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RESEARCH ARTICLE

Bite by Bite: Unveiling the Impact of Chewing Sticks on Endovascular Health and Neurovascular Coupling – A Narrative Review

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Abstract

Objective: This paper aims to explore the effects of chewing sticks, such as miswak (Salvadora persica) and neem (Azadirachta indica), on vascular health and neurovascular coupling, assessing their potential benefits for cardiovascular and cognitive functions.

Methods: A comprehensive literature review was conducted to analyze existing studies related to the physiological effects of chewing sticks. Emphasis was placed on their impact on vascular health, neurovascular coupling, and the mechanisms behind these effects, including the stimulation of the trigeminal nerve and the release of norepinephrine.

Results: Chewing stimulates the trigeminal nerve, which promotes the release of norepinephrine from the locus coeruleus, enhancing vascular dilation and regulating blood pressure. This process supports neurovascular coupling and may protect the blood-brain barrier, thereby improving cerebral circulation and reducing risks associated with cognitive decline and cardiovascular diseases. Additionally, the bioactive compounds found in chewing sticks—such as antioxidants and antimicrobial agents—may help reduce systemic inflammation and promote overall vascular health.

Conclusion: Chewing sticks represent a potential cost-effective and accessible strategy for improving cardiovascular and cognitive health, especially in populations with limited healthcare access. While preliminary findings are promising, further research, including clinical trials, is necessary to fully elucidate the therapeutic potential of chewing sticks for enhancing vascular and cognitive functions.

Key Words: *Chewing sticks; Neurovascular coupling; Vascular health; Trigeminal nerve stimulation; Oral hygiene; Periodontal health; Natural remedies; Traditional oral hygiene tools*

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Introduction

Chewing is a fundamental biological activity that plays a critical role in both the digestive process and overall human health [1]. While often regarded as a routine action, the act of chewing has far-reaching implications for cognitive function, brain health, and vascular regulation [2]. In particular, chewing hard substances such as chewing sticks may exert direct effects on the endovascular system, influencing the cardiovascular and cerebrovascular systems [3]. Although chewing sticks, known as miswak or neem sticks in various cultures, have been used for centuries as natural oral hygiene tools, their potential effects on vascular health remain underexplored in contemporary scientific literature [4,5].

In many cultures, the use of chewing sticks has been linked not only to better oral hygiene but also to systemic health benefits. The mechanical action of chewing stimulates key physiological mechanisms, including the trigeminal nerve and various brain pathways that regulate vascular tone and blood circulation [6]. These benefits are particularly relevant in a world where cardiovascular diseases (CVDs) remain the leading cause of mortality globally [7]. Given the rising incidence of these diseases, especially in regions with limited access to modern medical care, the use of natural remedies like chewing sticks could offer an accessible and low-cost means of preventing or managing vascular-related health issues.

This review aims to investigate the potential impact of chewing sticks on vascular health by examining their physiological effects, the underlying neural mechanisms involved, and their possible role in cardiovascular disease prevention. By expanding research on this traditional practice, this paper seeks to contribute to a broader understanding of how simple, everyday behaviors can influence long-term health outcomes.

Methods

Study design

This paper presents a narrative review of the literature on the impact of chewing sticks, specifically those derived from Salvadora persica (miswak) and Azadirachta indica (neem), on endovascular health and neurovascular coupling. The goal of this review is to assess the physiological mechanisms by which chewing sticks influence vascular health, cognitive function, and their potential therapeutic effects on cardiovascular diseases. The review was designed to synthesize both experimental and clinical findings from a range of sources to provide a comprehensive overview of the current state of knowledge.

Data sources and search strategy

A systematic literature search was conducted across several electronic databases to identify relevant studies published in English between 1970 and 2023. The selected databases include:

- PubMed: for clinical and biomedical studies,
- Scopus: for multidisciplinary research,
- Google Scholar: for a wider range of studies and grey literature, and
- Web of Science: for peer-reviewed articles in health and life sciences.

The following search terms were used in various combinations: “chewing sticks,” “miswak,” “neem,” “datun,” “chewing twigs,” “dental stick,” “masticatory sticks,” “vascular health,” “neurovascular coupling,” “chewing,” “periodontal ligament,” “trigeminal system,” “norepinephrine,” “cognitive function,” and “endovascular health.”

The search was limited to studies published in English, and the timeframe for inclusion was set from 1970 to 2023 to ensure the inclusion of both historical and recent findings.

Inclusion and exclusion criteria

Studies were included in the review if they met the following criteria:

- Relevance to the Topic: The study must have investigated the impact of chewing, specifically with regard to chewing sticks or similar tools, on vascular health, neurovascular coupling, or cognitive function.
- Study Design: Both experimental studies (e.g., in vitro, animal studies) and clinical studies (e.g., randomized controlled trials, observational studies) were included.
- Focus on Chewing Sticks: The study must have involved the use of chewing sticks derived from Salvadora persica (miswak), Azadirachta indica (neem), or related plant species commonly used as traditional oral hygiene tools.
- Publication Language: Only studies published in English were considered to maintain the consistency of the review process.

Studies were excluded based on the following criteria:

- Non-Relevant Topics: Articles that focused on the effects of modern oral hygiene tools (e.g., toothbrushes, mouthwashes) or unrelated interventions.
- Lack of Primary Data: Reviews, editorials, opinion papers, and theoretical articles that did not present original data were excluded.
- Non-Human Models: Studies that did not involve human participants or direct human-relevant biological mechanisms (e.g., studies on non-human animal models without clear extrapolation to human health) were excluded unless they provided crucial insights into the physiological mechanisms involved.

Data extraction and synthesis

After conducting the search, a total of 20 studies met the inclusion criteria. These studies were reviewed and analyzed for the following key aspects:

- Physiological Mechanisms: Studies that explored the neural and biochemical pathways activated during chewing, specifically how chewing sticks stimulate the trigeminal nerve, the release of norepinephrine from the locus coeruleus, and their effects on vascular tone and blood flow regulation.
- Impact on Oral Health: Research that investigated how the mechanical action of chewing sticks affects oral hygiene, periodontal health, and the vascular integrity of the gums, as well as any indirect effects on cardiovascular health.
- Vascular Health: Studies that examined how chewing influences endothelial function, blood pressure regulation, and vascular tone. This included investigations into the potential effects of chewing on conditions like hypertension, atherosclerosis, and endothelial dysfunction.
- Cognitive Function and Neurovascular Coupling: Articles that explored the role of chewing in neurovascular coupling, including the effects of chewing on cerebral blood flow, blood-brain barrier integrity, and the impact on neuroplasticity, cognitive function, and brain health.

The data extracted from each study were categorized according to the physiological systems involved (e.g., oral health, vascular system, neurovascular coupling). Results were synthesized qualitatively, comparing findings across different types of studies (e.g., experimental vs. clinical). Special attention was given to the physiological mechanisms implicated in the effects of chewing, particularly those related to neurotransmitter release and blood flow regulation.

Data analysis and reporting

The findings from the selected studies were synthesized in a narrative format, highlighting common themes and differences across studies.

The analysis focused on the physiological pathways through which chewing sticks exert their effects. For studies that explored neurovascular coupling, attention was paid to how chewing influenced cerebral blood flow, cognitive function, and brain health. Results were reported by study type (e.g., animal models, clinical trials) and by outcome (e.g., oral health, vascular health, cognitive function), with a special focus on the potential therapeutic implications of chewing sticks as an accessible, low-cost intervention for vascular and cognitive diseases.

The reviewed studies provide diverse insights into the effects of chewing and chewing sticks on physiological and cognitive health. Table 1 summarizes the key findings, including study designs, participant demographics, and primary outcomes, highlighting the scope and relevance of the included studies.

Results and Discussion

Chewing sticks as a traditional method of mastication

Chewing sticks, such as those made from Salvadora persica (miswak) or Azadirachta indica (neem), are used across various cultures, particularly in regions of the Middle East, Africa, and Asia, for their purported oral and systemic health benefits [4,5]. These natural tools have been employed for centuries, predating the modern toothbrush, and are still in regular use today in many parts of the world.

While the primary function of chewing sticks is oral hygiene, they contain a variety of bioactive compounds that may provide additional health benefits. Salvadora persica, for instance, contains compounds like saponins, flavonoids, tannins, and phenolic acids, which have antimicrobial, anti-inflammatory, and antioxidant properties [8] Figure 1. These properties are particularly beneficial in reducing the plaque-forming bacteria in the mouth, preventing periodontal disease, and potentially reducing systemic inflammation that can lead to cardiovascular diseases [11,12].

TABLE 1

Key studies exploring the physiological and cognitive effects of chewing and chewing sticks, highlighting study designs, participant details, and primary outcomes.

Author, year of publication	Study design	Number of participants	Key results	Focus	References
Natsui S, Sato M, Yokoyama T, et al., 2020	Cross-over experimental design	11	High chewing frequency increases prefrontal cortex oxygenation.	Chewing Frequency & Cognitive Function	[3]
Sharma A, Sankhla B, Parkar SM, et al. 2014	In-Vitro Study		Neem and babool chewing sticks reduce Streptococcus mutans.	Oral Health	[5]
Al-Ayed MSZ, Asaad AM, Qureshi MA, et al., 2016	Experimental Study		Salvadora persica extracts show antibacterial activity against multidrug-resistant bacteria.	Antibacterial Activity	[8]
Tramonti Fantozzi MP, De Cicco V, De Cicco D, et al. 2021	Experimental Study	30	Chewing improves cognitive functions; the side of chewing matters.	Chewing & Cognitive Improvement	[9]
Kim EK, Lee SK, Choi YH, et al. 2017	Observational Study	295	Poor chewing ability is related to cognitive impairment in the elderly.	Chewing Ability & Cognitive Impairment	[10]

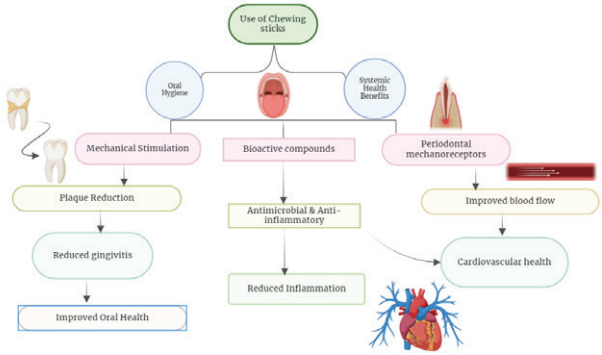

Figure 1) *Effect of chewing sticks on oral and vascular health.*

The use of chewing sticks has been linked to better oral health, as the mechanical stimulation provided by the act of chewing activates periodontal mechanoreceptors, which not only support gum and tooth health but also help maintain the integrity of the underlying vasculature that nourishes the oral tissues [9]. In fact, regular use of chewing sticks has been shown to improve oral hygiene, reduce the incidence of gingivitis, and even support the health of the blood vessels in the gums, which are critical for maintaining overall cardiovascular health.

Beyond their oral health benefits, chewing sticks may have systemic effects that promote vascular health. Given that the act of chewing stimulates the release of neurotransmitters like norepinephrine (NE), which is involved in blood flow regulation, it is plausible that their regular use could contribute to improved endothelial function and better blood pressure control [13,14]. By stimulating neural pathways that regulate vascular tone, chewing sticks could play a role in vascular dilation and improved blood circulation.

Physiological mechanisms of chewing

Chewing is a complex, multifaceted process that involves more than just mechanical mastication. It activates a series of neural and physiological pathways that can influence a range of bodily systems, including the central nervous system (CNS) and the endovascular system. When chewing hard substances, the mechanical forces applied to the teeth and gums activate sensory receptors in the periodontal ligaments [15] Figure 2. These signals are transmitted via the trigeminal nerve to various brain centers, most notably the locus coeruleus (LC) [14,16] which plays a crucial role in cognitive function, mood regulation, and neurovascular coupling [16-18].

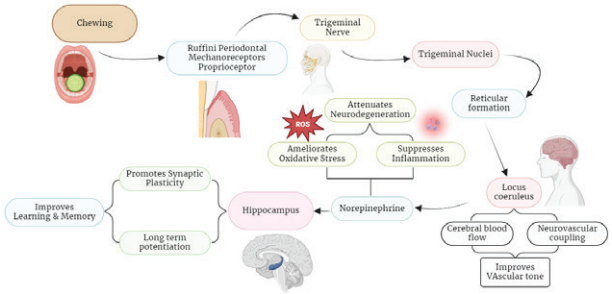

Figure 2) *Mechanism of chewing on cognition and vascular tone.*

One of the primary mechanisms through which chewing affects vascular health is the release of norepinephrine (NE) from the locus coeruleus (LC) [15]. Norepinephrine is a neurotransmitter that plays a central role in regulating the sympathetic nervous system, particularly in modulating vascular tone and blood flow [19]. By stimulating motoneurons, norepinephrine enhances vascular dilation, which facilitates improved blood circulation throughout the body [20]. The release of NE also supports neurovascular coupling, a process where neuronal activity regulates blood flow in the brain to meet its metabolic demand [18]. Through neurovascular coupling, chewing can promote cerebral blood-brain barrier (BBB) integrity and enhance perfusion in brain tissues, thus benefiting both central and peripheral vascular systems [20,21].

Chewing has also been shown to have a systemic impact on blood pressure regulation. Studies indicate that the mechanical act of

chewing can reduce stress-induced increases in blood pressure and promote a state of vascular relaxation [22]. This suggests that chewing hard substances may not only stimulate local oral health but could also contribute to improved cardiovascular function, particularly in preventing endothelial dysfunction, a key factor in the development of atherosclerosis [23].

Chewing and cognitive function: implications for vascular health

The benefits of chewing extend beyond the peripheral vasculature and into the realm of cognitive function. As chewing activates the locus coeruleus and other neural pathways involved in neurovascular coupling, it has been found to have significant implications for brain health [16,18]. Neuroplasticity—the brain's ability to adapt and reorganize in response to stimuli—has been positively influenced by the mechanical act of chewing [24]. Additionally, chewing stimulates the production of neurotrophic factors, which are essential for maintaining the structural integrity of the brain's vasculature and for supporting synaptic plasticity in regions such as the hippocampus [25].

Regular chewing has been associated with enhanced cognitive processing and improved attention [24]. This is particularly important in the context of neurodegenerative diseases such as Alzheimer's and Parkinson's diseases, where vascular health plays a significant role in disease progression [24]. Furthermore, chewing may help protect the blood-brain barrier (BBB), a selective permeability layer that shields the brain from harmful substances [20]. By enhancing BBB integrity and improving cerebral circulation, chewing could serve as a preventive measure for individuals at risk of cognitive decline or stroke.

Research into the neurovascular effects of chewing has shown that it may act as a natural cognitive enhancer, improving brain function and providing neuroprotective benefits against conditions like dementia [26]. This connection between vascular health and cognitive health underscores the potential of chewing sticks not only to improve oral health but also to promote overall well-being.

Influence of diet on chewing and vascular health

The type of diet a person consumes plays a critical role in both oral health and vascular function [27]. A diet that emphasizes soft foods can reduce chewing intensity, leading to a decline in the stimulation of periodontal mechanoreceptors and possibly impairing neurovascular function [28]. In contrast, a harder diet—one that requires more effort to chew—has been shown to promote better oral health by activating the periodontal mechanoreceptors, which help maintain gum health and stimulate blood flow in the gums and surrounding tissues [13].

Epidemiological studies have linked a soft diet and reduced mastication intensity to increased risks of vascular dementia, cardiovascular diseases, and other neurodegenerative conditions [10]. As depicted in Figure 3, soft diets reduce chewing intensity and impair neurovascular coupling, while harder diets support periodontal and vascular health. The reduction in chewing effort leads to a decline in hippocampal neurogenesis (the production of new neurons in the hippocampus), which may exacerbate cognitive decline and increase the risk of vascular diseases [29]. Furthermore, a softer diet may impair neurovascular coupling, which is essential for maintaining adequate blood flow to the brain [30]. This decline in synaptic plasticity could be a contributing factor to cognitive and cardiovascular diseases in the elderly.

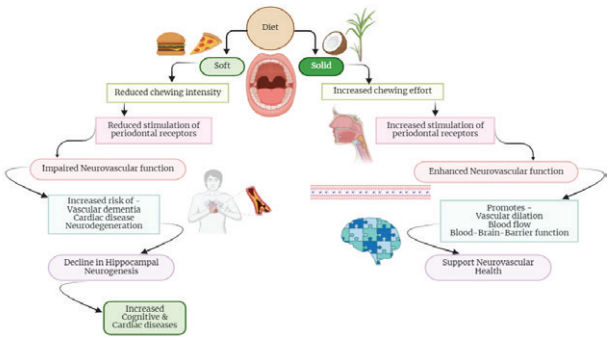

Figure 3) *Effect of soft diet vs. hard diet on chewing and vascular health.*

Conversely, a diet that includes harder foods requiring more chewing might support neurovascular health by promoting vascular dilation, increasing blood flow, and supporting the function of the blood-brain barrier [20] Figure 3. Therefore, the way we chew—and the foods we chew—may have far-reaching implications for our overall health.

Potential therapeutic implications and future research

Given the growing body of evidence supporting the positive effects of chewing on vascular and cognitive health, the incorporation of chewing sticks into daily routines presents a cost-effective, natural method of improving vascular function. This is particularly significant for populations in low-resource settings where access to modern healthcare and pharmaceutical interventions may be limited. Chewing sticks, made from plants like Salvadora persica or Azadirachta indica, could offer a simple and accessible alternative to enhance vascular health and prevent cardiovascular diseases [4,5].

However, while the potential benefits are promising, further research is needed to fully understand the mechanisms through which chewing sticks influence vascular health. Clinical trials are necessary to assess their impact on endothelial function, blood pressure regulation, and overall cardiovascular outcomes. Additionally, studies investigating the specific compounds in chewing sticks, such as antioxidants, antibacterial agents, and anti-inflammatory molecules, could shed light on their therapeutic potential. Research should also explore the long-term effects of chewing sticks on vascular health, particularly in populations at risk for stroke, dementia, and other cardiovascular diseases.

Conclusion

Chewing sticks, which have been used for centuries as a natural tool for oral hygiene, offer significant potential for improving oral and vascular health. The physiological mechanisms triggered by chewing—suggest that this simple act could have wide-ranging benefits for both vascular and cognitive health. Regular use of chewing sticks, particularly in combination with a healthy diet and lifestyle, could provide an inexpensive and accessible method of reducing cardiovascular risk, improving blood flow, and promoting brain health. While further research is required, the available evidence underscores the importance of traditional practices in modern health strategies, particularly in populations at risk for cardiovascular diseases and cognitive decline.

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