

Oral Health and Vitamins: Exploring Nutritional Strategies for Disease Prevention and Healing

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Abstract

Oral health is influenced by various factors, including nutrition and diet. Oral disease is a relevant public health issue, which is considered a common disease in many individuals. In this respect, vitamins may play an important role in the development and healing of oral diseases while promoting dental and oral health. Additionally, they serve as antioxidants, electron donors, or transcription effectors. They can be derived from food and supplements, or in rare situations, our bodies or gut bacteria can produce them on their own. It has been recommended that certain pathological conditions, such as obesity, cancer, and cardiovascular disease, can be prevented and treated with vitamins. Therefore, an approach to determine how various vitamin forms could enhance dental and oral health is required to advance knowledge of the possible advantages and disadvantages of using vitamin supplements.

Keywords: Carrier, Food, Oral Health, Supplement, Vitamins.

Introduction

Oral homeostasis refers to the harmonious and balanced state that exists between the oral microbiota, or the bacteria that exist in the mouth, and the host. Maintaining dental health and avoiding conditions like periodontitis, caries, and oral infections require maintaining oral homeostasis. Because certain mouth bacteria and infections can release toxins that damage other organs or cross the blood-brain barrier to cause neurological diseases, oral homeostasis is also associated with systemic health [1,2]. Oral homeostasis is affected by various factors, such as saliva, food, hygiene, stress, heredity, and environmental factors.

Saliva is a valuable resource that helps keep the pH balance and shield the mouth mucosa from infections. Diet provides both nutrients and energy for the composition and function of the oral microbiota. Maintaining good hygiene aids in cleaning the teeth and gums of food particles and plaque. Stress has the potential to modify the immune system and exacerbate oral inflammation. Genetics can influence an individual's susceptibility to specific oral disorders or predispose them to specific oral bacteria. Oral homeostasis can be upset by many microorganisms or substances that are exposed to the mouth due to environmental factors [3,4].

Vitamins are essential nutrients that play important roles in maintaining oral homeostasis, which is the state of balance and harmony between the host and the oral microbiota. Oral homeostasis is important for preventing oral diseases and maintaining good oral health. Vitamins can be considered as organic substances that the body needs to take in small amounts to perform specific biological functions that are necessary for the regular maintenance of the organism's growth and health [5]. They are necessary for maintaining the regular structure and functions of cells and cannot be created within the body. They may originate from plants or animals and are not crucial to the energy production

process [6]. Vitamins are key food components that are necessary for proper ingestion of other food components including proteins, lipids, and carbohydrates. They also function as transcription effectors, antioxidants, and electron donors. There are unquestionably many factors that contribute to the development of periodontal and oral disease, but among the risk factors, nutrition is commonly disregarded. In reality, dietary factors, especially vitamins, play a significant role in determining the balance between those risk factors and the host response, which ultimately decides the onset and progression of oral and dental disorders [7] (**Figure 1**).

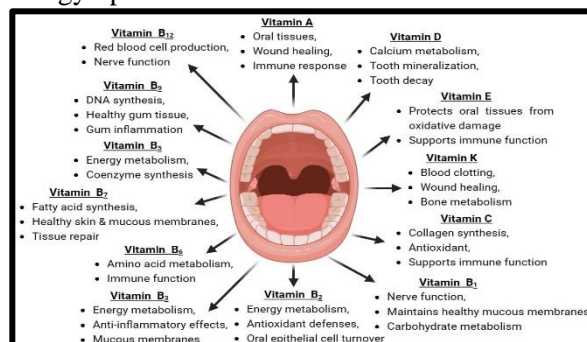


Figure 1. Classification of Vitamins and its Function

In general, vitamins fall into one of two categories: (I) Fat-soluble vitamins, such as A, D, E, and K (II) Water-soluble Vitamins: These comprise B and C [6]. Most vitamins must be obtained from food since our bodies are unable to produce them. The process that defines a vitamin's "bioavailability" depends on the quality of the food and the amount of nutrients that can be absorbed and used. The effectiveness of gastrointestinal absorption and digestion, among other physiological variables, regulates or influences bioavailability. Bioavailability is also affected by the methods used for food preparation and the source of nutrients [8].

The maintenance of oral and dental health is becoming more difficult since dental illnesses are usually regarded as a prevalent pathology in the population. They are influenced by a wide range of risk factors, including heredity,

systemic disorders, stress, smoking, alcohol, and hormone modification status. Dietary approaches to dental and oral health have mainly focused on reducing the intake of "undesirable" foods such as refined sugars. However, there is now a greater focus on promoting the intake of "healthy and curative food." The idea that a "nutrient as a medicament" has encouraged a growing number of research into novel compounds that fall under the category of dietary supplements to improve oral and dental health in humans. Vitamins have been discussed in dental caries, one of the most common oral diseases. There are theories as to how vitamins may affect caries, and these theories should be taken into consideration. A higher risk of caries may be linked to inadequate dietary intake of certain nutrients, including riboflavin, vitamin D, and vitamin B₁₂. There is relatively not much study

in the literature on the efficacy of various vitamins in preventing or treating them. It is important to do a review to highlight the findings that are available as evidence [6].

History and Nomenclature

Hopkins came up with the phrase "accessory factors" to refer to the unidentified but crucial elements found in whole diets. Funk discovered in 1913 that an amine, an active ingredient, could treat pigeon beri-beri by isolating it from rice polishings and then from yeast. He gave ancillary factors the Greek title "vita," which means "life." Later on, the last letter "e" is dropped from the term "vitamin." McCollum and Davis popularized the usage of vitamins A, B, and C in 1915.

The nomenclature is as follows,

- Fat-soluble vitamin A – prevents night blindness

- Vitamin B - Anti beriberi factor; vit B was found to be a complex mixture and nomenclature also became complex
- Vitamin C – anti - scurvy factor (ascorbic acid)
- Vitamin D – anti-cricket factor
- Vitamin E – fat-soluble factor
- Vitamin K – fat-soluble vitamin concerned with coagulation

Classification

All fifteen vitamins are essential for humans. They can be classified into two categories: fat-soluble and water-soluble vitamins. Vitamin K, a fat-soluble vitamin, acts as a coenzyme, while most water-soluble vitamins perform their functions with the assistance of coenzymes (**Figure 2**).

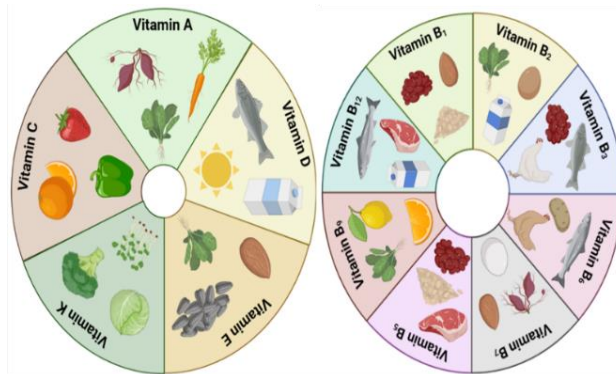


Figure 2. Major Sources of Vitamins

Synthesis of Vitamins by Intestinal Bacteria

- Vitamins are not synthesized in the body
- They are synthesized by bacteria in the colon
- Normal intestinal bacterial synthesis and absorption of vitamin K and biotin may be sufficient to meet the body's requirements

Fat Soluble Vitamins

Vitamin A

This vitamin is soluble in fat. Only present in foods originating from animals. The three forms of vitamin A are retinoic acid, retinol, and retinal. β carotene, or pro-vitamin A, is present in plant-based diets. One beta-carotene molecule can be converted into two vitamin A molecules.

Absorption, Transport and Mobilization

In the gut, dietary retinyl esters hydrolyze, releasing free fatty acids and retinol. Additionally, beta carotene hydrolyzes in the

gut to produce two moles of retinal, which is then converted to retinol. Chylomicrons contain retinol, which is then transported to lymph. The liver then absorbs them and stores them. The liver releases vitamin A in the form of free retinol as needed. Zinc is crucial for the mobilization of retinol. Plasma retinol-binding protein RBP, in conjunction with pre-albumin, is responsible for the circulation of retinol. After attaching to particular cell membrane receptors, it enters the cell and attaches itself to the DNA chromatin.

Biochemical Function and Role

Vitamin A deficiency extends the duration of the dark adaptation phase of the rhodopsin cycle (Wald's visual cycle). Retinoic acid and retinol, functioning as steroid hormones, play a vital role in cell growth, differentiation, and protein synthesis. They inhibit the production of keratin, which helps to keep the epithelial tissue healthy. Additionally, they are necessary for the synthesis of glycoproteins and mucopolysaccharides, which are important for growth and the secretion of mucus. Retinol has a crucial role in reproduction, gene expression, immunological function, and cholesterol synthesis. Carotenoids such as β carotene, which possess antioxidant properties, reduce the risk of cancer and heart attacks by combating oxidants and free radicals.

Recommended Dietary Allowance (RDA) and Dietary Source of Vitamin A

RDA of Vitamin A

- Man – 1000 retinol equivalents (3500 International unit IU); 750 – 1000 mcg per day
- Woman – 800 retinol equivalents (2500 IU); 750 mcg per day
- One IU = 0.3mg of retinol
- In pregnant and lactating mother's requirement increases – 1000 mcg per day
- Infants – 350 mcg per day
- Children – 400 - 600 mcg per day

Dietary source

Perform Vitamin A

Animal sources contain preformed vitamin A

- Liver
- Kidney
- Egg yolk
- Milk
- Cheese
- Butter
- Fish (cod or shark liver oil)

Proform Vitamin A

- Yellow and dark green vegetables
- Fruits
- Carotene
- Carrot
- Spinach
- Pumpkins
- Mango
- Papaya

Deficiency Manifestations

Causes

- Decreased intake
- Obstructive jaundice causing defective absorption
- RBP excretion through the kidneys in the case of chronic nephrosis.

Features

Effect on Eyes

Nyctalopia, often known as night blindness, is the difficulty of seeing in the dark due to an increased dark adaptation time. Keratomalacia: When xerophthalmia lasts for a long period, the cornea becomes destroyed due to ulceration and degeneration. This condition is known as keratomalacia, and it completely blinds the patient. Xerophthalmia: This condition is characterised by keratinization of the epithelial cells and dryness of the cornea and conjunctiva. Bitot's spots, which are white triangular plaques with

a superficial keratin build-up, are observed in specific conjunctiva locations.

Effect on Growth

Causes problems with skeletal development, which slows growth. Impact on the process of reproduction. Degeneration of the germinal epithelium is the cause of male sterility.

Effect on Skin and Epithelial Cells

Skin gets dry and rough. Increased bacterial infection results from the keratinization of epithelial cells in the GIT, urinary tract, and respiratory tract. The epithelium develops atrophied and hyperkeratosis conditions cause urinary stones.

Hypervitaminosis A

Overall typical serum vitamin A's usual range of 20–50 µg/dl is exceeded. Excessive consumption leads to toxicity. Dermatitis symptoms include increased intracranial tension, liver enlargement, skeletal decalcification, long bone discomfort, weight loss, irritability, hair loss, joint problems, and so on.

Treatment

Vitamin deficiencies need to be treated right away. Depending on the symptoms of deficiency, for one month, a dose of 7,500–15,000 mcg is given daily. Massive oral doses of 2,00,000 IU or 110 mg given over two days can reverse the early stages of xerophthalmia. Nutrition should be restricted due to hypervitaminosis.

Role in Oral Health and Oral Manifestations

Vitamin A deficiency causes abnormal dentinal tube development, gingivitis, periodontitis, and xerostomia, while excess vitamin A can lead to angular cheilitis. This essential nutrient may treat submucous fibrosis of the mouth, oral leukoplakia, and acute promyelocytic leukaemia. A regular dietary

supply of vitamin A is necessary [9]. It is crucial for healing oral wounds, stimulating growth, and defending against measles. Additionally, vitamin A maintains the oral cavity lining, supports bone growth, and normal cell development, prevents keratinization of mucous-forming cells, allows cell differentiation, stimulates osteoclasts, and ensures normal tooth spacing. Teeth, made from protein matrix mineralized with collagen, calcium, and phosphorus, require vitamins A and D. Vitamin A also aids in synthesizing glycoproteins like mucin and plays a vital role in tooth structure deposition and calcification. Deficiency leads to enamel hypoplasia, delayed tooth eruption, postponed alveolar bone growth, and enhanced osteoblast function [10]. The gingival epithelium keratinizes, becoming hyperplastic, increasing susceptibility to periodontal disease. Salivary glands undergo typical keratinizing metaplasia. Vitamin A reduces oral leukoplakia and prevents its development by affecting epithelial cell differentiation [11]. Deficiencies result in enamel hypoplasia, gingivitis, periodontitis, hyperkeratotic white patches, xerostomia, and an increased risk of caries due to reduced mucin production [12,13]. Antioxidant properties of vitamin A can improve periodontal health and reverse premalignant lesions like leukoplakia, particularly in individuals consuming betel and quid-tobacco. High doses of lycopene (8 mg/day) also enhance oral health [14,15]. Low vitamin A levels significantly increase gum disease risk, linking low antioxidant levels to periodontal disease [16].

Vitamin D

It is a fat-soluble vitamin. It has a structure that is similar to sterols and behaves like a hormone. It was isolated by Angus who named it calciferol. Ergocalciferol (vitamin D₂) and cholecalciferol (vita, D₃) are sources of vitamin D activity and are referred to as pro vitamins. It is regarded as a sunshine vitamin.

Calcitriol is the active form of vitamin; it acts as a hormone. Vitamin D acts as antirachitic vitamin

Absorption, Transport and Storage

Bile plays a vital role in the absorption of vitamin D in the small intestine. Vitamin D travels throughout the body through lymph, where it attaches itself to plasma α_2 -globulin and enters the circulation. This depends upon the source of vitamin D. The intestinal mucosal cells in the duodenum and jejunum absorb vitamin D that is ingested into the gut and bundle it into lipoproteins known as chylomicrons. The CM carry vitamins to the liver or adipose for storage or eventual use of tissue. Vitamin D is produced in the skin as a result of exposure to sunlight and carries it to the liver called vitamin D binding protein (DBP), which carries it to the liver.

Biochemical Functions and Role

It regulates the blood's phosphate and calcium levels. Calcium levels in plasma (normal: 9–11 mg/dl) are stabilized by calcitriol in the kidney, bone, and intestine. The absorption of calcium and phosphate in the gut is enhanced by calcitriol. Calcium uptake for deposition as calcium phosphate is stimulated by calcitriol in bone osteoblasts. So, it is necessary for the development of bones. By improving reabsorption, calcitriol reduces the amount of calcium and phosphate excreted by the kidney. Calcitriol functions like a steroid hormone.

Recommended Dietary Allowance (RDA) and Dietary Source

RDA of vitamin D

- Daily requirement – 400 IU or 10mg of cholecalciferol
- In India – 200 IU or 5 mg cholecalciferol
- Children – 10 mcg (400 IU)/ day
- Adults – 5 to 10 mcg (200 IU)/day
- Pregnancy, lactation – 10 mcg/ day

- Senior citizens above the age of 60 – 600 IU/ day

Dietary source

- Provided to the body in three ways
- By also irradiating foods like yeast that contain precursors of vit D and fortification of foods (milk, butter etc)
- Exposure of skin to sunlight for synthesis of vit D
- Egg yolk
- Fatty fish
- Fish liver oils

Deficiency Manifestations

Causes

- Insufficient exposure to sunlight
- Vegetarians
- Chronic alcoholics
- Consumption of a diet lacking vitamin D
- Individuals with kidney and liver disease
- Fat malabsorption syndrome

Features

Rickets in Children

Characterised by inadequate mineralization resulting in skeletal deformities, supple and flexible bones postponement of tooth development. Frontal bones, knock-knee, bow legs, pigeon chest, and rickety rosary bossing.

Osteomalacia in Adults

Also known as adult rickets. Bones undergo demineralization. Diaphyses of both long and flat bones are affected. Softening of the bone increases its susceptibility to fractures. Blood levels of phosphate and calcium are extremely low. And also increased in serum alkaline phosphatase.

Hypervitaminosis D

The most toxic beginning at overdoses (10–100 times RDA)–1500 units daily. Toxic effects include the demineralization of bone (resorption), increased intestinal absorption of calcium, and increased amount of calcium in the plasma (hypercalcemia). Leads to weight loss, nausea, vomiting, renal calculi, and increased thirst.

Treatment

Dietary enrichment of vitamin D through milk consumption. For six to twelve weeks, the curative treatment includes 2000–4000 IU of calcium daily. Patients with Osteomalacia who have intestinal malabsorption disorders need higher dosages of calcium and vitamin D. And 40,000–1,000,000 IU of vitamin D and 15–20 gm of calcium lactate respectively.

Role in Oral Health and Oral Manifestations

Vitamin D plays a critical role in maintaining oral health by supporting the integrity of tooth structure and preventing conditions like gum disease and tooth decay. It facilitates the formation of tooth enamel, which is predominantly composed of calcium and phosphorus. Dentin, the layer beneath enamel, contains living cells that protect the tooth's blood supply and nerves. Vitamin D is essential for the immune factors released by dentin, crucial for protecting and repairing teeth from infections and decay when damaged. Insufficient vitamin D levels can compromise this defence system, impairing the teeth's ability to fend off decay and infections [17]. Teeth, as living tissues, require continuous care, and their health is closely intertwined with overall immune function and calcium balance, both of which are influenced by vitamin D. Issues like tooth decay and gum disease are prevalent among both children and the elderly. Gum disease, characterized by symptoms like bleeding gums, is a chronic

inflammatory condition that reflects broader systemic health concerns [18]. Vitamin D deficiency can exacerbate conditions like vitamin D-resistant rickets, which adversely affect teeth and supporting tissues. This deficiency can lead to structural abnormalities in dentin, allowing bacteria to penetrate deeper layers of the tooth, potentially leading to more serious dental issues [19]. Calcitriol, the active form of vitamin D, acts through the vitamin D receptor (VDR) to regulate various biological processes, including calcium absorption and immune system modulation. In dental health, vitamin D has been shown to influence periodontitis, with studies suggesting benefits from vitamin D and calcium supplements in managing non-surgical treatments. Vitamin D also plays a role in orthodontic therapy by improving bone remodelling around teeth, particularly in cases of vitamin D deficiency [17]. Overall, maintaining adequate levels of vitamin D is crucial not only for dental health but also for the optimal functioning of the musculoskeletal system. Its role in regulating bone metabolism and immune responses underscores its importance in preventing conditions that affect both teeth and supporting structures [20].

Vitamin E

In 1936, Evans and his associates isolated compounds of vitamin E and named as tocopherol; Greek tokos – childbirth, pheros – to bear, ol – alcohol (tocopherol is the generic name of vitamin E, which means ‘the alcohol which brings forth offspring’). It is an antioxidant. It is essential for normal reproduction – known as an anti-sterility vitamin. Alpha-tocopherol is the active form of vitamin E.

Absorption, Transport and Storage

Vitamin E is absorbed along with fat in the small intestine. It is stored in muscle, liver, and adipose tissue. The normal plasma level of tocopherol is less than 1 mg/dl.

Biochemical Functions and Role

It contains anti-oxidant properties. Membrane antioxidants are considered necessary for maintaining the integrity and structure of the cell's membrane. It stops PUFA in different tissues and membranes from peroxidizing. RBCs are shielded from haemolysis by vitamin E oxidising agents. Maintains the gonads' germinal epithelium and is connected to reproductive processes. Vitamin E is necessary for the skeletal muscle to store creatine levels appropriately. It delays the incidence of cataracts when combined with beta-carotene, vitamin C, and vitamin A.

Recommended Dietary Allowance (RDA) and Dietary Source

RDA of Vitamin E

- Increased intake of PUFA (polyunsaturated fatty acid) increases requirements
- Man, pregnant women – 10 mg (15 IU) of alpha-tocopherol
- Woman – 8 mg (12 IU)
- Lactation - 12 mg/ day
- Alpha-tocopherol in 1 mg is equivalent to 1.5 IU

Dietary Source

- Vegetable oils are amazing sources of vitamin E
- Oils from wheat germ, cotton seeds, peanuts, corn, and sunflowers.
- Meat
- Milk
- Butter
- Eggs

Deficiency Manifestations

Features

Associated with sterility, Degenerative changes in muscle, Megaloblastic anaemia, Changes in the central nervous system, Increased fragility of erythrocytes, Minor neurological symptoms

Toxicity of Vitamin E

It is the least toxic.

Role in Oral Health and Oral Manifestations

Nutrient deficiencies can lead to atrophic degenerative changes and enamel organ pigmentation loss. Vitamin E is crucial for stabilizing membrane structures by scavenging peroxy free radicals, thus preventing oxidative stress, which is particularly relevant in managing periodontal disorders [21]. It also reduces periodontal inflammation by influencing prostaglandin synthesis. High vitamin E diets improve wound healing and reduce gingival inflammation [22]. Its immune-supporting properties inhibit nitrosamine formation from nitrites in food, potentially preventing precancerous oral lesions [23]. Topical vitamin E effectively treats oral mucositis from cancer therapy [24]. While studies on vitamin E supplements for periodontal diseases and recurring, aphthous stomatitis suggest a role in managing oxidative stress, its direct therapeutic benefit is uncertain [25]. Vitamin E deficiency leads to various oral anomalies [26].

Vitamin K

It is a fat-soluble vitamin with a specific coenzyme function. Needed for coagulation and the synthesis of blood clotting factors. They are naphthoquinone derivatives.

Absorption, Transport and Storage

It is consumed or produced by gut microorganisms. Its absorption takes place along with fat (chylomicrons) and is dependent on bile salts. It is stored mainly in the liver and to a lesser extent in other tissues.

Biochemical Functions and Role

They are concerned with the blood clotting process. Certain blood clotting factors undergo post-translational alteration as a result. The clotting factors II (prothrombin), VII, IX (Christmas factor) and X are precursors in the liver. Vit K acts as a coenzyme for the

carboxylation of glutamic acid where it converts glutamate to γ – carboxyglutamate. Dicumarol – anticoagulant found in spoiled sweet clover and Warfarin – synthetic analogue inhibit vitamin K action and formation of γ – carboxyglutamate. Their role in clotting γ – carboxyglutamic acid residues of clotting factors are negatively charged and they combine with positively charged calcium ions to form a complex. The complex then binds to phospholipids on the membrane surface of platelets leading to increased conversion of prothrombin to thrombin.

Recommended Dietary Allowance (RDA) And Dietary Source

RDA Of Vitamin K

- Adult – 70 to 140 mcg/day
- Children - 35 to 75 mcg/ day

Dietary Source

- Egg yolk, meat, liver, cheese and dairy products and intestinal bacterial synthesis will meet daily requirements as long as absorption is normal.
- Cabbage, cauliflower, tomatoes, alfalfa, spinach and other green vegetables.

Deficiency Manifestations

Causes

Occurs in a condition of lipid malabsorption which causes the result of obstructive jaundice. The bacterial flora will be destroyed by prolonged antibiotic therapy and vitamin K insufficiency may result from gastrointestinal illnesses with diarrhoea.

Features

Leads to a lack of active prothrombin in the circulation. As a result, blood coagulation is adversely affected. Individuals bleed profusely even for minor injuries. Blood clotting time is increased and prothrombin time is increased.

Hypervitaminosis K

Administration of large doses produces hemolytic anaemia and jaundice, particularly in infants. The toxic effect is due to the increased breakdown of RBC.

Antagonists of Vitamin K

Compounds – heparin, and bishydroxy coumarin act as anticoagulants and are antagonists to vitamin K. Salicylates, and dicumarol are also antagonists to vitamin K. Dicumarol inhibits the synthesis of prothrombin.

Role in Oral Health and Oral Manifestations

If prothrombin levels are below 35%, bleeding may occur after brushing, and spontaneous gingival haemorrhages can happen if levels drop below 20%. Vitamin K deficiency rarely causes oral issues, except for bleeding during oral surgery or injury. This is important for patients on vitamin K antagonist medications; consulting their physician about stopping these medications before surgery may be necessary [27]. Vitamin K supports bone health by stimulating osteoblast genes, promoting differentiation, and activating bone mineralization proteins. It also helps prevent cavities by inhibiting enzymes that break down carbohydrates in microorganisms [28].

Water Soluble – Non-B Complex

Vitamin C

Vitamin C (ascorbic acid) is a water-soluble versatile vitamin. Antiscorbutic action is only present in L-ascorbic acid and dehydroascorbic acid. It is a strong reducing agent.

Absorption, Transport and Storage

It is rapidly absorbed from the intestine. The body does not keep much of this vitamin. It is excreted in urine.

Biochemical Functions and Role

Collagen Formation

Vitamin C plays the role of coenzyme in the hydroxylation of proline and lysine while procollagen is converted to collagen (post-translational modification). Hydroxyproline and hydroxylysine are essential for collagen cross-linking and the strength of the fibre. Vitamin C is important for the maintenance of normal connective tissue and the wound-healing process.

Bone Formation

Vitamin C is required for bone formation, Iron and haemoglobin metabolism. Ascorbic acid keeps iron in ferrous form, which improves iron absorption. Useful in the reconversion of methemoglobin to haemoglobin.

Tryptophan Metabolism

Essential in hydroxylation of tryptophan to hydroxyl tryptophan in the synthesis of serotonin. Vitamin C is helpful in tyrosine metabolism.

Folic Acid Metabolism

Vitamin C is required for the formation of tetrahydrofolate (FH₄) which is involved in the maturation of erythrocytes. Vitamin C is involved in peptide hormone synthesis and corticosteroid hormone synthesis. It is a strong antioxidant and reduces the risk of cancer, cataracts and coronary heart diseases. It is involved in immunological function. Therapeutic use – for treatment of ulcers, trauma and burns.

Recommended Dietary Allowance (RDA) And Dietary Source

RDA of Vitamin C

- Adult – 60 – 70 mg/ day
- Additional intakes of 20 – 40 %increase for women during pregnancy and lactation

Dietary Source

- Citrus fruits
- Gooseberry
- Guava
- Green vegetables (cabbage, spinach)
- Tomatoes,
- Potatoes,
- High content of vitamin C is found in the adrenal gland and gonads
- Milk is a poor source

Deficiency Manifestations

Features

Scurvy, commonly recognized as a deficiency in vitamin C, remains a significant nutritional concern with historical significance and contemporary health implications. Vitamin C is essential for overall health, acting as a potent antioxidant that protects cells from free radical damage. It also supports the maintenance and development of teeth, skin, cartilage, and bones. Factors such as low socioeconomic status, food insecurity, and limited access to nutrient-rich foods are often associated with inadequate vitamin C intake. Classic symptoms of vitamin C deficiency include gingival bleeding, corkscrew hairs, and perifollicular haemorrhages. Early identification and treatment are crucial for managing this rare but treatable condition [29].

Role in Oral Health and Oral Manifestations

There is scientific proof that indicates a clear relationship between vitamin C deficiency and periodontal disease. Lower plasma levels of vitamin C are associated with more severe periodontal issues such as gingival haemorrhage, despite adequate oral hygiene. Chewing gum that releases vitamin C has been proven to reduce the buildup of dental calculus in healthy individuals. Vitamin C supplements effectively improve periodontal health by reducing inflammation, thanks to their antioxidant properties and role in

collagen synthesis, crucial for wound healing. Severe vitamin C deficiency leads to scurvy, characterized by bleeding gums and increased tooth mobility due to impaired collagen in periodontal ligaments and dental tissues. Additionally, vitamin C helps reduce gum bleeding and inflammation in patients with gingivitis and periodontitis, including those with type 2 diabetes [30]. Vitamin C also inhibits *Streptococcus mutans*, a bacterium linked to tooth decay, underscoring its role in dental health [31].

Water Soluble Vitamins

B Complex Group of Vitamins

They are grouped because all of them function in the cells as coenzymes.

Vitamin B₁

Thiamine is an anti-beriberi or antineuritic vitamin. It is a water-soluble, energy-releasing vit. It has a specific coenzyme, thiamine pyrophosphate (TPP) - mostly associated with carbohydrate metabolism. Only natural compound with thiazole ring

Absorption, Transport and Storage

All living cells require the B-complex vitamins, yet all animal tissues—except nicotinic acid and choline—are unable to synthesize them. Therefore, ingestion of food, the byproducts of the intestinal flora, or a combination of both must occur for the B vitamins to be absorbed from the digestive system. The majority of B-complex vitamins are bonded in their natural state within the cells of plant or animal tissues. Because of this, the breakdown of these cellular structures is necessary for the release of the vitamin and subsequent absorption from the gut. With the probable exception of vitamin B12, the body does not store any significant amounts of the B complex vitamins, thus if consumption exceeds the need, the excess is eliminated in urine [18].

Biochemical Functions and Role

The energy-releasing processes in the carbohydrate are closely related to the coenzyme, TPP or carboxylase. TPP plays an important role in the transmission of nerve impulses. Acetylcholine production and ion translocation in neural tissue depend on TPP.

Recommended Dietary Allowance (RDA) And Dietary Source

RDA of Vitamin B₁

Requirements depend on the intake of carbohydrates. Adult – 1 to 1.5 mg/ day (about 0.5mg/1,000 Cals of energy). Children – 0.7 to 1.2 mg/day

Dietary Source

Pregnancy and lactation, old age and alcoholism – 2mg/day. Cereals, pulses, oil seeds, nuts, and yeast are good sources. Thiamine is mostly concentrated in the outer layer (bran) of cereals and parboiled and milled rice. Polishing of rice removes 80% of thiamine. Also present in animal foods like pork, liver, heart, kidney, milk etc.

Deficiency Manifestations

Features

A condition known as beriberi is caused by deficiency. Anorexia, weakness, constipation, nausea, mental depression, peripheral neuropathy, irritability, and other early symptoms. Numbness in legs and complaints of 'pins and needle sensations' are reported. In adults, 2 types of beriberi reported as Wet beriberi, Dry beriberi and Infantile beriberi also occur.

Wet beri – beri (cardiovascular beriberi)

Characterized by oedema of legs, face, trunk and serous cavities. Breathlessness and palpitation are present. Calf muscles are slightly swollen. Blood pressure is higher in the systole while lower in the diastole. A fast and bounding pulse is observed. Heart failure makes the heart weak, and it can even cause death.

Dry beri – beri (neurological beriberi)

Associated with neurological manifestations resulting in peripheral neuritis. Muscles become weak and walking becomes difficult. The affected ones may need support for a walk, may become bedridden and may even die if not treated.

Mixed beri – beri

Symptoms mixed are referred to as mixed beriberi

Infantile beriberi

Observable in children born to thiamine-deficient mothers. Characterized by sleeplessness, restlessness, vomiting, convulsions and bouts of screaming due to cardiac dilatation

Wernicke – Korsakoff syndrome

Also known as cerebral beriberi. Seen in chronic alcoholics. This syndrome is brought on by inadequate ingestion or poor intestinal absorption of thiamine. Characterized by loss of memory, apathy and rhythmical to and fro motion of the eyeballs. In thiamine deficiency, pyruvate enters the brain crossing blood-brain barrier, its accumulation results in disturbed metabolism leading to polyneuritis.

Treatment

Complete rest. Thiamine 50 mg IM for 3 days and 10 mg thrice daily by oral route. Infantile beriberi treated via mother's milk. The mother should receive 10,000 to 20,000 mcg IM once in a day for 3 days.

Antagonists

Pyriethamine and oxythiamine are two important anti-metabolites of thiamine.

Role in Oral Health and Oral Manifestations

There is hypersensitivity of oral mucosa. Pain in tongue, teeth, jaw and face. Thiamine insufficiency in children is linked to postnatal

amelogenesis impairment, recurrent aphthous stomatitis, and enamel hypo mineralization. A decrease in the serum thiamine has been correlated with the development of cleft lip and palate in their fetuses [32,33].

Riboflavin (Vitamin B₂)

Riboflavin through its coenzymes takes part in a variety of cellular oxidation-reduction reactions.

Coenzymes of riboflavin

Flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD) are two coenzyme forms of riboflavin.

Absorption, Transport and Storage

Is easily absorbed from the gastrointestinal system, and it is phosphorylated in the intestine's walls as well as other bodily tissues.

Biochemical Functions and Role

The flavin coenzymes take part in a variety of redox processes necessary for generating energy. The coenzymes FAD and FMN are linked to specific enzymes involved in the metabolism of carbohydrates, lipids, proteins, and purines.

Recommended Dietary Allowance (RDA) And Dietary Source

RDA of Vitamin B₂

Adult – 1.2 to 1.7 mg, Pregnant and lactating women – (additional intake) higher intakes by 0.2 – 0.5 mg/day)

Dietary Source

Rich source

- Milk and milk products
- Eggs
- Liver
- Kidney

Moderate source

- Cereals
- Fruits
- Vegetables

- Fish

Deficiency Manifestations

Causes

It is uncommon – as it is synthesized by intestinal flora. Riboflavin deficiency accompanies other deficiency causes such as beriberi and kwashiorkor and can be seen more in chronic alcoholics.

Antagonists

Galactoflavin is an antagonist of riboflavin.

Features

- Dermatitis
- Circumcorneal vascularization

Role in Oral Health and Oral Manifestations

Symptoms include cheilosis (fissures at corners of the mouth), Angular stomatitis – inflammation at the corners of the mouth, Glossitis (tongue smooth and purplish) – and magenta-coloured tongue. Symptoms of riboflavin deficiency can be found in the lips (cheilosis lesions), corner of the mouth (angular stomatitis), tongue (fissured and magenta colouration), and mucosa (recurrent aphthous ulcerations) [34,35].

Niacin

Niacin or nicotinic acid is also known as the pellagra preventive (P.P) factor of Goldberg. The coenzymes of niacin NAD⁺ and NADP⁺ can be synthesized by the essential amino acid, tryptophan and it is a pyridine derivative.

Biochemical Functions and Role

The coenzymes NAD⁺ and NADP⁺ are involved in a variety of oxidation-reduction reactions. Many enzymes in the class of oxido reductases depend on NAD or NADP to function. The electron transport chain oxidizes the generated NADH to make ATP. Niacin inhibits lipolysis in the adipose tissue and decreases the circulatory free fatty acids. Niacin is used in the treatment of

hyperlipoproteinemia type II b (elevation of LDL and VLDL).

Recommended Dietary Allowance (RDA) And Dietary Source

RDA of Niacin

- Adult – 15 to 20 mg
- Children – 10 to 15 mg, One NE (niacin equivalent) = 1 mg niacin or 60 mg of tryptophan
- Lactating and pregnancy – an additional 5 mg required.

Dietary Source

Rich source

- Liver
- Yeast
- whole grains
- Cereals
- Pulses like beans
- Peanuts

Moderate source

- Milk
- Fish
- Eggs
- Vegetables

Deficiency Manifestations

Causes

Dietary deficiency of tryptophan. Pellagra is seen in people who consume a staple diet of wheat, and corn. The staple diet contains leucine in high quantities. Leucine inhibits the conversion of niacin to NAD⁺. Lack of synthesis of vit B₆. Tryptophan cannot be converted to niacin when there is a pyridoxal deficit. Carcinoid syndrome – tumour utilizes a major portion of available tryptophan for the synthesis of serotonin, so tryptophan is unavailable.

Features

Results in a condition called pellagra. Skin, the digestive system, and the central nervous system are all affected by disease. Symptoms –

3 Ds – “dermatitis, diarrhoea, dementia”, if not treated rarely lead to death 4th D. Dermatitis – inflammation of skin found in areas of skin exposed to sunlight (neck, dorsal part of feet, ankle and parts of face) and bright red erythema occurs. Casal's necklace is a region of the neck with increased pigmentation. Diarrhea – form of loose stools often with blood and mucus. Prolonged diarrhoea leads to weight loss. Dementia is a condition when the nervous system begins to deteriorate. Dementia symptoms include anxiety, irritability, memory loss, and insomnia (sleeplessness).

Role in Oral Health and Oral Manifestations

Oral mucosa: it turns a blazing red, hurts, and produces a lot of saliva. Tongue: The epithelium of the tongue is desquamated entirely. The tongue gets thick, swollen, and red. In severe cases, there is significant reddening and the tongue loses all of its papillae. Intraoral symptoms of niacin deficiency include glossitis, stomatitis, rash around the nose, angular stomatitis, and cheilosis [36].

Pyridoxine (Vitamin B₆)

The three substances that makeup vitamin B₆ are pyridoxine, pyridoxal, and pyridoxamine. These are derivatives of pyridine.

Biochemical Function and Role

In processes including transamination, decarboxylation, deamination, transsulfuration, condensation, and others, pyridoxal phosphate is involved.

Recommended Dietary Allowance (RDA) and Dietary Source

RDA of Vitamin B₆

- Adult – 2 – 2.2 mg/day
- Pregnancy lactation – 2.5 mg/ day

Dietary Source

Animal sources

- Egg yolk
- Fish
- Milk

Vegetable source

- Wheat
- Corn
- Roots and tuber

Deficiency Manifestations

Causes

Insufficient pyridoxine can lead to neurological symptoms such as depression, irritability, nervousness, and mental disorientation. Severe deficiency may cause convulsions and peripheral neuropathy due to decreased biogenic amine production (serotonin, GABA, norepinephrine, and epinephrine). In children, reduced GABA production from B6 deficiency can result in epilepsy. Haemoglobin levels drop, causing hypochromic microcytic anaemia due to decreased heme production. Impaired synthesis of niacin coenzymes (NAD⁺ and NADP⁺) from tryptophan occurs, and high urinary xanthurenic acid levels indicate B6 insufficiency, often observed in infants, alcoholics, and women using oral contraceptives.

Pyridoxine Antagonists

Isoniazid is a pyridoxine antagonist. The antagonists of vitamin B6 are deoxypyridoxine and methoxypyridoxine.

Role in Oral Health and Oral Manifestations

The oral manifestations of peroxide deficiency include gingivitis, cheilitis, discomfort and discolouration of the tongue, halitosis, and recurrent mouth ulcers [37].

Cobalamin (Vitamin B₁₂)

Vitamin B₁₂ is also referred to as anti-pernicious anaemia. It's a special vitamin that only bacteria can produce neither plants nor mammals can make.

Transport, Storage, and Absorption

Protein-bound forms of vitamin B₁₂ are present in the food. The stomach's acid hydrolases are the enzymes that release. The B₁₂ diet is the extrinsic component of Castle. The stomach secretes a special protein called intrinsic factor (IF).

Biochemical Functions and Role

Methionine is synthesised from homocysteine, and methylmalonic CoA is isomerized to succinyl CoA.

Recommended Dietary Allowance (RDA) And Dietary Source

RDA of Vitamin B₁₂

- Adult – 3microgram
- Children – 0.5 – 1.5 microgram/ day
- Pregnancy and lactation – 4 micrograms/ day

Dietary Source Dietary Source

Vitamin B₁₂ is exclusively found in animal products like liver, kidney, milk, eggs, fish, pork, and poultry. Curd surpasses milk due to its higher B₁₂ content from Lactobacillus. This vitamin is produced solely by anaerobic bacteria, not plants, and enters animal diets through consumed flora or preying on other animals.

Deficiency Manifestations

Features

Vitamin B₁₂, also known as cobalamin, is a water-soluble vitamin found in animal products like dairy, eggs, and red meat. Parietal cells in the stomach produce intrinsic factor, a glycoprotein essential for the terminal ileum to absorb vitamin B₁₂. This vitamin

serves as a cofactor for enzymes involved in fatty acid, myelin, and DNA synthesis post-absorption. Insufficient vitamin B₁₂ can lead to neurological and hematologic disorders. Although the liver stores excess vitamin B₁₂, depletion occurs when absorption is hindered due to dietary deficiencies, malabsorption, or lack of intrinsic factors. Diagnosis and treatment require coordinated efforts among healthcare professionals to ensure optimal patient care [37]

Treatment

Vitamin B₁₂ is typically administered intramuscularly in therapeutic doses ranging from 100 to 1000 mcg. This supplementation is crucial for treating deficiencies, with the treatment duration and method varying depending on the underlying cause. For strict vegans who develop deficiencies, oral B₁₂ supplements suffice for replenishment [38]. Patients deficient in intrinsic factors, due to conditions like pernicious anaemia or gastric bypass surgery, benefit from parenteral B₁₂ doses as oral intake isn't adequately absorbed without intrinsic factors. The standard recommendation is a monthly intramuscular injection of 1000 mcg B₁₂. Initially, newly diagnosed patients receive weekly intramuscular injections of 1000 mcg B₁₂ for four weeks to restore their B₁₂ stores. Studies indicate that high-dose oral B₁₂ can be equally effective, even without intrinsic factors, by saturating intestinal B₁₂ receptors. Regular B₁₂ monitoring is essential for those prone to deficiency, such as individuals with Crohn's disease or celiac disease, to detect and address declining B₁₂ levels promptly. Treatment is initiated as B₁₂ levels decrease significantly, but routine prophylactic treatment before a deficit is not recommended.

Role in Oral Health and Oral Manifestations

Vitamin B₁₂ deficiency manifests with various oral symptoms such as glossitis,

aphthous stomatitis, atrophic lingual papillae, burning tongue (glossopyrosis), angular stomatitis, dysphagia, oral pallor, glossodynia resembling "Bald tongue of sandwich" seen in pellagra [36,39,40]. Older adults commonly report glossodynia, linked to factors like trauma, infections, anaemia, diabetes, nutritional deficiencies, and trigeminal neuropathy. These conditions can cause recurring ulcers, cheilitis, lingual paresthesia, and oral burning or itching. Thorough blood tests are crucial, as 64.3% of oral symptoms due to vitamin B12 insufficiency occur without anaemia or abnormal cell size [41].

Conclusion

Vitamins are essential micronutrients that play various roles in maintaining oral homeostasis, which is the balance of physiological processes in the oral cavity. Vitamins are involved in the development and maintenance of oral tissues, such as the mucosa, teeth, bone, and gums. They also regulate the immune system, wound healing, energy production, and antioxidant defence in the oral environment. Vitamin deficiency can

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lead to various oral diseases and disorders, such as periodontitis, caries, cleft lip and palate, oral cancer, and mucositis. Therefore, adequate intake of vitamins from dietary sources or supplements is important for oral health and prevention of oral diseases.

Acknowledgements

We would like to express our sincere gratitude to the Centre for Global Health Research, Saveetha Medical College and Hospitals, Saveetha Institute of Medical and Technical Sciences (SIMATS), Saveetha University, Chennai, India, for providing support for this research work. Finally, we thank all those who contributed to this work, directly or indirectly, and helped make this research possible.

Conflict of Interest

The authors declare that they have no conflict of interest.

Funding

The authors have no relevant financial or non-financial interests to disclose.

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