

Diet and Nutrition in Oral Cancer: Risk and Protective Factors

¹Dr. Gowri S, ²Dr. J. Dinakar, ³Dr. Ann tryphennae, ⁴Dr. Harshini G

¹Professor and Head, Dept. of Oral Pathology and Microbiology, Sri Ramakrishna Dental College and Hospital, Coimbatore, TNDRMGRU

²Principal, Dept. of Oral Pathology and Microbiology, Sri Ramakrishna Dental College and Hospital, Coimbatore, TNDRMGRU

³Assistant Professor (Former), Dept. of Oral Pathology and Microbiology, Sri Ramakrishna Dental College and Hospital, Coimbatore, TNDRMGRU

⁴Assistant Professor, Dept. of Oral Pathology and Microbiology, Sri Ramakrishna Dental College and Hospital, Coimbatore, TNDRMGRU

Citation of this Article: Dr. Gowri S, Dr. J. Dinakar, Dr. Ann tryphennae, Dr. Harshini G, "Diet and Nutrition in Oral Cancer: Risk and Protective Factors" IJDSR – April – 2026, Vol. – 8, Issue - 2, Page No. 15-21.

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Corresponding Author: Dr. Gowri S, Professor and Head, Dept. of Oral Pathology and Microbiology, Sri Ramakrishna Dental College and Hospital, Coimbatore, TNDRMGRU, Tamil Nadu, India

Type of Publication: Original Research Article

Conflicts of Interest: Nil

ABSTRACT

Oral cancer remains a significant global health burden with increasing incidence and mortality. While tobacco and alcohol are well-established risk factors, diet has emerged as an important modifiable contributor to oral carcinogenesis. Approximately one-third of cancers are linked to dietary factors. Diets rich in fruits, vegetables, and micronutrients exert protective effects through antioxidant and anti-inflammatory mechanisms, whereas consumption of processed foods, red meat, refined sugars, and alcohol promotes carcinogenesis via oxidative stress, chronic inflammation, and DNA damage. Nutritional

deficiencies, particularly of vitamins A, C, E, and folate, further increase susceptibility. Additionally, dietary patterns influence the oral microbiome and epigenetic pathways, contributing to tumor development and progression. This review highlights dietary risk and protective factors, underlying biological mechanisms, and the role of nutrition in prevention. Emphasis is placed on the importance of lifestyle modification and dietary counseling in dental practice for reducing oral cancer risk.

Keywords

Oral Cancer, Diet, Carcinogenesis, Antioxidants,

Inflammation, Nutrition.

INTRODUCTION

Oral cancer represents an increasing global health burden, with rising incidence, mortality, and disability-adjusted life years (DALYs) over recent decades. According to the International Agency for Research on Cancer (2022), oral cancer ranks 15th in global cancer mortality, accounting for 188,438 deaths, predominantly in males. Despite advances in management, five-year survival remains around 40–50%. Major risk factors include tobacco, alcohol, betel quid chewing, and human papillomavirus infection, with incidence continuing to rise worldwide [1].

In addition to these established behavioral risk factors, increasing attention has been directed toward dietary patterns in oral cancer development. The World Health Organization estimates that nearly 30% of cancers are linked to diet and nutrition. Accordingly, the American Cancer Society (2020) recommends a healthy dietary pattern emphasizing nutrient-dense foods such as fruits, vegetables, and whole grains, while limiting red and processed meat, processed foods, sugary beverages, and refined grains [2].

Nutritional status plays a crucial role in carcinogenesis, disease progression, and treatment tolerance. Diets rich in fresh fruits, vegetables, fish, and seafood may exert protective effects, mediated through mechanisms such as inflammation, oxidative stress, and regulation of gene expression and DNA repair [3].

Low intake of fruits, vegetables, beta-carotene, and vitamin C has been associated with increased risk, whereas balanced consumption of omega-3 and omega-6 fatty acids, vitamin D, probiotics, and

reduced sugar intake may offer protective benefits.

Vitamin E supplementation has also been linked to a lower risk of oral and pharyngeal cancers.

Malnutrition due to inadequate calorie intake is common among oral cancer patients, contributing to weight loss and reduced treatment tolerance.

Diet and nutrition also influence the risk of secondary malignancies in head and neck squamous cell carcinoma (HNSCC). While low antioxidant intake is associated with increased cancer risk, supplementation with β -carotene, vitamin E, and retinoids has not demonstrated effectiveness in preventing second cancers; however, β -carotene may reduce radiotherapy-related side effects [4].

Tob Dietary Risk Factors

acco, Alcohol, and Diet Interaction

Tobacco use, in both smoked and smokeless forms, remains a major modifiable risk factor influencing lifestyle and dietary patterns. Evidence indicates differences in diet among heated tobacco product (HTP) users, conventional smokers, and non-smokers. Smokers tend to consume fewer micronutrients and dietary fiber, along with higher alcohol intake, which increases with greater tobacco use.

The combined effects of tobacco, alcohol, and poor nutrition significantly increase oral cancer susceptibility. Alcohol interferes with absorption and utilization of essential nutrients, while tobacco exposure leads to structural and functional damage of the oral mucosa, thereby facilitating the action of carcinogens.

Beer consumption is linked to poorer dietary quality than wine or spirits, while alcohol impairs nutrient absorption and tobacco damages the oral mucosa, collectively increasing susceptibility to carcinogens.

These observations emphasize the need for an integrated approach in patient counselling, where dietary habits, type of tobacco use, and lifestyle factors are evaluated alongside demographic and physical health parameters. Future research should incorporate objective nutritional assessments, including biochemical measures, and examine the long-term health implications of HTP use [5][6]

Hot Food and Beverages

Strong evidence links smoking and alcohol with oesophageal squamous cell carcinoma (ESCC), while emerging risk factors include hot food and beverages, poor oral health, PAH exposure, and diet. Frequent intake of very hot foods may cause thermal injury, increasing cancer risk. [7].

Red and Processed Meat

High consumption of red and processed meat is associated with an increased risk of oral cancer, primarily due to carcinogenic compounds formed during processing and high-temperature cooking, including heterocyclic amines (HCAs) and N-nitroso compounds which are known to induce DNA damage. The International Agency for Research on Cancer classifies processed meat as a Group 1 carcinogen and red meat as a Group 2A carcinogen. Meat and meat products may also contain mutagenic substances such as polycyclic aromatic hydrocarbons (PAHs) and heterocyclic aromatic amines (HAAs), which contribute to carcinogenesis. Frequent consumption, especially with cooking methods like smoking, frying, or roasting, may increase oral cancer risk [8].

Protective Dietary Factors

Fruits and Vegetables

Fruits and vegetables protect against oral cancer through antioxidants, vitamins, and fiber that

neutralize free radicals and support immunity. Dietary patterns influence cancer risk via systemic inflammation, measured by CRP, interleukins, and TNF- α . The Dietary Inflammatory Index (DII) reflects this, with higher scores indicating increased risk and lower scores reduced risk of oral cancer [9].[10]

Red fruits such as blackberries, strawberries, and grapes are rich in polyphenols, especially resveratrol, which exerts antioxidant, anti-inflammatory, and anticancer effects by regulating proliferation, adhesion, migration, invasion, apoptosis, and angiogenesis [11].

Micronutrients and Phytochemicals

Vitamins C and E, along with flavonoids, carotenoids, beta-carotene, and lycopene from vegetables, protect against oxidative damage, regulate cancer pathways, support immune function, and help prevent DNA damage while promoting cell differentiation ^{[12],[13]}.

Folate

Folate deficiency has been linked to increased cancer risk, particularly in the gastrointestinal tract, due to impaired DNA synthesis and altered DNA methylation that may trigger proto-oncogene activation [14].

Green Tea and Curcumin

Oxidative stress caused by excess reactive oxygen species can damage DNA and initiate cancer, while antioxidant-rich diets help counter these effects.

Green tea and turmeric contain potent bioactive compounds with antioxidant and anti-inflammatory actions. Regular intake may inhibit tumor growth, reduce cell proliferation, and promote apoptosis. Their combined use shows promise in chemoprevention of oral potentially malignant disorders, supported by biomarker-based evidence ^[15].

Fish and Dairy

Fish and certain dairy products may offer protective benefits due to omega-3 fatty acids and calcium that support immune and tissue health. Omega-3 fatty acids such as docosahexaenoic acid and eicosapentaenoic acid possess antioxidant and anti-inflammatory effects, reduce oxidative stress, suppress cyclooxygenase-2 expression, and may inhibit tumor growth [16].

Selenium, Zinc, and Copper

Selenium supplementation may help reduce oxidative stress and support management of potentially malignant disorders and oral squamous cell carcinoma [17].

Zinc deficiency has been associated with increased susceptibility to oral cancer, with reduced levels frequently observed in tumor patients due to its role in inflammatory and antioxidant processes [18,19].

Copper has a dual role in oral pathology, where deficiency impairs antioxidant defenses by reducing SOD1 activity and elevated levels are linked to premalignant lesions and squamous cell carcinomas, particularly in oral submucous fibrosis, while micronutrients such as iron, zinc, and selenium may offer protective benefits with effects varying by population and gender [20,21].[22].

Infectious Agents

Infectious agents like HPV and HIV have been studied as risk factors, while others show no clear association. Environmental factors, including use of untreated water sources and biomass smoke exposure, have also been linked to increased ESCC risk [23,24].

Dietary pattern, Ultra-Processed and Pro-Inflammatory Foods

Healthy dietary patterns rich in fruits, vegetables, cereals, and unsaturated fats are associated with a reduced risk of oral and oropharyngeal cancers. In contrast, Western diets high in processed foods, fast foods, and animal products tend to increase risk. Mediterranean-style diets, which are anti-inflammatory in nature, show protective effects, whereas pro-inflammatory diets are linked to higher cancer risk [2].

Diets high in fried foods, refined sugars, and ultra-processed products promote oxidative stress and chronic inflammation due to low protective nutrients and harmful additives, and when inflammation persists, it disrupts homeostasis and increases the risk of noncommunicable diseases, including cancer, diabetes, and cardiovascular disorders [25].

Protective foods such as citrus and red fruits, green leafy vegetables, green tea, and omega-3-rich fish support antioxidant defence, reduce inflammation, and promote apoptosis. In contrast, refined sugars, processed meats, and fried foods promote carcinogenesis through chronic inflammation and mutagen formation, driven by micronutrients and bioactive compounds with antioxidant, anti-inflammatory, anti-angiogenic, and anti-proliferative properties [26].

Biological Mechanisms of Diet in Carcinogenesis

Diet is a key modifiable factor in oral cancer, contributing to nearly one-third of cases. Diets high in processed foods, red meat, refined sugars, and alcohol increase risk through inflammation, oxidative stress, and DNA damage, especially with tobacco use, whereas diets rich in fruits, vegetables, whole grains, and omega-3 fatty acids offer protection via antioxidant and anti-inflammatory effects.

Micronutrients and bioactive compounds support immune function and regulate carcinogenic pathways, while the oral microbiome also influences tumor progression; overall, balanced dietary patterns, particularly Mediterranean-style diets, along with reduced tobacco and alcohol use, play a crucial role in prevention [27].

Beyond oxidative stress and inflammation, diet influences carcinogenesis through epigenetic modifications such as DNA methylation and histone changes, with deficiencies like folate causing genomic instability, while also affecting insulin resistance and IGF-1-mediated proliferation and apoptosis. Pro-inflammatory diets activate pathways such as NF- κ B and STAT3, whereas bioactive compounds like polyphenols modulate these pathways and exert chemo preventive effects [28].

Oral Microbiome

The oral microbiome is increasingly recognized for its role in oral carcinogenesis, with specific bacteria such as *Porphyromonas gingivalis* and *Fusobacterium nucleatum* contributing to tumor progression. These microorganisms may influence cancer development through chronic inflammation and modulation of cellular pathways.

Emerging evidence suggests that alterations in the oral microbiome may partly explain the occurrence of oral squamous cell carcinoma (OSCC) in individuals without traditional risk factors. Notably, reduced microbial diversity has been observed in OSCC patients [29].

Additionally, periodontal pathogens such as *Fusobacterium*, *Peptostreptococcus*, and *Treponema* are enriched in the tumor microenvironment and may enhance tumor aggressiveness. This effect is mediated

through activation of TLR/MyD88 and integrin/FAK signalling pathways, highlighting the importance of microbial interactions in cancer progression [30].

Antioxidants

Antioxidant-rich foods such as fruits, vegetables, nuts, whole grains, legumes, green tea, and spices provide vitamins and bioactive compounds that neutralize reactive oxygen species, reduce oxidative stress and DNA damage, support immune function, and aid cancer prevention. However, antioxidant supplements (e.g., β -carotene, vitamin E, retinoids) show inconsistent benefits in cancer prevention, particularly for second primary tumors in HNSCC, though some may help reduce radiotherapy-related side effects.[32]

Clinical Implications for Dental Practice

Dental professionals play a crucial role in oral cancer prevention through dietary counselling and lifestyle modification. Routine dental visits provide an opportunity to assess dietary habits, identify high-risk behaviours, and educate patients regarding the importance of balanced nutrition. Counselling should emphasize increased intake of fruits, vegetables, and antioxidant-rich foods, along with reduction of processed foods, tobacco, and alcohol consumption. Early identification of nutritional deficiencies and referral for dietary management can improve patient outcomes and reduce disease burden.

Life Style Modifications

Dietary habits play an important role in cancer risk and outcomes. Diets rich in fruits, vegetables, whole grains, and lean proteins are associated with a lower risk of cancer and better survival. Alongside diet, regular physical activity supports overall health by improving immunity, maintaining healthy body

weight, and helping regulate hormones, thereby reducing the risk of recurrence.

Lifestyle choices such as smoking and alcohol consumption also have a significant impact. Continuing to smoke after a cancer diagnosis can worsen prognosis, while quitting at the time of diagnosis has been shown to improve survival. Similarly, reducing alcohol intake is recommended, as it can positively influence recovery and decrease the likelihood of recurrence.

CONCLUSION

Diet significantly influences oral cancer risk. Unhealthy dietary patterns, especially when combined with tobacco and alcohol use, promote carcinogenesis through inflammation and oxidative stress. In contrast,

diets rich in fruits, vegetables, and essential nutrients offer protective effects. While natural antioxidant intake is beneficial, supplementation shows limited benefit. Overall, a balanced, nutrient-rich diet and healthy lifestyle are key strategies for oral cancer prevention.

The research underscores the need for heightened awareness, surveillance, and prevention efforts, especially in regions with high oral cancer incidence. Policymakers are urged to implement screening programs and public health education to combat the disease.

Table 1. Dietary Factors in Oral Cancer Risk and Prevention

Risk Factors	Protective Factors
Processed meat, red meat	Fruits and vegetables
Refined sugars, fried foods	Green tea, turmeric
Alcohol, tobacco	Omega-3 rich fish
Ultra-processed foods	Whole grains, legumes

3.

REFERENCES

1. Alajaji SA, Khoury ZH, Jessri M, et al. The role of artificial intelligence in digital pathology for oral epithelial dysplasia research. *Head Neck Pathol.* 2024;18(1):38-46.

2. Abdul NS, Shivakumar GC, Sangappa SB, et al. Applications of artificial intelligence in oral and maxillofacial pathology: systematic

4. review and meta-analysis. *BMC Oral Health.* 2024; 24:122.

5. Alsanie IS, Qannam A, Bello IO, Khurram SA. Exploring the role of artificial intelligence in oral pathology: diagnostic and prognostic implications. *J Oral Pathol Med.* 2025;54(7):487-497.

6. Xu Z, Lin A, Han X. Current AI applications and challenges in oral pathology. *Oral (Basel)*. 2025;5(1):2.
7. Alotaibi S, Deligianni E. AI in oral medicine: is the future already here? *Br Dent J*. 2024; 237:765-770.
8. Rajinikanth V, Ramesh A, Sekar D. Deep learning-based grading of oral epithelial dysplasia: challenges and opportunities. *Oral Oncol*. 2023; 144:105564.
9. Gupta A, Arora VS, Verma M. Machine learning in histopathology: pitfalls and best practices. *Arch Pathol Lab Med*. 2023;147(9):1065-1074.
10. Chen C, Tang P, Wang Q. Convolutional neural networks for OSCC detection in histologic sections. *J Clin Pathol*. 2024;77(3):186-195.
11. Lee JH, Han JH, Kim EJ, et al. AI-assisted clinical photograph analysis for oral lesion detection. *Oral Dis*. 2024;30(5):1358-1366.
12. Sharma P, Singh A, Joshi P. Explainability in AI models in oral pathology: bridging the gap to clinical adoption. *Comput Med Imaging Graph*. 2025;102:102219.
13. Wang C, Li W, Qin B. Automated OSCC margin assessment using deep learning models. *Int J Oral Maxillofac Surg*. 2023;52(12):1645-1653.
14. Pereira T, Dias J, Rodrigues J. Tumor microenvironment quantification in OSCC using AI: diagnostic and prognostic applications. *Cancer Med*. 2024;13(4):553–567.
15. Kumar N, Tripathi R, Singh S. Federated learning for multisource oral pathology image datasets. *IEEE J Biomed Health Inform*. 2023;27(11):4891-4900.
16. Tan SH, Haron H, Abas A. Challenges in implementing AI for digital and clinical oral healthcare. *Front Oral Health*. 2024; 5:898761.
17. Patel V, Patel A, Shah J. AI-enabled triage for oral lesions in community screening. *Public Health*. 2025; 216:123-131.
18. Banerjee S, Gupta S. Tele-oral medicine and AI: a collaborative pathway for underserved regions. *Telemed J E Health*. 2023;29(10):1462-1470.
19. Dhanabalan K, Williams P, Malhotra R. AI-integrated documentation and clinical decision support in dentistry. *J Dent Res*. 2024;103(8):817-824.