

Impact Of Vegetarianism and Veganism On Oral Health

Research Article

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Abstract

Vegetarians and especially vegans have a number of nutritional features, which leads to the fact that the risks of certain metabolic disorders and diseases are somewhat different from those of omnivores. This is also true for the state of the oral cavity. Thus, low serum vitamin B12 and selenium are likely to make vegetarians and vegans more prone to the development of dental caries. At the same time, high consumption of magnesium, ascorbate, folate, carotenoids, and vitamin E inadvertently has a beneficial effect on the oral soft tissue condition in vegans and vegetarians. In particular, it was found that they are less likely to suffer from inflammatory periodontal diseases.

Also, there is evidence that the oral microbiome in vegetarians is slightly different from that of omnivores. Vegetarians usually have a lower bacterial content, but probably they have more candida.

Keywords: Nutrition; Micronutrients; Periodontitis; Caries; Microbiota; Inflammation.

Introduction

In recent years, people are more enticed towards vegetarianism and veganism. 5% of the total US population was considered to be vegetarians in 2013 [1]. 2.2% and 0.3% of the population of Switzerland were vegetarians and vegans in 2005 respectively [2]. Similarly, 4% of total Finns were vegetarians and 1% of them were vegans in 2008 [3, 4], while 7% of the UK population in 2018 was estimated to be vegans [5].

Vegetarianism includes several eating patterns: from a diet that excludes all animal-derived products (vegans) to diets that include eggs and dairy products (lacto-ovo-vegetarians or just vegetarians) [6]. The group that eats dairy products but no eggs is called lacto-vegetarian, while the opposite is typical for ovo-vegetarians [7]. People become vegetarians for ethical, religious, and environmental reasons. In addition, many people refuse animal food to improve or maintain their health [8]. In many cases, vegetarian diets are helpful in the prevention and treatment of certain diseases like hypertension, diabetes, dementia, cardiovascular diseases, and

even gallstone and rheumatoid arthritis. Change in meat, fruit, and vegetable consumption was found to decrease total mortality to 6 - 10%. Finally, Springmann et al. believe that change in the diet could save \$700-\$1,000 billion (US) per year in the healthcare sector [9].

Several types of research have revealed that these diets can have a positive effect on decreasing ischemic heart disease mortality, the incidence of hypertension, hyperlipidemia, obesity, type 2 diabetes mellitus, and even some kind of cancer [10, 11]. Moreover, western vegetarians have lower BMI compared with omnivores, and constipation as well as appendicitis were seen less in this group [12, 13]. On the other hand, they are at higher risk of osteoporosis and certain forms of anaemia [14, 15].

Vegan and vegetarian diets have a significant impact on somatic status due to the fact that they differ from mixed ones in chemical composition (especially vegan). Thus, both positive and negative clinical effects are primarily due to the influence of individual nutrients on metabolic processes.

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Methodology

The search strategy involved the biomedical databases: PubMed, Google Scholar, e-Library, NepJOL, INDMED and MJIRI. The articles were searched in English, Russian, Ukrainian, Nepalese, Indian and Iranian languages. Articles published till December of 2020 were included in this review. Keywords used to search relevant articles include: ((vegetarian) OR (vegetarianism) OR (vegan) OR (veganism) OR (plant-based diet)) AND ((oral cavity) OR (oral conditions) OR (oral health) OR (dental health) OR (teeth) OR (caries) OR (periodontal attachment) OR (periodontitis) OR (oral microbiota) OR (oral inflammation)). The equivalent words in local languages were used to search in regional databases. Other requests were performed to find additional information.

Results and Discussion

Nutritional Factors In Vegetarians and Vegans

Protein: Deficiency of protein and amino acids in oral cavity can lead to delayed tooth eruption, reduced tooth size, decreased enamel recuperation, salivary gland dysfunction [16], impaired response to infection and wound healing of soft oral tissue and compromised antibacterial properties of saliva [17]. Moreover, there are several defence proteins in saliva whose effects are additive and synergistic, providing efficient molecular defence network of the oral cavity [18]. Similarly, proteins in the diet are helpful in protecting the teeth from sugar that adhere to the teeth [19]. Furthermore, secretive proteins like mucines are paramount in forming a barrier against the reduction of humidity, against the chemical and physical penetration of irritants and even against the bacteria [20]. Finally, researchers have even came up with a solution to use protein for rebuilding tooth enamel or even for treating dental caries [21]. Vegetarian diet provides enough amount of protein and amino acids whereas vegans might be at risk of insufficient intake of methionine [22, 23].

Macro and Trace Elements: Collagen is the most important component of the organic matrix of the teeth and selenium has the ability to replace sulphur in bonds of collagen, which can reduce dental caries [24]. Some studies show that a vegetarian diet may be associated with a higher risk of dental erosion and caries [25-27]. It may be due to the lack of selenium in the vegetarian diet [28-31]. At the same time, Sekhri et al. did not find an association between selenium status and caries incidence [32].

Fluorine is another element that can prevent dental caries by forming a layer of protection around the teeth. The fluorine can replace hydroxyapatite ($\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$) to fluorapatite ($\text{Ca}_{10}(\text{PO}_4)_6\text{F}_2$) which is more resilient to acids formed by oral flora [33, 34]. Staufenbiel et al. reported that a vegetarian diet may increase the risk of caries and erosion, and topical fluoride application was shown to be effective in preventing caries but not in preventing erosion. Furthermore, fluoride-containing toothpaste was rarely used in vegetarians which even elevated chances of getting caries [25], and increased incidence of dental caries [35]. In our previous study vegans consumed more fluorine than other groups whereas the omnivores had the lowest intake, less than vegans, vegetarians and those, who adhered to the Great Lent [36]. However, the fluorine content in sea foods is approximately two times higher than in other products [37]. At the same time, it

should be noted that a potent source of fluorine is actually water, so its level in the human body depends upon its concentration in drinking water [38]. Moreover, not only fluorine and selenium are essential for normal enamel metabolism: caries incidence was also associated with inadequate potassium and copper supply in Sekhri et al. study [32]. However, potassium deficiency is rarely found among vegetarians and vegans as compared with omnivores [12, 13, 39-43]. But the level of copper in the human body still remains a million-dollar question [29, 44].

A population-based analysis revealed that nutritional magnesium supplementation might improve periodontal health, reducing periodontal attachment loss. Besides, there is also evidence that magnesium deficiency increases the risk of periodontitis development [45]. Fortunately, magnesium is abundant in vegetarians and vegans as compared to omnivores [39].

Iron is also an important element to be discussed. Its deficiency results in atrophy of the lingual papillae, burning, and redness of the tongue, angular stomatitis, dysphagia, and the pallor of the oral tissues due to underlying anaemia [17, 46]. Lack of iron can also lead to salivary gland dysfunction [17] and suppressed anti-inflammatory and immune response of oral soft tissue [46]. Vegans consume more iron than omnivores, however non-heme iron from plant sources is significantly less absorbed, and iron stores in vegans are usually lower than in omnivores. This makes them more prone to developing iron-deficiency anaemia and the above symptoms [40, 44, 47].

Zinc plays a huge role in human metabolic processes [48]. It can improve taste and appetite, which can reduce malnutrition [49]. Plant foods are low in zinc, and most importantly, they contain phytates that reduce zinc absorption, which significantly increases the risk of zinc deficiency in vegetarians and especially vegans [29], [44], [50-53]. This can lead to flattened filiform papillae, ulcers, xerostomia, changes to the epithelium of the tongue [46], and increased recovery period of wounds [54].

Vitamins: Vitamin C plays an important role in maintaining a good condition of gums. It stimulates the immune response, reduces inflammation in oral soft tissues, and there by prevents gingivitis and periodontitis [17, 55, 56], ulcers [56], and candidiasis [57]. Similarly, a lack of ascorbic acid disrupts collagen synthesis, which eventually results in bleeding from gums and prolonged wound healing [16]. Furthermore, vitamin C deficiency impedes dentine formation and promotes the destruction of pulp. Vegetarians and vegans consume more vitamin C than omnivores [39, 58]. In another study by Staufenbiel et al. vegetarians had better periodontal conditions due to less inflammation, less periodontal damage, better dental home care, and even healthier lifestyle [59]. The better oral condition can be due to the high consumption of not only vitamin C but also carotenoids and other antioxidants.

Deficiencies of vitamins B1, B3, and B6 are associated with angular cheilosis, cracked lips, ulcerative gingivitis, periodontal diseases, and sore tongue [17]. Status of these vitamins is comparable between vegans, vegetarians, and omnivores [39, 41, 60]. At the same time, vegetarians and especially vegans usually lack vitamin B12 [14, 61, 62]. So, a meta-analysis conducted by Smits et al. revealed that a vegetarian diet was associated with a higher risk of dental erosion and more decayed, missing, and filled teeth, which might be due to the lack of vitamin B12 [26]. It was also found,

that B12 deficiency can lead to dental caries [63], haemorrhagic gingivitis, detachment of periodontal fibres [17], angular cheilosis, recurrent aphthous ulcers [64], halitosis, and bone loss [17].

Folic acid is also a vitamin, whose level is adequate in vegetarians and vegans [39, 41]. This might contribute in usual metabolism and proliferation of mucosal epithelium of oral cavity [65, 66], and similarly, reduce the risk of cancer in the oral cavity and pharyngia [67], and gingival inflammation in vegetarians [35, 42, 68]. A meta-analysis done by Haghghatdoost et al. showed that vegetarians also have reduced inflammation of any kind [69].

Vitamin E is an antioxidant whose deficiency may be associated with oral cancer [46]. Besides this, the lack of vitamin E was found to decrease immune response and impede the working mechanism of the anti-inflammatory system of the soft tissue of the oral cavity [17]. Fortunately, vitamin E deficiency is not widespread [70]. The vegetarians and vegans, especially those who consume enough amount of oil derived from plants [71] have enough vitamin E [39, 41].

Adequate vitamin A status prevents periodontitis [72, 73], gingival [74] and enamel hypoplasia, impaired tooth formation [16, 75], decreased epithelial tissue development, resorption of alveoli, gingivitis [74], atrophy of the salivary glands and decreased cleansing action of saliva [75], xerostomia, reduced resistance to infections, and impaired growth of teeth [35]. Vegetarians and vegans don't seem to lack it in comparison to omnivores. Indeed, vegans are found to have a higher level of carotenoids [39, 41, 42].

Vitamin D and calcium play an indispensable role in tooth formation and its maintenance by taking part in enamel mineralization [76]. Despite the fact that vitamin D is synthesized endogenously under the sun's UV radiation [77], this pathway adequately provides the body with calciferol only those who live in low latitudes. In countries with a temperate climate, food makes a major contribution to vitamin D status [78]. Following a plant-based diet can increase the risk of vitamin D deficiency [39]. It also negatively affects calcium status [79]. In addition to it, calcium from plant sources has poorer bioavailability, which leads to the fact that vegans often have calcium deficiency [39, 41, 42, 80], and an increased risk of osteoporosis [14]. On the contrary, vegetarians have the highest calcium intake among all groups [39, 41]. Vitamin D deficiency leads to enamel hypo-calcification and hypoplasia, demineralization of the jaw alveoli, as well as to an increased risk of periodontitis [81, 82].

Table 1 provides information on the manifestations of nutritional deficiencies in the oral cavity, status of certain nutrient in vegetarians and vegans, as well as potential food sources of the nutrients for these groups.

Table 1: Macro - and micronutrients and their sources with corresponding symptoms of its deficiency in oral cavity and status in vegetarians and vegans.

Oral Environment

Some vegetarian foods need much more chewing so continuous wear and tear might result in poor dental status. Furthermore, protein intake affects saliva acidity. Vegetarians and vegans often consume less protein than omnivores [41, 102], which is probably

why they have lower saliva pH [103]. At the same time, Laffranchi et al. have found the opposite results: in their study omnivores had lower saliva pH [104].

The bacterial level can be another concern, which is controlled by different factors such as temperature, pH, nutrient level, hydrodynamics, and the presence of specific ions. All these factors may affect bacterial growth and biofilm development [105]. *Porphyromonas gingivalis* and *Fusobacterium nucleatum* may have a role in cancer development, so, it could be used as a poor predicational indicator in precancerous lesions. Also, improvement of oral hygiene and treatment of periodontitis can be beneficial in limiting the development of cancer [106]. According to Salli et al., sucrose can promote but xylitol could decrease bacterial colonization and proliferation within an early *Streptococcus mutans* biofilm in a dental simulator [107]. Xylitol may also influence the ability of certain *Streptococcus mutans* strains to adhere to the hydroxyapatite and reduce caries incidence and amount of plaque. In the same way, another critical food could be honey. Honey mainly consists of glucose and sucrose but it may have antibacterial properties against *Streptococcus viridans* [108]. Phenolic compounds in honey have an antibacterial effect [109]. Amirmozafari et al. came across that the oral cavity of the vegetarians has fewer bacteria as compared with omnivores [110]. They concluded that it is due to antibacterial and antioxidant capacity in the saliva of vegetarians.

Another problem in the oral cavity is related to fungi. Research by Patil et al. has shown that diet can play an important role in oral candidal prevalence, which was higher in vegetarians (68.5%) than in non-vegetarians (41%). However, *Candida albicans* was the most common species in both vegetarians (35%) and non-vegetarians (39%) [111]. Paillaud et al. demonstrated that the risk of oral candidiasis increases significantly with malnutrition. In its turn, mucosal lesions caused by candidiasis further impair nutrition. Vitamin C deficiency was found to be the most significant independent risk factor associated with oral candidiasis [57].

Conclusion

Only a few studies were dedicated to assessing the status of the oral cavity in vegetarians and vegans. The results show that vegetarians and vegans are at higher risk of caries formation. This might be due to the poor status of vitamin B12 and selenium. At the same time, the conducted researches testify that vegans and vegetarians rarely suffer from the inflammatory diseases of the oral cavity like periodontitis and gingivitis and, in general, have healthier periodontal tissues as compared with omnivores. It is possibly due to the higher consumption of folic acid, vitamin C, carotenoids, vitamin E, and magnesium. Taking these findings into account, vegetarians and especially vegans might be recommended to use a toothbrush with medium and hard bristles more frequently than omnivores because they need to clear the plaque more thoroughly and fortunately, they have a lower risk of gingival damage.

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Table 1. Macro and micronutrients and their sources with corresponding symptoms of its deficiency in oral cavity and status in vegetarians and vegans.

Nutrient	Plant sources (+ vegetarian sources).	Symptom of deficiency in the oral cavity.	Risk of deficiency in vegetarians/vegans.
Protein and amino acids	Legumes (beans, lentils, peas, peanuts), nuts, seeds, soy foods (tempeh, tofu) + eggs, dairy [83].	Delayed tooth eruption, reduced tooth size, decreased enamel recuperation, salivary gland dysfunction [16], compromised or impaired response to infection and wound healing of oral soft tissue, compromised antibacterial properties of saliva [17].	Vegetarian diet supplies more than an adequate amount of protein and amino acids where as vegans might be in a modest risk of insufficient intake of methionine [22, 23].
Vitamin C	Citrus fruits, kiwi, mango, and, vegetables such as broccoli, tomatoes, peppers [84].	Irregular dentin formation, dental pulpal alterations, bleeding gums, delayed wound healing, defective collagen formation [16], 20% greater chance for periodontal disease [55, 56], depressed anti-inflammatory and immune response of oral soft tissue [17], gingivitis and ulcer of oral cavity [56], candidiasis [57].	As compared with omnivores, vegetarians and vegans have significantly higher levels of vitamin C [39, 58].
Vitamin B1	Whole-grains, brown rice, soybeans, nuts, dried beans, peas + eggs, dairy [85].	Cracked lips, angular cheilosis [16].	Vegetarians and vegans are supplied with vitamin B1 as well as omnivores are [39, 41, 60].
Vitamin B3 (niacin)	Bran, yeast, eggs, peanuts, whole-grain cereals, legumes, seeds + eggs, dairy [86].	Inflammation of the tongue, angular cheilosis, and ulcerative gingivitis [16].	No significant difference in niacin status was found between vegetarians and non-vegetarians [39, 41].
Vitamin B6	Potatoes, grains, legumes, non-citrus fruits + eggs, dairy [87].	Periodontal disease, sore tongue, burning sensation in the oral cavity [16].	Vegans, vegetarians, and omnivores are equally supplied with vitamin B6 [39, 41, 60].
Vitamin B9	Green leafy vegetables, legumes, pulses [88].	Increase the risk of the oral cavity and pharyngeal cancers [67], gingival inflammation [35, 42], disrupted proliferation of epithelium of oral cavity [65], bleeding of the gums [66].	Omnivores lack vitamin B9 in comparison with vegans and vegetarians [39, 41, 89].
Vitamin B12	Only fortified foods (nutritional yeast, plant milks) and supplements + eggs, dairy [83].	Angular cheilosis, halitosis, bone loss, haemorrhagic gingivitis, detachment of periodontal fibres [16], recurrent aphthous ulcers [17, 64], dental caries [63].	Vegans are at higher risk of its deficiency as cobalamin is almost absent in plant foods. Vegetarians are better supplied with it than vegans but still worse than omnivores [14, 61, 62, 89].
Vitamin E	Coconut, maize, olive, peanut, soybean, wheat germ, and sunflower oils [71].	Oral cancer [46], depressed anti-inflammatory and immune response of oral soft tissue [17].	Status of vitamin E among vegetarians, vegans, and omnivores is almost the same [39, 41].
Vitamin A/carotenoids	Carotenoids - tomatoes, carrots, squashes/pumpkins, yellow maize, mangoes, papayas [90]. Retinol - only eggs and dairy [91].	Increased risk of periodontitis [72, 73], gingival hypoplasia [74], decreased epithelial tissue development, impaired tooth formation, enamel hypoplasia [16, 75], resorption of alveoli, gingivitis [74], atrophy of the salivary glands, decreased cleansing action of saliva [75], xerostomia, depressed anti-inflammatory and immune response of oral soft tissue [17, 35], lack of recuperation of epithelium [74], reduced resistance to infections, and impaired growth of the teeth [35].	Supply of vitamin A seems to be almost the same in vegetarians, vegans and omnivores. But the status of carotenoids is higher in vegans [39, 41, 42].
Vitamin D	Fortified products + eggs [92].	Vitamin D deficiency and resulting calcium deficiency lead to hypomineralization of maxilla, mandible, and teeth, increased brittleness of teeth, compromised tooth integrity, delayed eruption of deciduous teeth, absence of lamina dura, abnormal alveolar bone patterns [16], decreased jaw bone density and strength to anchor tooth structure [17], periodontitis, gingivitis [81, 93, 94], inhibition of cementogenesis and cementoblast differentiation [95]. Since vitamin D has an immunomodulating function, its deficiency increases inflammation of oral cavity and risk of periodontitis [81, 82].	Vegans are at higher risk of vitamin D deficiency than vegetarians omnivores. However, in temperate latitudes, all three groups are at high risk of vitamin D deficiency [41, 42].
Calcium	Low-oxalate leafy greens (broccoli, bok choy, cabbage, collard, dandelion, kale, watercress), calcium-set tofu, almonds, almond butter, fortified plant milks, sesame seeds, tahini, figs, blackstrap molasses + dairy [83].		Plant sources often have reduced bioavailability. Therefore, vegans are at the greatest risk of calcium deficiency. However, vegetarians usually consume the highest amount of calcium among all three groups, because of high dairy consumption [39, 41, 42, 80].
Magnesium	Seeds, avocado, broccoli, spinach [96], nuts and beans [97, 98].	Increased risk of periodontitis development [45].	Magnesium is abundant in vegetarians and vegans compared to omnivores [29, 39, 43].
Potassium	Potassium content is higher in dry fruits, nuts and beans, in seaweed, fresh fruits and vegetables, in potatoes, parsley, spinach and mushrooms [97, 98].	Dental caries incidence was also associated with imbalanced potassium level [32].	Vegetarians and vegans usually consume more potassium and have a higher concentration than omnivores [12, 13, 39-43].
Iron	Legumes (beans, lentils, peas, peanuts), green leafy vegetables, soybeans and soy foods, quinoa, potatoes, dried fruit, dark chocolate, tahini, seeds (pumpkin, sesame, sunflower), sea vegetables (dulse, nori) + eggs, dairy [83].	Salivary gland dysfunction, dysphagia, angular cheilosis [17], recurrent aphthous ulcers [64], atrophy of the lingual papillae, glossitis [46], angular stomatitis [46], painful tongue with a burning sensation [17], depressed anti-inflammatory and immune response of oral soft tissue, burning and redness of the tongue [46], paleness of gums and lips [46].	Serum ferritin is lower in vegetarians and vegans than in non-vegetarians. Haemoglobin levels are similar or slightly lower in vegetarians and vegans than in non-vegetarians even though vegetarians and vegans consume a higher amount of iron [40, 44, 47].
Zinc	Legumes (beans, lentils, peas, peanuts), soy foods, nuts, seeds, oat + eggs, dairy [83, 97].	Decrease in taste sensation [49], changes to the epithelium of the tongue, increase in cell numbers, flattened filiform papillae, ulcers, and xerostomia [46], increase in the recovery period of wound [54].	Vegetarians have comparable or in some cases lower levels of zinc than omnivores [29, 99]. Vegans are at higher risk of its deficiency than other groups [44, 50-53].
Copper	Legumes, nuts, seeds [100], poppy, cocoa, chocolate, brewer's yeast, strawberries, gooseberries, rosehips, mushrooms, buckwheat, whole grains [97].	Increased incidence of dental caries [32].	Plant-based diets are rich in copper [44], however, the veracity of the claim that vegetarians and vegans lack copper has yet not been proved [29, 44].
Selenium	Cereals, milk, nuts + eggs, dairy [101]. However, selenium content in food is highly dependent upon its soil concentration, where it was grown [31].	Increased incidence of dental caries [24].	Vegetarians and vegans may lack selenium [28, 30, 31].
Fluoride	Depends mainly on water content [38].	Increased incidence of dental caries [25, 35].	Fluorine intake decreases with a reduction in plant food consumption [36].

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