin A formulations are also utilized as regeneration stimulants for treating poorly healable tissues, boosting infection resistance, and treating sterility prophylactically [28, 29].

1.2.2 Vitamin D

Source

Vitamin D is mostly contained in animal-derived products including liver, butter, milk, yeast, and vegetable oils, but not in vegetables, fruits, or cereals. Vitamin D is very abundant in cod liver. The daily vitamin D requirement for children ranges from 12 to 25 lg; for adults, the daily requirement is 10 times lower [30, 31].

Chemical nature and biologically active forms

Vitamin D is made up of fat-soluble secosteroids (a form of steroid with a "broken" ring) generated from cholesterol, which are chemically related to steroids. Vitamin D3 (cholecalciferol) is an example of a 9,10-secosteroid. Calcitriol is one of several vitamin D vitamers. The most active D vitamins are D2 (ergocalciferol) and D2 (cholecalciferol) (cholecalciferol). Ergocalciferol (D2) is produced from the plant sterol (provitamin D). When UV light energy is absorbed by the precursor molecule 7-dehydrocholesterol, vitamin D3 (cholecalciferol) is produced in the skin of mammals (present in the skin of humans and animals). Dihydroergocalciferol is vitamin D4. UV irradiation produces the less active vitamers D4, D5, D6, and D7 from their respective plant precursor's dihydroergosterol, 7-dehydrositosterol, 7-dehydrostig-masterol, and 7-dehydrocampesterol. Neither ergo- nor cholecalciferols, on the other hand, are physiologically active and cannot perform regulatory activities. In the course of metabolism, they produce physiologically active molecules that behave like steroid hormones [32, 33].

Biochemical functions

The biological activity of 1,25-dihydroxycalciferols is 10 times greater than parent calciferols. Vitamin D is important for calcium metabolism and equilibrium. Vitamin D regulates the transit of calcium and phosphate ions across cell membranes and hence works as a calcium and phosphate ion regulator in the circulation. At least three vitamin D-related processes are included in this control: absorption of calcium and phosphate ions via the epithelium of the small intestine mucosa, mobilization of calcium from bone tissue, and reabsorption of calcium and phosphate in kidney tubules [34, 35].

The mechanism of action of vitamin D

Calcium is absorbed in the small intestine through facilitated diffusion, which is aided by a specific calcium-binding protein (CaBP), and active transport, which is aided by Ca^{2+} ATPase. By operating on the genetic cellular machinery of the small intestine mucosa, 1, 25-dihydroxycalciferols trigger the synthesis of CaBP and protein components of Ca^{2+} ATPase. Vitamin D-induced activation of Ca^{+} ATPase, which is found in the membranes of renal tubules, appears to result in calcium ion reabsorption in the tubules. However, the mechanisms of vitamin D's role in phosphate transmembrane transfer in the colon and kidneys, as well as calcium mobilization from bone tissue, are yet unknown. The impact of vitamin D is reflected in increased calcium and phosphate concentrations in the blood [36].

Deficiency

When vitamin D deficiency occurs in youngsters, it causes osteomalacia, often known as rickets, which is a softening of the bones. This condition is caused by a vitamin D deficient diet combined with insufficient UV irradiation (for the generation of endogenous vitamin D). A lower calciferol-responsive tissue sensitivity (presumably due to the lack of calciferol-binding receptors) could potentially be the cause. All vitamin D–controlled processes, such as the intestinal uptake of calcium ions and phosphate (even if the infant's dietary supply of these nutrients from dairy products is adequate) and their reabsorption in the kidneys, are hindered in rickets. The level of calcium and phosphorous in the blood is dropped as a result, and bone mineralization is inhibited, meaning no mineral materials are deposited on the newly produced collagen matrix of growing bones. As a result, distortion of skeletal bones of the limbs, skull, and thorax is seen in children with rickets. When the supply of vitamin D to the body is normal, a relative shortage might emerge. This could be triggered by a damaged liver or kidney, as these organs are important in the generation of active vitamin D forms [37, 38].

Uses

Natural vitamin D preparations (cod liver oil) and synthetic vitamin D preparations (ergocalciferol or cholecalciferol) are utilized in medical practice. Vitamin D preparations are employed in the prevention and treatment of rickets, as well as the treatment of other diseases (tuberculosis of the bones and joints and tuberculosis of the skin) [39].

1.2.3 Vitamin E

Sources

Wheat germ, celery, lettuce or other green leafy vegetables, parsley, spinach, turnip leaf, watercress, and vegetable oils, particularly sunflower oil, corn oil, cottonseed oil, and olive oil, are all good sources of tocopherol for humans. Wheat seedling oil has a lot of tocopherol. Tocopherol is scarce in animal-derived products, particularly dairy products. The recommended daily intake of tocopherol for adults is 20 to 50 mg [40].

Chemical nature and biologically active forms

Vitamin E is a methylated derivative chemical that comes in eight distinct forms, four of tocopherol and four of tocotrienol. The quantity and position of methyl groups on the chromanol ring dictate the a (alpha), b (beta), c (gamma), and d (delta) forms of tocopherols and tocotrienols. Tocopherols and tocotrienols are structurally similar, with the same methyl structure at the ring, the same Greek letter—methyl—notation, and an isoprenoid side chain; tocopherols have saturated isoprenoid side chains, whereas tocotrienols have unsaturated hydrophobic isoprenoid side chains with three double bonds (farnesyl isoprenoid tails) [41, 42].

Biochemical functions

Tocopherol is a biological antioxidant that controls the rate of free radical reactions in living cells by inhibiting spontaneous chain reactions of peroxide oxidation of unsaturated lipids in biomembranes. Tocopherol is a biological antioxidant that provides for the stability of cell biomembranes in the organism. Since selenium acts as a cofactor for glutathione peroxidase, which inactivates lipid hydroperoxides, a close link between tocopherol and selenium in lipid peroxide oxidation regulation has been shown. Vitamin A's biological activity is increased by tocopherol, which protects the vitamin's unsaturated side chain against peroxide oxidation. Tocopherol and its derivatives are likely engaged in other regulatory mechanisms that have yet to be found [43, 44].

Deficiency

Vitamin E hypovitaminosis in adults has never been documented. In experimental animals, tocopherol deficiency manifests as a specific membrane pathology: membrane resistance to peroxide attack is reduced, and increased permeability leads to the loss of intracellular components, such as proteins that are normally present; in premature infants, vitamin deficiency manifests as hemolytic anemia (due to a low stability of the erythrocyte membranes and their breakdown); in premature infants, tocopherol deficiency manifests as a specific membrane path. Susceptibility of erythrocytes to peroxide hemolysis; atrophy of the testes (conducive to male sterility); death of the embryo in pregnant females; muscular dystrophy and loss of intracellular nitrogenous components and muscle proteins; hepatic necrosis; and local encephalomalacia, especially cerebromalacia are all possible causes of tissue membrane pathology in E hypovitaminosis. Spinocerebellar ataxia, myopathies, peripheral neuropathy, ataxia, skeletal myopathy, retinopathy, and immune response impairment are all symptoms of vitamin E deficiency [45, 46].

Uses

Synthetic D,L-a-tocopherol acetate in vegetable oil and concentrated oil extracts of tocopherol combinations from wheat seedlings are commercially available. Tocopherolic preparations are used as antioxidants to prevent excessive lipid peroxide accumulation; they are also used in the prophylaxis (preventive measures) of sterility and impending abortion, liver diseases, muscular atrophy, and the treatment of congenital erythrocyte membrane disturbances in neonates and premature infants, among other things [47].

1.2.4 Vitamin F

Source

Vitamin F is made up of essential fatty acids (EFAs), particularly omega-3 and omega-6 fatty acids, which can only be obtained through food. Fish, canola oil, and walnut oil; raw nuts, seeds, legumes, grape seed oil, and flaxseed oil; and hemp seed, olive oil, soy oil, canola (rapeseed) oil, chia seeds, pumpkin seeds, sunflower seeds, leafy vegetables, walnuts, avocados, all kinds of sprouts; and meat, shellfish, salmon, trout, mackerel, and tuna. Vitamin F may be abundant in vegetable oils. The daily need for vitamin F in adult people is 5 to 10 g [48].

Chemical nature and biologically active

Vitamin F is a fat-soluble vitamin that contains unsaturated fatty acids, which are found in liquid vegetable oils, and saturated fatty acids, which are present in animal fat. Vitamin F is the sum of unsaturated fatty acids that cannot be produced in the tissues but are required for the organism's regular function. Only a-linoleic acid (an omega-3 fatty acid) and linoleic acid (LA) are recognized to be needed for humans (an omega-6 fatty acid). C-linoleic acid is another omega-6 fatty acid. They are polyunsaturated fatty acids (PUFA), with a-linolenic acid (ALA) having an 18-carbon chain with three cis double bonds and linoleic acid (LA) having an 18-carbon chain with two cis double bonds [49, 50].

Biochemical functions

Vitamin F is required for the formation of prostaglandins, which regulate metabolism. Vitamin F helps the tissue metabolism by preserving vitamin A reserves and facilitating vitamin A action. Vitamin F aids in the digestion of phosphorus and stimulates the conversion of carotene to vitamin A in the body, working in combination with vitamin D to make calcium available to the tissues. It is necessary for the correct functioning of the reproductive system, as well as the nutrition of skin cells and the health of mucous membranes and nerves. Vitamin F helps to minimize the risk of heart disease by lowering cholesterol levels in the blood [51, 52].

Deficiency

Unambiguous deficient symptoms have not been described in people. F hypovitaminosis is often associated with follicular hyperkeratosis, or excessive keratinization of the skin epithelium around the hair follicles. These symptoms are similar to those of vitamin A insufficiency. Vitamin F deficiency in animals can cause sterility [53].

Uses

Arachidonic acid is clearly an important fatty acid, and it is the only one that can cure all deficient symptoms. The essential fatty acid formulations xxlinetol and linol have clinical applications, primarily in the prophylaxis (preventive measures) of cholesterol deposition in arterial walls under atherosclerosis; they are also useful in the local treatment of skin problems [54].

1.2.5 Vitamin K

Source

Phylloquinomes (K1) and their derivatives are found in plants (e.g., cabbage, spinach, as well as root crops and fruits) and animal (liver) products, and are fed to the organism, whereas menaquinones (K2) are produced by the small intestinal bacterioflora or derived from naphthoquinone metabolism in the organism's tissues. The daily vitamin K requirement for adults is approximately 2 mg [55].

Chemical nature and biologically active

Vitamin K is a quinone with an isoprenoid side chain that refers to a series of substances that are 2-methyl-1, 4-naphthoquinone derivatives chemically. The "quinone" ring is shared by all K vitamins, although the length, degree of saturation, and number of side chains vary. Two naphthoquinone series, phylloquinones (K1-series) and menaquinones, are found in this fat-soluble vitamin (K2-series). Menaquinones (MQ or MK-n) are a group of related compounds that are separated into short chain (e.g., MK-4) and long chain (e.g., MK-7, MK-8, and MK-9 with 7, 8, and 9 isoprene units, respectively) menaquinones based on the length of the isoprenoid chain. Vitamin K synthetic preparations (menadione, vicasol, and synkayvite) are 2-methyl-l, 4-naphthoquinone derivatives. They are transformed into physiologically active menaquinones in the body. Menadione is a vitamin K analog with a methyl group in the second position that is occasionally used as a nutritional supplement or as a provitamin since it is metabolized by the human body into K2 [56, 57].

Biochemical functions

Vitamin K regulates blood clotting in the body by assisting in the formation of many blood clotting system components, including factor II (prothrombin), factor VII (proconvertin), factor IX (Christmas factor), and factor X. (Stewart factor). Vitamin K is required for the conversion of preprothrombin, a prothrombin precursor, to prothrombin. The liver is involved in this process. Vitamin K activates the microsomal carboxylase, which promotes the c-carboxylation of glutamic acid residues in prothrombin molecules. Prothrombin is generated and then attached to phospholipids by Ca^{2+} ions before being cleaved by enzymes to produce thrombin. The latter causes a fibrin clot to form in the blood coagulation system [58, 59].

Deficiency

A specific tendency to hemorrhagic illness, especially in traumas, is an indication of vitamin K deficiency. In adult humans, the gut flora provides the organism with a complete supply of vitamin K. K hypovitaminosis in babies (with a still-developing gut flora) could be caused by a vitamin K deficiency in the diet. Drugs that restrict the gut flora, as well as liver and gallbladder illnesses that result in decreased bile acid synthesis, are major causes of K hypovitaminosis (which are needed for the vitamin uptake). Furthermore, the liver produces active forms of vitamin K and is involved in the creation of a number of blood coagulation components as well as the conversion of preprothrombin to thrombin [60].

Uses

Vitamin K1 preparations or its synthetic counterpart vicasol are utilized in medical practice. They can be used to treat hemorrhagic illness or hemophilic hemorrhage. Human hepatocellular carcinoma, a frequent and deadly form of liver cancer, has been found to be safely suppressed by vitamin K2 (menaquinone). It has a number of impacts on these tumours, reducing the ability of growth factors and their receptor molecules to induce tumour development and progression. It stops the cell cycle from continuing, preventing further replication. It also causes apoptosis, or programmed cell death, through numerous unique ways. Three synergistic anticancer mechanisms of vitamin K have recently been discovered. DNA-building enzymes are inhibited by vitamin K3. Vitamins K2 and K3 stop new blood vessels from forming, which is necessary for tumour tissue to grow quickly. Vitamin K3 also affects microtubule-based intracellular communication networks, preventing cells from growing in a coordinated manner [61, 62].

1.2.6 Water-Soluble Vitamins B1, B2, B3, B7, B9, B12 (B Complex), and C

Vitamin B1 (thiamin), vitamin B2 (riboflavin), vitamin B3 (niacin), vitamin B5 (pantothenic acid), vitamin B6 (pyridoxine), vitamin B7 (biotin), vitamin B9 (folic acid), vitamin B12 (cobalamin), and vitamin C (ascorbic acid) are examples of water-soluble vitamins. A vitamin B complex is made up of all eight vitamins in the B group (B1, B2, B3, B5, B6, B7, B9, and B12). They are structurally diverse, and each B vitamin is either a cofactor (usually a coenzyme for critical metabolic activities) or a precursor for the production of one. Vitamin C is a cofactor in many enzymatic reactions and can help protect against oxidative stress by acting as an antioxidant