Effects of Acidic Beverages on Teenagers Dental Enamel – A literature review

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Abstract

1.Background/Objectives: This review article explores the significant relationship between dietary choices, particularly the consumption of acidic and sugary beverages, and oral health outcomes. Understanding the impact of these dietary factors is essential for developing preventive strategies and promoting healthier habits. 2.Methods: A comprehensive analysis of recent studies was conducted to evaluate the effects of acidic and sugary beverages on dental health, focusing on dental erosion, caries development, and changes in salivary ph. Additionally, the role of marketing strategies in influencing consumer behavior was examined. 3.Results: Findings indicate that frequent consumption of acidic beverages leads to enamel erosion and contributes to caries formation. Public health initiatives aimed at educating individuals about healthier dietary choices play a crucial role in mitigating these effects. Furthermore, marketing strategies significantly influence beverage consumption patterns, highlighting the need for targeted interventions. 4.Conclusion: The evidence underscores the necessity of preventive measures, including dietary counseling and improved oral hygiene practices, to reduce the adverse effects of acidic and sugary beverages. Further research is needed to explore the long-term implications of dietary habits on oral health and to develop effective intervention strategies.

Keywords: oral health, acidic beverages, sugary drinks, dental erosion, salivary pH, preventive measures

INTRODUCTION

Teenagers' oral health problems today are closely linked to their dietary choices, particularly the consumption of food and beverages. Research shows that diet and oral health are interconnected in numerous ways [1,2]. Many adolescents are consuming high levels of sugar found in soft drinks and carbonated drinks, and inadequate dental hygiene further exacerbates their oral health issues.

Dental caries remains the leading cause of disease in both developed and developing countries [1]. The etiology of dental caries is multifactorial, influenced by socio-economic factors, behaviour, genetics, oral pH control, bacterial colonization and adhesion, the physicochemical properties of teeth, time, carbohydrate intake, and lifestyle [1,2,3]. Acidic foods and drinks, characterized by low pH levels, play a critical role in the development of dental erosion [1]. However, it is important to note that the pH of a food substance alone is not sufficient to cause erosion [1].

During the COVID-19 pandemic, there was a notable increase in the consumption of carbonated drinks among children, leading to a rise in the DMFT (Decayed, Missing, and Filled Teeth) index. The first carbonated beverages emerged in the latter half of the nineteenth century. Today, carbonated drinks based on fruit syrups are widely popular due to their refreshing taste [1,4,5]. Changes began in the 1890s, when industries developed beverage-based alternatives to cola extracts, initially thought to have medicinal properties [1,6]. The proliferation of manufacturing companies has made these beverages readily available, raising significant concerns about their cariogenic and erosive characteristics [7,8].

Research has highlighted certain foods and beverages with high acidity levels, such as fruits, fruit juices, alcoholic beverages, and carbonated drinks, as well as the timing of their consumption—whether during main meals or as snacks [9]. If left unaddressed, enamel erosion can lead to dentinal hypersensitivity and pain [10,11]. Dental erosion affects both primary and permanent dentition [12].

The consumption of soft drinks leads to a reduction in salivary pH [13]. A pH of 5.5 is recognized as the "critical pH" for enamel dissolution, while the critical pH for dentin is 6.8 [14]. Carbonated drinks exhibit extrinsic acidity, with pH values as low as 2.5 due to the carbonic acid formed when CO2 is added, alongside other acids like citric, phosphoric, and tartaric acids [8,15,16]. Factors such as the type and quantity of acids present, the buffering capacity, and the drink's temperature all contribute to its enamel-dissolving potential [17,18, 19]. Additionally, organic acids produced by the fermentation of sugar in beverages by oral microorganisms in plaque further contribute to demineralization and caries. The unique characteristics of dental enamel differ at both the macro- and micro-structural levels [20,21].

Thus, analyzing the mechanisms of enamel erosion requires a microscopic perspective [22,23]. The erosive power of these drinks has been studied chemically using Fourier infrared spectroscopy (micro FTIR) [24,25]. This review aims to assess findings from the past 10 years in comparison with current data to evaluate the evolution of teenage carbonated beverages consumption and its effects.

Frequent consumption of carbonated beverages among adolescents leads to a significant reduction in salivary and oral pH, resulting in increased enamel erosion and a higher risk of dental caries.

Aim and objectives

The main objective of this study is to evaluate the effects of carbonated drinks on the dental enamel of adolescents. Specifically, the study aims to analyze changes in pH and acid concentrations in carbonated beverages, assess the impact of these beverages on the integrity

of dental enamel, and identify correlations between the frequency of carbonated drink consumption and the severity of dental enamel deterioration.

MATERIAL AND METHODS

PubMed, Scopus, and Web of Science were searched for papers relevant to our topic, covering the period from January 1, 2012, to January 31, 2022, with a restriction to English-language publications. The search strategy utilized a combination of keywords aligned with our investigation's primary objective: studying the relationship between acidic drinks consumption and teenagers' oral health.

Eligibility Criteria

The inclusion criteria were as follows: (1) participants must be teenagers; (2) studies should be human in vivo or in vitro research; (3) publications must be in English; (4) only open access studies were considered; (5) articles and reviews needed to be published no later than 2012; (6) randomized clinical trials were included; (7) research must focus on the effects of carbonated drinks on dental enamel.

The exclusion criteria included: (1) animal studies; (2) publications in languages other than English; (3) non-open access studies; and (4) case reports/series, reviews, editorials, and book chapters published after 2012.

The review followed the PICOS criteria:

- **Participants:** Teeth from teenagers were included, both in vivo and in vitro.
- **Interventions:** Significant consumption of any acidic beverages.
- **Comparisons:** No significant consumption of any acidic beverages.
- **Outcomes:** Damage to dental enamel.

Study: Clinical trials on human teeth, encompassing both in vivo and in vitro studies.

RESULTS

The initial search provided a total of 350 items (PubMed n = 130, Scopus n = 120, WOS n = 100), and after removing 180 duplicates, 170 articles remained. A total of 156 articles progressed to the screening phase, when an additional 118 were excluded for lack of relevant data. Other 38 items were excluded for the following reasons: 22 due to lack of free full text, 3 involving animal studies, and 13 deemed off-topic, resulting in 20 records that met the eligibility criteria for inclusion. Of these, 4 were in vivo studies (Table 1), 4 were in vitro studies (Table 2), and 12 were reviews (Table 3). A PRISMA chart was included to visually summarize the process of selecting studies, ensuring transparency and reproducibility in the systematic review process (Figure.1) [26].

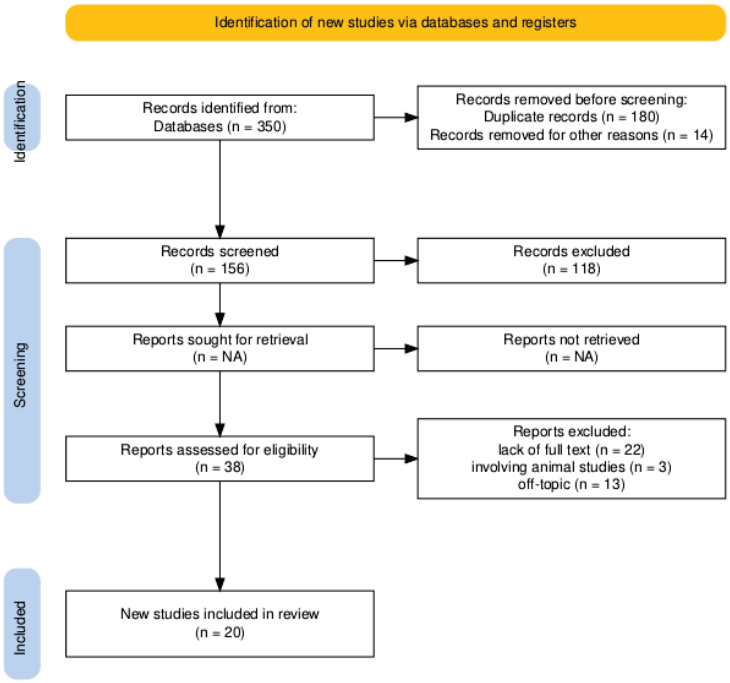

Figure 1. PRISMA flowchart of study selection

Table 1. Selected articles that included in vivo studies

Study	Year of publication	Focus of the Investigation	Type of Study	Sample Size	Results
Pachori et al. [3]	2018	Effects of foods and beverages on salivary pH	Clinical study measuring salivary pH	50	Various foods and beverages significantly changed salivary pH, with acidic foods lowering it notably.
Hadilou et al. [4]	2022	Impact of sugary and acidic beverages on dental caries	Cross-sectional study using DMFT index	5.006	Increased DMFT dex linked to frequent consumption of sugary and acidic beverages.
Al-Zwaylif et al. [8]	2018	Dietary acids and their effect on tooth wear	Clinical study measuring tooth wear	5,586	Strong correlation between dietary acid intake and increased tooth wear.
Hans et al. [12]	2016	Sugary beverages and their impact on salivary pH	Clinical study assessing salivary pH	120	Significant drop in salivary pH after sugary beverage consumption, affecting enamel demineralization.

Table 2. Selected articles that included in vitro studies

Study	Year of Publication	Focus of Investigation	Type of study	Sample Size	Results
Gondivkar et al.) [7]	2018	Erosive potential of soft drinks and fruit juices	In vitro study measuring enamel dissolution	21	High erosive potential observed in soft drinks and packaged fruit juices.
Morgado et al. [13]	2022	Impact of still and carbonated waters on dental erosion	In vitro analysis of enamel	105	Both still and carbonated waters affected dental erosion based on pH levels, with carbonated water posing higher risk.
Charpe MP et al. [20]	2019	Erosive potential of carbonated beverages on teeth	In vitro study examining enamel solubility	15	Significant increase in enamel solubility due to exposure to carbonated beverages.

Seredin et al. [21]	2022	Use of nanocrystalline hydroxyapatite for enamel protection	Laboratory study using nanocrystalline hydroxyapatite	50	Promising results for nanocrystalline hydroxyapatite in protecting enamel against acid-induced erosion.

Table 3. Selected review-type articles

Study	Year of Publication	Focus of Investigation	Type of Study	Sample Size	Results
Scardina & Messina [2]	2012	Relationship between diet and oral health	Literature review of clinical and epidemiological studies	N/A	Emphasized the role of a balanced diet in maintaining good oral health and preventing diseases.
Elmore B. [5]	2012	Beverage industry influence on public health	Policy analysis	N/A	Discussed the beverage industry's impact on public health and consumption patterns.
Johansson et al. [27]	2017	Increasing concern over dental erosion due to beverage consumption	Literature review	26	Linked growing dental erosion concerns with rising soft drink and juice consumption.
Kregiel D. [14]	2015	Health risks associated with soft drinks	Literature review on health risks	N/A	Highlighted microbial contamination and erosive impacts of soft drinks on dental enamel.
Barbour & Lussi [16]	2014	Nutrition and environmental factors contributing to dental erosion	Comprehensive review	N/A	Discussed how nutrition and environmental factors contribute to dental erosion.
Davari et al. [9]	2013	Review of dentin hypersensitivity and dietary factors	Literature review	N/A	Noted that acidic foods and drinks exacerbate dentin hypersensitivity through enamel erosion.
Buzalaf et al. [17]	2012	Role of saliva in protecting against dental erosion	Literature review	N/A	Emphasized saliva's protective role against dental erosion and the impact of acidic beverages.
Alcântara et al. [10]	2018	Lifestyle factors and cervical dentin hypersensitivity	Questionnaire-based clinical study	308	Identified a link between acidic diets and cervical dentin hypersensitivity symptoms.

The studies collectively highlight that acidic and sugary beverages significantly lower salivary pH, increasing the risk of enamel demineralization and dental caries. Frequent consumption of these beverages is consistently linked to higher DMFT scores, indicating greater tooth decay. Dietary acids, soft drinks, fruit juices, and carbonated beverages show strong erosive potential, contributing to enamel wear and dissolution.

DISCUSSIONS

The studies included in this review demonstrate a clear connection between dietary choices, particularly the consumption of acidic and sugary beverages, and oral health outcomes. The findings consistently highlight that:

Dietary Influence on Oral Health: The relationship between diet and oral health is multifaceted, with evidence indicating that acidic foods and beverages can lead to dental erosion and increase the risk of caries. Studies such as those by Pachori et al. (2018), in their

article "Effects of Foods and Beverages on Salivary pH," and Hadilou et al. (2022), in "Impact of Sugary and Acidic Beverages on Dental Caries," emphasize the need for increased awareness regarding the erosive potential of common dietary choices among adults.

Salivary pH and Erosion Risk: The importance of salivary pH as a protective factor against dental erosion is reinforced by multiple studies. The findings of Hans et al. (2016) in "Sugary Beverages and Their Impact on Salivary pH" suggest that frequent consumption of acidic beverages significantly lowers salivary pH, which can contribute to enamel demineralization and subsequent dental issues.

Impact of Beverage Marketing: Marketing strategies employed by beverage companies, as explored by Huse et al. (2022) in "Coca-Cola's Marketing Strategies and Soft Drink Consumption," play a significant role in shaping consumer behavior. The increasing consumption of sugary drinks, often marketed as refreshment, highlights the necessity for public health interventions aimed at reducing their intake to mitigate the associated oral health risks.

Preventive Measures and Interventions: There is a growing recognition of the need for preventive measures, including dietary counseling and education on oral hygiene practices, to minimize the impact of harmful dietary choices on dental health. The findings of Buzalaf et al. (2012) in "Role of Saliva in Protecting Against Dental Erosion" underscore the critical role of saliva in protecting against erosion, suggesting that maintaining salivary flow should be a focus of preventive strategies.

Future Research Directions: The literature indicates a significant gap in longitudinal studies that explore the long-term effects of dietary choices on oral health. Future research should aim to investigate the cumulative effects of dietary habits over time and identify effective interventions that can promote better oral health outcomes in diverse populations.

Enamel, despite being the hardest tissue in the body, remains susceptible to chemical exposure from substances found in sodas and other beverages [33]. Two key parameters for evaluating the damage caused by the acids in carbonated drinks are the roughness and hardness of the enamel surface. Research has indicated that increased roughness often represents the initial stages of enamel erosion [34]. Daily consumption of carbonated drinks significantly heightens the risk of tooth erosion [12, 40, 41]. Alarmingly, these beverages, now ubiquitous in modern society, frequently replace water as a primary source of hydration [33].

Dental issues rank among the most prevalent health concerns among young people [32]. The most commonly consumed acidic beverages include soft drinks and fruit juices [33]. Certain studies have shown that poor nutrition during childhood leads to carious surfaces on teeth [31]. These studies employed targeted maximum likelihood estimation to effectively address modeling challenges associated with longitudinal data in pediatric research [31,35,36]. Additionally, some in vivo studies have investigated the prevalence of dental caries in adolescents, attributing findings to inadequate oral hygiene and poor dietary habits [32].

Various factors influencing the erosive potential of different carbonated beverages and fruit juices have been explored [8]. The erosive potential of a beverage is notably impacted by its mineral content and its capacity to chelate calcium from foods and beverages [34]. Consequently, erosion is not solely determined by the pH of carbonated drinks, which is primarily influenced by the content of carbonic acid in dissolved carbon dioxide [24]. Daily consumption of soft drinks has been associated with dental deterioration, and drinking these beverages with meals correlates with both mild and severe tooth decay [9].

Saliva plays a critical role in physiological conditions, providing buffering capacity and forming a protective barrier that minimizes direct contact between enamel and acidic drinks, thus shielding teeth from acid attacks [8]. The rising consumption of carbonated drinks among children and adolescents contributes to increased dental erosion and caries [1,

9]. The issue of enamel erosion is particularly concerning for deciduous teeth [39]. Categories such as sports and energy drinks, fruit juices, and carbonated soft drinks rank among the most acidic beverages, significantly diminishing enamel surface hardness due to mineral loss. Participation in sports has been closely linked to erosive injuries, with dietary needs associated with various physical activities emerging as strong predictors of these injuries among teenagers [1, 22].

CONCLUSIONS

In conclusion, the evidence presented in this review underscores the significant impact that dietary choices, particularly the consumption of acidic and sugary beverages, have on oral health. The studies collectively emphasize the urgent need for public health initiatives focused on educating individuals about the potential risks associated with their dietary habits. Key takeaways from the research highlight the critical role of salivary pH and its relationship to dietary intake, with acidic beverages posing a notable risk to dental health. Additionally, the review calls for targeted marketing regulations and health campaigns aimed at reducing the consumption of erosive beverages. Preventive strategies, such as dietary modifications and improved oral hygiene practices, are also highlighted as essential measures to mitigate the risks of dental erosion and caries. Ongoing research remains crucial in further understanding the complex interactions between diet and oral health, paving the way for innovative preventive measures and therapeutic interventions that can improve oral health outcomes for individuals of all ages.

Conflicts of Interest

The authors declare no conflict of interest.

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