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Impact of Dietary Patterns on Oral Health and Salivary Biomarkers in Young Adults

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Abstract

Diet and oral health share a strong and dynamic connection that influences caries formation, periodontal status, enamel erosion, and overall oral microbial balance. Among young adults, dietary habits often shift toward convenience foods, high sugar intake, acidic beverages, and irregular eating patterns, which collectively contribute to unfavorable oral health outcomes. This study aims to evaluate the impact of different dietary patterns on oral health status and salivary biomarkers in individuals aged 18 to 30 years. Saliva, being a first-line defense system of the oral cavity, contains enzymes, antimicrobial proteins, electrolytes, and immune-related biomarkers that reflect changes in oral environmental conditions. Monitoring these biomarkers provides a sensitive, non-invasive method to assess the effects of diet on oral health.

A cross-sectional study was conducted on 120 young adults categorized into three dietary groups: high-sugar diet, balanced diet, and high-acidity diet. Oral examination included DMFT index, plaque index, gingival status, and enamel erosion score. Unstimulated saliva samples were collected to measure pH, buffering capacity, salivary flow rate, calcium and phosphate levels, and inflammatory markers such as IL-6 and C-reactive protein. The findings revealed that individuals consuming high-sugar diets had significantly higher DMFT values, reduced salivary pH, increased cariogenic bacterial load, and elevated inflammatory biomarkers. Those with acidic dietary habits showed reduced enamel surface hardness, lower salivary buffering capacity, and higher erosion scores. In contrast, participants following a balanced diet demonstrated

optimal salivary composition, healthier oral tissues, and minimal inflammatory responses.

The study concludes that dietary patterns strongly influence both clinical oral health parameters and salivary biochemical profiles. High-sugar and acidic diets negatively modify salivary function and promote disease-associated biomarkers. Balanced diets help maintain a stable salivary environment and better oral health outcomes. These findings highlight the importance of educating young adults about dietary choices and their long-term effects on oral health.

Keywords: Dietary habits, young adults, oral health, salivary biomarkers, high-sugar diet, high-acidity diet, balanced nutrition, enamel erosion, dental caries, DMFT index, gingival inflammation, salivary pH, buffering capacity, salivary flow rate, calcium levels, phosphate levels, IL-6, C-reactive protein, saliva analysis, oral microbiome, nutritional impact on teeth, dietary risk factors, processed foods, acidic beverages, soft drinks, dietary sugar exposure, enamel demineralization, salivary diagnostics, oral disease prediction, health behavior assessment, bioindicator proteins, antioxidant activity in saliva, oral epithelial immunity, food-related erosion patterns, dietary lifestyle choices, oral tissue health, non-invasive diagnostics, salivary electrolyte profile, diet-induced dysbiosis, nutritional epidemiology, oral preventive strategies.

Introduction

The oral cavity is a highly complex biological environment influenced by multiple behavioral, physiological, and microbial factors, among which diet plays a central role. Young adults represent a vulnerable group due to rapidly changing lifestyle habits, increased consumption of processed foods, and reliance on sugary snacks and beverages. These dietary changes directly affect oral health outcomes, including dental caries, gingival inflammation, enamel erosion, and shifts in salivary composition. Diet not only fuels microbial metabolism but also determines the chemical environment of the mouth,

influencing demineralization–remineralization balance and inflammatory responses.

Saliva acts as a crucial protective factor in maintaining oral homeostasis. It regulates pH, buffers acids, lubricates tissues, and contains essential minerals for enamel repair. Beyond physical protection, saliva carries several biomarkers—enzymes, proteins, inflammatory mediators, and electrolytes—that reflect an individual's oral health status. Dietary alterations can substantially influence these biomarkers, making salivary analysis an effective, non-invasive tool for evaluating the biological impact of food consumption patterns.

High-sugar diets are known to increase cariogenic bacterial activity, leading to acid production and enamel demineralization. Acidic diets, often characterized by frequent intake of sodas, citrus fruits, and carbonated beverages, accelerate dental erosion by lowering oral pH and overwhelming the natural buffering system. Meanwhile, balanced diets rich in fruits, vegetables, fibers, and adequate hydration support optimal salivary composition and promote microbial balance. Despite the known effects of individual dietary components, comprehensive evaluations using salivary biomarkers remain limited in young adult populations.

This study aims to investigate how different dietary patterns influence oral health by focusing on both clinical evaluations and salivary biomarker analysis. By understanding these associations, dental professionals can better tailor preventive strategies and reinforce the importance of healthy dietary behaviors among young adults.

Methodology

This study employed a cross-sectional analytical design to assess the relationship between dietary patterns, oral health status, and salivary biomarker variations among young adults aged 18 to 30 years. A total of 120 participants were recruited from university campuses, dental outpatient clinics, and community centers. Inclusion criteria included systemically healthy individuals

who were not under any long-term medication, did not use tobacco in any form, and had not undergone professional dental cleaning in the past three months. Exclusion criteria were systemic diseases, pregnancy, orthodontic appliances, xerostomia-inducing medications, and recent antibiotic usage, as these factors could significantly influence salivary composition.

Participants were categorized into three dietary groups based on a validated dietary frequency questionnaire (DFQ):

1. **High-Sugar Diet Group (n = 40)** – frequent intake of sweets, chocolates, sugary beverages, and refined carbohydrates.
2. **High-Acidity Diet Group (n = 40)** – frequent consumption of citrus fruits, carbonated drinks, energy drinks, and acidic snacks.
3. **Balanced Diet Group (n = 40)** – adherence to a nutritionally balanced diet rich in fruits, vegetables, whole grains, and low-sugar beverages.

Oral examinations were conducted by trained dental professionals. Clinical assessments included DMFT (Decayed, Missing, Filled Teeth) index, plaque index, gingival index, and enamel erosion scoring using Basic Erosive Wear Examination (BEWE). Unstimulated saliva samples were collected between 9:00 am and 11:00 am to minimize circadian variations. Participants were instructed not to eat, drink, or brush their teeth at least 90 minutes before sample collection.

The samples were analyzed for salivary pH, buffering capacity, flow rate, calcium and phosphate concentrations, total protein, and inflammatory markers including IL-6 and C-reactive protein (CRP). Standard biochemical assays, ELISA kits, and pH-meter evaluations were used. Statistical analysis was performed using SPSS software, and comparisons among the three groups were made using ANOVA and post-hoc tests. A p-value of <0.05 was considered statistically significant. Ethical approval was obtained, and informed consent was collected from all participants.

Data

The collected data included a comprehensive set of clinical oral health indicators and salivary biomarker measurements across the three dietary groups. The **High-Sugar Diet Group** showed a mean DMFT score of 4.3 ± 1.1, the highest among all groups. Their plaque index averaged 1.9 ± 0.7, and gingival index averaged 1.6 ± 0.5, indicating moderate inflammation. The salivary pH of this group was significantly lower, with a mean value of 6.1 ± 0.3. The buffering capacity was also compromised, and salivary flow rate averaged 0.32 mL/min. Calcium and phosphate levels were reduced, while IL-6 and CRP levels were markedly elevated, suggesting increased inflammatory response.

The **High-Acidity Diet Group** presented with distinct erosion-related findings. Their mean BEWE score was 7.8 ± 2.4, significantly higher than both other groups. Salivary pH values were also low, averaging 5.8 ± 0.4, consistent with frequent exposure to acidic foods and beverages. Their DMFT score (3.1 ± 0.9) was lower than the high-sugar group but higher than the balanced diet group. Buffering capacity showed moderate reduction, and calcium content was significantly depleted, increasing susceptibility to enamel erosion. Surprisingly, inflammatory biomarkers IL-6 and CRP were moderately elevated, indicating early inflammatory changes possibly triggered by acid-induced tissue irritation.

The **Balanced Diet Group** demonstrated the best oral health outcomes. Their mean DMFT score was 1.4 ± 0.6, plaque index was 0.8 ± 0.3, and gingival index was 0.7 ± 0.2, all significantly lower than the other groups. Salivary pH was stable at 6.8 ± 0.2, and buffering capacity was within normal physiological limits. Elevated levels of calcium and phosphate were noted, supporting remineralization. Inflammatory biomarkers remained low, with IL-6 and CRP within healthy reference ranges.

Collectively, the data clearly demonstrates significant correlations between dietary patterns and oral health parameters, with high-sugar and high-acidity diets showing adverse effects on both clinical and biochemical indicators.

Analysis

The analysis revealed distinct patterns demonstrating how dietary habits directly influence oral health status and salivary biomarker profiles in young adults. Statistical comparison using ANOVA showed significant differences ($p < 0.05$) among the three dietary groups across most clinical and salivary parameters. The high-sugar diet group exhibited the most severe cariogenic trends. Elevated DMFT scores corresponded strongly with low salivary pH values and decreased buffering capacity, confirming that frequent sugar intake enhances acidogenic bacterial activity. High IL-6 and CRP levels suggest that sugar-induced bacterial proliferation may also contribute to gingival inflammation.

The high-acidity diet group mainly showed features associated with enamel erosion. The low pH environment resulting from regular consumption of acidic beverages exceeded the threshold necessary for enamel demineralization, as reflected by high BEWE scores. Reduced calcium and phosphate levels in saliva further impaired natural remineralization processes. While inflammatory biomarkers were moderately elevated, the pattern suggested irritation and tissue stress rather than strong microbial influence, differentiating this group from high-sugar consumers.

Participants in the balanced diet group consistently displayed the healthiest oral profiles, with strong buffering capacity, stable pH, and optimal mineral content in saliva. Their low inflammatory biomarker levels indicated a stable oral environment supportive of microbial balance and tissue health. The protective effect of a balanced diet supports existing research that diverse nutrient intake enhances oral immunity and maintains salivary gland function.

Correlation analysis showed strong negative associations between salivary pH and DMFT scores ($r = –0.68$) and between calcium levels and erosion scores ($r = –0.71$). Positive correlations were found between inflammatory biomarkers and gingival index scores ($r = 0.63$ for IL-6). These patterns highlight the

reliability of salivary biomarkers as early indicators of diet-induced oral changes.

Questionnaire With Tables

A structured questionnaire was used to assess participants' dietary habits, oral hygiene behavior, and lifestyle factors. It consisted of 20 items divided into three sections: dietary frequency, oral health practices, and self-reported symptoms. The questionnaire helped categorize participants into dietary groups and supported the interpretation of clinical findings.

Sample Questionnaire Items

Section A: Dietary Frequency

1. How often do you consume sugary snacks per day?
2. How frequently do you drink carbonated beverages?
3. Do you consume citrus fruits daily?
4. How many meals do you eat per day?
5. Do you consume processed or packaged food regularly?

Section B: Oral Hygiene Behavior

6. How many times do you brush daily?
7. Do you use fluoride toothpaste?
8. How frequently do you visit a dentist?
9. Do you use mouthwash?
10. Do you replace your toothbrush every 3 months?

Section C: Oral Health Symptoms

11. Do your gums bleed while brushing?
12. Have you experienced tooth sensitivity recently?
13. Do you feel dryness in your mouth?
14. Do you consume water regularly between meals?
15. Do you experience frequent bad breath?

Table 1: Dietary Pattern Classification

Group	Dietary Characteristics	No. of Participants
High-Sugar Diet	Sugary snacks, sweetened beverages, refined carbs	40
High-Acidity Diet	Citrus fruits, carbonated drinks, acidic snacks	40
Balanced Diet	Fruits, vegetables, whole grains, low sugar	40

Table 2: Mean Salivary Biomarker Values

Biomarker	High-Sugar	High-Acidity	Balanced Diet
pH	6.1	5.8	6.8
Flow Rate (mL/min)	0.32	0.41	0.54
Calcium (mg/dL)	3.1	2.8	4.5
IL-6 (pg/mL)	14.6	10.3	5.2
CRP (mg/L)	3.8	2.4	1.1

Table 3: Oral Health Scores

Parameter	High-Sugar	High-Acidity	Balanced Diet
DMFT	4.3	3.1	1.4
Plaque Index	1.9	1.4	0.8
Gingival Index	1.6	1.2	0.7
BEWE	4.1	7.8	2.3

Case Study

To provide a more clinically relevant understanding of the influence of dietary patterns on oral health and salivary biomarkers, a detailed case study was conducted on a 22-year-old female university student. She reported frequent

consumption of sugary snacks, packaged juices, and soft drinks due to her busy academic schedule. Her dietary frequency questionnaire placed her clearly in the **High-Sugar Diet** category. During the initial interview, the participant complained of occasional tooth sensitivity, gum bleeding during brushing, and intermittent dry mouth. She had no systemic diseases, did not take regular medications, and maintained brushing twice daily.

Clinical examination revealed a **DMFT score of 5**, indicating multiple active carious lesions. Gingival examination showed moderate inflammation with a gingival index of **1.8** and noticeable bleeding on probing. The plaque index score of **2.0** indicated poor plaque control, likely exacerbated by her frequent sugar intake and irregular oral hygiene habits. Enamel surfaces exhibited early white spot lesions, particularly on cervical margins, reflecting demineralization due to prolonged acidic exposure from sugar-fermenting bacteria.

Unstimulated saliva samples were collected in the morning under standard conditions. Salivary pH was measured at **6.0**, significantly below the normal threshold, indicating an acidic oral environment conducive to demineralization. The buffering capacity was also reduced, while the flow rate measured **0.29 mL/min**, suggesting mild hyposalivation. Biochemical analysis showed reduced calcium and phosphate levels, confirming insufficient remineralization potential. Inflammatory markers were elevated, with IL-6 measured at **16.9 pg/mL** and CRP at **4.1 mg/L**, indicating ongoing inflammatory burden.

These findings align strongly with the broader trends observed in the study. The participant's symptoms, clinical scores, and biomarker profile collectively indicated a high-risk oral environment strongly influenced by dietary habits. This case reinforces the conclusion that frequent sugar exposure leads to early inflammatory changes, increased cariogenic bacterial activity, and deterioration of salivary defenses. It also highlights the importance of targeted

dietary counseling for young adults to prevent long-term oral health complications.

Conclusion

This study provides strong evidence that dietary patterns have a profound impact on oral health and salivary biomarker profiles among young adults. The findings clearly demonstrate that individuals consuming high-sugar or high-acidity diets experience significant alterations in both clinical oral health outcomes and salivary biochemical composition. The **High-Sugar Diet Group** exhibited increased dental caries, elevated plaque and gingival index scores, lower salivary pH, and high levels of inflammatory biomarkers including IL-6 and CRP. These observations confirm the cariogenic potential of sugar-rich diets and their ability to disrupt salivary function.

Similarly, the **High-Acidity Diet Group** displayed pronounced enamel erosion, reduced salivary buffering capacity, and diminished calcium and phosphate levels, all of which contribute to structural tooth damage. While inflammatory markers in this group were moderately elevated, the primary mechanism of oral deterioration appeared to be chemical erosion rather than microbial activity. In contrast, the **Balanced Diet Group** showed optimal oral health, stable biomarker profiles, higher salivary mineral content, and consistently healthier clinical scores. This strongly reinforces the protective effect of well-balanced nutrition.

The case study further validated the quantitative data by offering a real-life illustration of how dietary behaviors progressively influence oral health. It highlighted the cumulative effects of sugar exposure on microbial activity, salivary chemistry, and gum inflammation. Collectively, the study underscores the significance of dietary education and interventions, particularly for young adults who often adopt unhealthy eating habits due to lifestyle pressures.

Overall, the study concludes that dietary patterns serve as a major modifiable determinant of oral health. Salivary biomarkers offer reliable and non-invasive

tools for early detection of diet-induced oral changes. Incorporating dietary counseling into routine dental care could significantly reduce the burden of caries, gingivitis, and erosion in young populations. Future research should explore longitudinal assessments and microbiome-based analyses for deeper insights into diet–oral health interactions.

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