World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(REVIEW ARTICLE)

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The Effect of Fiber Consumption on Metabolic Health and Oral Surface Cleanliness

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World Journal of Advanced Research and Reviews, 2025, 28(01), 1279-1284

Publication history: Received on 08 September 2025; revised on 13 October 2025; accepted on 16 October 2025

Article DOI: https://doi.org/10.30574/wjarr.2025.28.1.3545

Abstract

Background and aim: Fiber plays a crucial role in maintaining human health. A recommended diet is one that provides an adequate amount of dietary fiber. Healthier dietary habits, particularly an increased intake of fiber, can contribute to the prevention of both periodontal diseases and systemic metabolic disorders. This study aims to analyze the effects of fiber consumption on oral health and cleanliness as well as overall systemic health.

Purpose: To evaluate the impact of dietary fiber consumption on oral surface cleanliness and systemic metabolic health, with emphasis on its potential role in preventing periodontal diseases and metabolic disorders.

Methods: This research employed a literature review method using PubMed and Google Scholar databases. A total of six relevant studies were selected for analysis.

Results: Increased dietary fiber intake was associated with improved oral cleanliness, enhanced insulin sensitivity, and a lower incidence of obesity, cardiovascular disease, and metabolic syndrome. The mechanical properties of fibrous foods contributed to oral biofilm reduction, while systemic effects supported overall metabolic regulation.

Conclusion: Dietary fiber plays an essential role in maintaining oral health and preventing systemic diseases. Diet composition may also influence the body's response to periodontal therapy. Moreover, dietary fiber can help reduce body weight in obese individuals and assist those with insulin resistance in controlling blood glucose levels.

Keywords: Teeth; Food; Metabolism; Fiber; Oral Health; Systemic Health

1. Introduction

The oral cavity consists of various structures and tissue surfaces that are influenced daily by mechanical and chemical factors, including variations in food intake (1). In recent years, oral health has been considered a predictor of systemic mortality. This relationship can be explained through two main mechanisms: the inflammatory effects of chronic periodontal infections on the circulatory system and the effects of masticatory dysfunction on dietary behavior, nutrition, and systemic diseases (2). Teeth are the only non-shedding surfaces attached to the human body, and these stagnant surfaces provide opportunities for a high accumulation of microbial biofilm. A high-fiber diet is believed to prevent the formation of dental biofilm by physically disrupting its formation as a natural result of oral processes, mastication, and the consumption of fibrous foods. Most of the evidence supporting the mechanical effect of dietary fiber on dental calculus comes from animal studies, although several human studies have also supported this hypothesis (1).

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Dietary fiber, as defined by the American Association of Cereal Chemists International, refers to the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the small intestine (3). Optimal fiber intake can be achieved through the daily consumption of vegetables, legumes, grains, and vegetable oils. These foods are rich in essential nutrients such as vitamins, minerals, antioxidants, and fiber, providing the benefits of a healthy and balanced diet. Most nutrition experts recommend a fiber intake of 18 to 38 grams per day for adults, which is equivalent to about 8 to 20 grams per 1000 kcal. Meanwhile, the WHO, FAO, and EFSA recommend an average daily intake of 25 grams of fiber for adults (4). Global dietary guidelines encourage the consumption of fiber-rich foods across all age groups. According to the Dietary Guidelines for Americans, the Adequate Intake (AI) for children aged 1 to 3 years is 19 grams per day, and for those aged 2 to 3 and 4 to 8 years, the AI is 14 grams per 1000 kcal. According to the European Food Safety Authority (EFSA), the AI for children aged 1 to 3 and 4 to 6 years is 10 grams per day and 14 grams per day, respectively. In Australia, the recommended AI for dietary fiber is 14 grams per day for children aged 1 to 3 years and 18 grams per day for those aged 4 to 8 years, while for infants aged 0 to 12 months, no AI has been established (3).

There are two forms of dietary fiber based on their solubility in water: soluble fiber and insoluble fiber. Soluble fiber forms a colloidal solution in the intestine when combined with water, which can slow digestion and nutrient absorption, leading to prolonged satiety, reduced appetite, and a lower glycemic index of foods. Insoluble fiber, on the other hand, remains intact throughout the digestive system, accelerates intestinal transit, and plays an important role in the body's detoxification process. Soluble fibers include pectin, beta-glucans, and oligosaccharides. The richest sources of soluble fiber are apples, pears, citrus fruits, carrots, broccoli, peas, cucumbers, celery, and oats. Both soluble and insoluble fibers are present in varying amounts in plant-based foods. The most fiber-rich foods include cereal bran (wheat and oats), whole grains, legumes (lentils and beans), and dried fruits (plums and apricots) (4).

Metabolic syndrome (MetS) is a cluster of conditions that increase the risk of several chronic diseases, including cardiovascular disease (CVD) and type 2 diabetes mellitus (T2DM). Conditions associated with MetS include obesity, hypertension, hyperglycemia or insulin resistance, and dyslipidemia. The most commonly used diagnostic criteria for MetS are those from the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) and the International Diabetes Federation (IDF), both of which include fasting plasma glucose, blood pressure, triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and body fat. According to the National Health and Nutrition Examination Survey in the United States, the overall prevalence of MetS increased from 32.9 percent in 2003–2004 to 34.7 percent in 2011–2012. These estimates indicate the urgent need to control and prevent MetS (3).

Higher natural dietary fiber intake is associated with a lower incidence of metabolic diseases such as obesity, diabetes, and cardiovascular disease, and it plays an important role in intestinal health. Increased intake of neutral detergent fiber (NDF) produces various physiological effects both locally in the gut and systemically. For instance, NDF can significantly alter the intestinal environment, influence the gut microbiome, and affect gastrointestinal immune and endocrine responses, nitrogen cycling, and microbial metabolism. These gut-related changes may subsequently alter the physiology and biochemistry of other major organs involved in nutrient management and detoxification, such as the liver and kidneys (4).

Therefore, this study aims to analyze the effects of fiber consumption on oral health and cleanliness as well as on systemic health

2. Methodology

2.1. Search Strategy

Articles were searched using predetermined databases in January 2023. The literature search was conducted through PubMed and Google Scholar databases. The keyword used in this literature search was "fiber diet and dental health." Articles outside of this keyword were not included in the search.

2.2. Inclusion Criteria

The inclusion criteria used in this study were as follows: the literature must be available in full text, written in English, published as a journal article or accepted manuscript, involve human subjects, include participants of various age groups, and employ an observational cross-sectional study design.

2.3. Exclusion Criteria

The exclusion criteria used in this study were as follows: literature written in languages other than English, studies involving non-human subjects, and articles that were not available in full text or open access.

2.4. Quality Assessment and Data Synthesis Strategy

The literature was identified based on the specified keyword search and selected according to title and abstract relevance. The full text of each article was then reviewed to determine whether the study met the inclusion and exclusion criteria established for this research.

3. Result

Based on the results of the literature search, six studies were identified as relevant to the keywords used in this research. Five of these studies demonstrated a correlation between fiber consumption and systemic health, while two studies revealed an association between fiber intake and oral and dental health. Table 1 presents the data extracted from the six studies that were identified.

4. Discussion

The classification of carbohydrates is based on molecular size. While sugars (one to two monomers) and most oligosaccharides (three to nine monomers) are digestible, polysaccharides containing ten or more monomers are generally indigestible. Although technically classified as carbohydrates, the inability of these compounds to be digested, which is related to their molecular size, defines the essential nature of dietary fiber.

The classification of dietary fiber is also based on water solubility. In general, there are two main types of dietary fiber: soluble and insoluble. The primary sources of soluble fiber are fruits and vegetables, whereas cereals and wheat products are the main sources of insoluble fiber. However, most naturally available high-fiber foods contain varying proportions of both soluble and insoluble fibers. Although fermentation through the action of gut microbiota occurs for most dietary fibers to some extent within the digestive tract, the fermentation of soluble fibers tends to occur more readily compared to the fermentation of insoluble cereal fibers (5).

Table 1 Data Extraction

Author	Year	Resarch Findings
Chen et al (3)	2018	Dietary fiber intake was inversely associated with the risk of metabolic syndrome (MetS), and this relationship was supported by several mechanistic studies. However, the findings were limited by the small number of cohort studies; therefore, no definitive conclusion could be drawn at this time. Further validation is needed due to high heterogeneity in cross-sectional studies and the lack of statistical significance in cohort analyses. Because of several inherent limitations in the original studies, potential confounding factors such as physical activity should be considered (for example, through statistical adjustment) in future research. The influence of different types of fiber on the risk of MetS is also an interesting area for further investigation. Overall, this meta-analysis suggests that well-designed prospective studies are required to confirm the association between dietary fiber intake and MetS risk.
Joye et al (6)	2020	Higher consumption of whole grains as a source of dietary fiber is associated with a lower risk of cardiovascular disease, diabetes, obesity, and certain digestive disorders. However, despite the well-documented benefits of dietary fiber consumption, the intake level remains below the recommended range. The same is true for the consumption of whole-grain products.
Ioniță-Mîndrican et al (4)	2022	Dietary fiber is an essential nutrient that provides numerous benefits to the human body. It has no caloric value but is required for the normal functioning of the digestive tract and overall health. Although it is neither digested nor absorbed, dietary fiber supports optimal intestinal function and contributes to body detoxification. Its main role is to prevent constipation and improve intestinal motility. Fiber is also important in weight management because it promotes long-term satiety and plays a significant role in preventing chronic diseases.
Barber et al (5)	2020	Dietary fiber plays a crucial role in supporting overall metabolic health, primarily through pathways involving insulin sensitivity. Furthermore, a clear association

		exists between dietary fiber intake and several pathologies including cardiovascular disease, colon health, intestinal motility, and colorectal cancer risk. Fiber intake is also correlated with mortality rates. The gut microbiota acts as an important mediator of the beneficial effects of dietary fiber, including appetite regulation, metabolic processes, and chronic inflammatory pathways.
Inomata et al (2)	2014	A significant association was observed between occlusal force and the intake of vegetables, as well as nearly all vitamins and minerals, after adjustment for socioeconomic factors. Moreover, after further adjustment for the number of remaining teeth, participants with higher occlusal force exhibited substantially greater intake of vitamins A, C, B6, folate, and dietary fiber.
Mendonça et al (7)	2019	The presence of periodontitis and tooth loss was associated with poor dietary patterns characterized by reduced intake of nutrients and healthy foods essential for cardiovascular prevention. In addition, higher triglyceride levels were observed in individuals with periodontitis compared to those without it. The findings indicate that the presence of periodontitis in patients with coronary artery disease (CAD) is linked to changes in dietary intake that may contribute to an increased risk of cardiovascular disease.
Nielsen et al (8)	2016	Dietary fiber intake was inversely associated with periodontal disease among adults in the United States aged 30 years and above. Using NHANES 2009–2012 data (n = 6,052), the study found that participants in the lowest quartile of fiber intake had a significantly higher risk of moderate-to-severe periodontitis (OR: 1.30; 95% CI: 1.00–1.69) compared to those in the highest quartile. Whole-grain intake also showed an inverse association with disease severity, while fruit and vegetable intake was not significantly related. These findings suggest that adequate fiber consumption, particularly from grains, may reduce inflammatory oral diseases such as periodontitis and contribute to better oral and systemic health.
Swarnamali et al (9)	2023	This systematic review and meta-analysis evaluated six human interventional studies investigating dietary fiber and periodontal disease. The pooled results revealed that fiber-rich diets significantly reduced several periodontal parameters, including Clinical Attachment Loss (−0.48 mm), Bleeding on Probing (−27.6%), Periodontal Inflamed Surface Area (−173.9 mm^2), Plaque Index (−0.02), and Gingival Index (−0.41), with a non-significant reduction in Probing Depth. The findings highlight the anti-inflammatory effects of dietary fiber, supporting its potential role in improving oral surface cleanliness and periodontal health, which may indirectly benefit metabolic regulation
Liang et al (10)	2024	Using NHANES 2015–2020 data, this cross-sectional study examined 2,412 diabetic patients to explore the association between the dietary fiber-to-carbohydrate ratio (FCR) and dental caries. Participants with higher FCR (≥0.13) had significantly lower odds of untreated dental caries (OR: 0.72; 95% CI: 0.52–0.99) and dental caries experience (OR: 0.63; 95% CI: 0.42–0.93) compared to those with lower FCR (<0.13). The study concluded that higher fiber intake relative to carbohydrates is linked to better oral health and may reduce caries risk among diabetic individuals by promoting oral surface cleanliness and metabolic balance.

In recent years, growing evidence has suggested a bidirectional relationship between periodontal disease and nutrition or dietary intake, meaning that periodontal disease can influence diet, and diet can also affect periodontal disease. For instance, individuals with periodontitis tend to consume less fiber compared to those with a healthy oral condition. A diet high in fiber and low in fat improves periodontal disease markers in high-risk subjects. Diet may also influence the response to periodontal therapy, as higher intake of fruits, vegetables, and antioxidant nutrients has been associated with enhanced periodontal healing. Periodontitis has been linked to four specific types of food such as fried foods, nuts, sweets, and fruits, as well as to the consumption of monounsaturated fatty acids below the recommended nutritional levels and elevated blood triglyceride concentrations. Moreover, patients with more than twenty teeth are more likely to consume the recommended amount of fiber and have higher total caloric intake. Conversely, having fewer teeth is associated with lower fiber and total energy intake. Individuals with twenty or more teeth have significantly higher fiber intake compared to those with fewer than twenty teeth. Fruits, vegetables, and whole grains are good sources of fiber and micronutrients such as magnesium, potassium, folate, and vitamin E, all of which are consumed in smaller

quantities by participants with fewer than twenty teeth in this study (7). Nielsen et al. (8) further supported this association by showing that dietary fiber intake was inversely related to periodontal disease among adults aged 30 years and older in the United States. Using NHANES 2009–2012 data (n = 6,052), they found that individuals in the lowest quartile of fiber intake had a 30% higher risk of developing moderate-to-severe periodontitis compared to those in the highest quartile (OR: 1.30; 95% CI: 1.00–1.69). Whole-grain intake was also inversely associated with disease severity, indicating that sufficient fiber consumption—particularly from grains—may help reduce inflammation-related oral diseases and promote overall systemic health.

A systematic review and meta-analysis that included six human interventional studies, strengthening this evidence through experimental findings. They reported that fiber-rich diets significantly improved several clinical periodontal parameters, including reductions in clinical attachment loss (−0.48 mm), bleeding on probing (−27.6%), periodontal inflamed surface area (−173.9 mm^2), plaque index (−0.02), and gingival index (−0.41). These results demonstrate the anti-inflammatory and oral cleansing effects of fiber, highlighting its role in maintaining periodontal health and potentially supporting metabolic balance through the reduction of systemic inflammatory markers (9). In addition, Liang et al. (10) explored the link between dietary fiber and dental caries in diabetic patients using NHANES 2015–2020 data (n = 2,412). They found that a higher dietary fiber-to-carbohydrate ratio (FCR ≥ 0.13) was associated with significantly lower odds of untreated dental caries (OR: 0.72; 95% CI: 0.52–0.99) and dental caries experience (OR: 0.63; 95% CI: 0.42–0.93). These findings suggest that increasing fiber intake relative to carbohydrate consumption may improve oral surface cleanliness, reduce cariogenic bacterial activity, and contribute to better metabolic stability, particularly in populations with diabetes. Together, these studies demonstrate that dietary fiber plays a dual role—supporting oral health by reducing inflammation and plaque accumulation, and promoting metabolic health by regulating glycemic control and reducing systemic inflammatory burden. This dual mechanism underscores the importance of adequate fiber intake as a preventive strategy against both oral and systemic diseases.

Dietary fiber can promote weight loss in overweight or obese individuals and prevent weight regain. The mechanisms by which dietary fiber affects obesity are thought to involve energy dilution, reduced nutrient absorption rates, appetite suppression, regulation of energy homeostasis, and modulation of gut microbiota turnover. The level of dietary fiber consumption, solubility and viscosity, fermentability, and molecular structure can lead to differences in weight regulation (3). In whole grains, the fiber contained may include β-glucan. Compared to cellulose, a structurally related polymer composed exclusively of β-1-4 linked D-glucose units, β-glucan has been shown to increase postprandial satiety and reduce body weight, BMI, and total energy intake. Consumption of β-glucan from cereal sources has been shown to significantly reduce body weight and BMI. The mechanism behind prolonged satiety is likely related to the gel-forming ability of soluble β-glucan and other soluble fibers, as well as the bulking effect of insoluble fibers. Additionally, the release of appetite-suppressing hormones such as cholecystokinin has been observed in response to β-glucan consumption at a minimum dose of 3.8 g per day.

In patients with insulin resistance, fiber helps improve the glycemic index (GI) of foods, reduce the risk of obesity, enhance glucose homeostasis, regulate hormonal responses, modulate inflammatory cytokines, and alter gut microbiota composition. The effect of dietary fiber on GI is related to its physicochemical properties, including particle size, fiber amount and type, viscosity, amylose and amylopectin content, delayed gastric emptying time, and reduced glucose absorption (3). Cereal-derived dietary fiber has been found effective in reducing postprandial blood glucose response and improving insulin response. Soluble dietary fiber has the capacity to increase the viscosity of gastric contents. The increased intestinal viscosity caused by cereal fibers plays a key role in reducing glucose absorption. Higher viscosity also slows gastric emptying and decreases the rate of starch digestion, including the production of related monosaccharides and disaccharides. Consequently, this high viscosity may lead to delayed glucose absorption. The slower digestion rate may also result from the formation of a thick layer around the food bolus, which limits digestive enzyme access to the bolus interior and reduces contact with the absorptive surfaces of the gastrointestinal tract (6).

Highly viscous soluble fibers can reduce plasma cholesterol levels more effectively than insoluble fibers or fibers with very low viscosity. The cholesterol-lowering effect of soluble dietary fiber may be associated with increased fecal bile acid excretion, reduced postprandial glycemic response, and fermentation products of soluble dietary fiber. The cholesterol-lowering effects of insoluble fiber have been observed in several studies, and the mechanism is believed to involve the promotion of satiety and fullness. Despite its positive effects on blood cholesterol, fiber intake has not been shown to significantly affect triglyceride reduction or HDL-C increase. Furthermore, dietary fiber supplementation or a high-fiber diet intervention can lead to a statistically significant reduction in diastolic blood pressure. The mechanisms underlying the blood pressure-lowering effects of dietary fiber remain unclear. Increasing dietary fiber intake may reduce hypertension risk by controlling contributing factors such as improving insulin resistance and lowering LDL-C. High fiber intake may also modify the gut microbiota composition and enhance the abundance of acetate-producing bacteria (3).

5. Conclusion

Dietary fiber intake contributes significantly to both oral and systemic health. From an oral perspective, fibrous foods enchance salivary secretion and exert a natural mechanical cleansing effect on tooth surfaces, reducing biofilm accumulation and promoting overall oral cleanliness. Diet can influence the response to periodontal therapy, as a higher intake of fruits, vegetables, and antioxidant nutrients has been associated with improved periodontal tissue healing. Dietary fiber can help individuals who are overweight or obese to lose weight and maintain a healthy body weight. Fiber may assist individuals with insulin resistance by improving the glycemic profile of foods, reducing the risk of obesity, enhancing glucose homeostasis, regulating hormonal responses, modulating inflammatory cytokines, and altering gut microbiota composition. The cholesterol-lowering effect of soluble dietary fiber may be attributed to increased fecal bile acid excretion, a reduced glycemic response to food intake, and the fermentation products of soluble dietary fiber. Collectively, these findings highlight that adequate fiber consumption not only benefits metabolic functions but also plays an essential role in maintaining oral hygiene and preventing periodontal disease.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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