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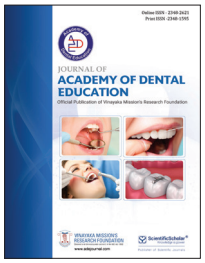

Original Article

Assessment of erosive potential of frequently used Indian spices

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ABSRACT

Objectives: Indian spices are central to the country's cuisine but may contribute to increased acidity, potentially leading to dental erosion. This study investigates the erosive potential of common Indian spices and examines how temperature affects pH changes. Also, this study analyses the temperature dependent changes in selected spices

Material and Methods: Using a Safeseed digital pH meter with 0.1 pH accuracy, the pH of various spices and spice blends from two major Indian brands was measured. Temperature-dependent pH variations were tested across three temperature levels (60–100°C) for set durations.

Results: Coriander and red chili powder displayed the lowest pH values, while panipuri masala had the least titratable acidity. Individual spices were generally less erosive compared to spice blends, which demonstrated significant pH variations with temperature. These findings suggest that excessive consumption of certain spices and blends may increase the risk of stomach and dental erosion, reinforcing the need for moderated intake for optimal health.

Conclusion: The study highlights the importance of moderating spice intake to prevent dental erosion, providing essential insights for patient counseling and preventive dental practices. Its broader clinical relevance includes raising public awareness about the impact of diet on oral health and encouraging further research into the real-world effects of dietary acidity on dental health.

Keywords: Acidity in food, Dental erosion, Indian spices, pH assessment, Spice mixtures, Stomach health, temperature dependence

INTRODUCTION

The history of Indian spices dates back to the time when Christopher Columbus set sail for the Indies in search of pepper. India's fascination with exotic flavors catalyzed the flourishing spice trade across Southeast Asia as early as 2000 BCE. Spices, derived from seeds, fruits, roots, bark, or other plant components, are primarily used to enhance the flavor, color, and preservation of food.

Beyond their culinary significance, spices are renowned for their versatile medicinal properties, which have made them globally popular.[1] However, alongside these benefits, spices are believed to stimulate salivary and gastric acid secretion.[2] This dual nature makes them a double-edged sword, as their acidity poses the risk of dental erosion and harm to tooth structure.

Dental erosion is defined as the irreversible loss of dental hard tissue caused by a chemical process unrelated to bacterial activity.[3] Among non-carious tooth surface lesions, dental erosion

is the most prevalent. Contributing factors include acidic beverages, sugary foods, and, notably, certain spices. Eroded tooth surfaces often appear irregular, with rounded, smooth grooves and ridges, where groove width exceeds their depth.[4]

Commonly used spices in Indian households include cumin, coriander, turmeric, black pepper, and red chili powders, alongside popular spice blends such as garam masala, pav bhaji masala, chole masala, sambhar masala, panipuri masala, and biryani masala. Studies have identified a significant association between the pH of spices and tooth surface erosion. The erosive potential of spices can be assessed by evaluating their pH and titratable acidity.[5]

This study aims to examine the erosive potential of frequently used Indian spices and analyze the impact of temperature on their pH changes.

MATERIAL AND METHODS

Ethical approval

The study was initiated after receiving ethical clearance from the Institutional Review Board.

Spice selection

Eleven spices and spice blends were chosen for the study. This included five single-ingredient spices and six multi-ingredient spice mixtures. The raw individual spices were sourced from local markets, while the spice blends (masalas) were procured from two prominent Indian brands, designated as C1 (Company 1) and C2 (Company 2), to minimize observational bias.

Solution preparation

Spice solutions were prepared by mixing 6 g of spice powder with 60 mL of distilled water (1:10 ratio) using a calibrated weighing scale to ensure accuracy. This process resulted in a homogeneous 60 mL solution [Figure 1].

Measurement of titratable acidity

Titratable acidity was assessed using a calibrated digital pH meter, pre-set to a neutral pH of 7 for accuracy. A 30 mL portion of the prepared solution was placed in a beaker equipped with a magnetic stirrer to ensure homogeneity during testing. Figure 2 indicates measurement of pH of spices solution using a calibrated pH meter.

Effect of temperature on Ph

The influence of temperature on pH was evaluated by placing the solutions in an incubator at four different temperature levels: 40°C, 50°C, 60°C, and 70°C [Figure 3]. This approach was intended to simulate various environmental conditions and their effects.

Figure 1: Individual spices and spices mix in solution.

Figure 2: Measurement of pH of spices solution using a calibrated pH meter.

Data recording and statistical analysis

All results were documented in an Microsoft Excel spreadsheet. Statistical analysis was performed using a two-way analysis of variance (ANOVA) test to determine the significance of the observed pH variations.

Figure 3: An incubator for maintaining varying temperatures.

RESULTS

pH and titratable acidity

Among individual spices, coriander and red chili powder exhibited the lowest pH values, indicating the highest acidity, followed by cumin, turmeric, and black pepper powders [Table 1]. For spice blends, panipuri masala displayed the lowest titratable acidity, followed by chole masala, sambhar masala, pav bhaji masala, garam masala, and biryani masala.

Temperature influence on pH

An inverse relationship between temperature and pH was observed, with pH values decreasing consistently as the temperature increased. This trend underscores the temperature-sensitive nature of the spices' acidity. Detailed patterns of these changes are provided in Table 2.

The two-way ANOVA test revealed significant differences in pH values for the masalas of C1 and C2 across the tested temperatures, with $P < 0.01$. In addition, significant differences were noted in the initial pH values of C1 and C2 ($P < 0.02$). However, no statistically significant differences ($P > 0.1$) were observed for the pH of individual spices at varying temperatures.

Table 1: Mean pH values of individual spices ingredient.

Ingredient	pH
Cumin	5.6
Coriander	4.2
Turmeric	5.9
Red chilli	4.2
Black pepper	6.4

Table 2: Mean pH values of spices mix.

Masala	pH	
	C-1	C-2
Garam masala	5.2	5.1
Pavbhaji masala	4.6	5.2
Sambhar masala	4.1	5.1
Chole masala	4.1	5.2
Panipuri masala	3.0	3.4
Biryani masala	5.5	5.1

DISCUSSION

Dental erosion refers to the chronic, pathological, and localized loss of dental hard tissue caused by non-bacterial acids, either extrinsic or intrinsic in origin.[6] Contributing factors to this condition include dietary habits such as frequent consumption of acidic foods and beverages, occupational acid exposure, medications, and conditions that affect saliva flow rates.[7] Intrinsic erosion occurs when gastric acids enter the oral cavity due to conditions such as regurgitation, vomiting, or gastroesophageal reflux disease.[8] Enamel erosion typically occurs when the tooth surface is exposed to solutions with a pH lower than the critical value of 5.5, especially with repeated or prolonged exposure.[9]

Indian cuisine, known for its rich use of spices, incorporates ingredients that, while flavorful and medicinally beneficial may have erosive effects on dental structures. This study aimed to assess the erosive potential of commonly used Indian spices and explore the effect of temperature on their pH.

All the spices studied had an initial pH below 5.5 [Table 3], suggesting a potential risk for dental erosion. However, spices are typically consumed as additives with food items such as vegetables, cereals, pulses, or meat, which may dilute their erosive impact. In addition, the quantity of spices used varies by individual preferences and cooking practices. Although saliva can buffer acidity during a single acidic attack, repeated exposures reduce its effectiveness, increasing the risk of enamel erosion.

Among the spice mixtures evaluated, panipuri masala exhibited the highest erosive potential due to its lowest titratable acidity, followed by chole masala, sambhar masala, pav bhaji masala, garam masala, and biryani masala. Temperature analysis revealed a clear inverse relationship between pH values and temperature, with acidity increasing at higher temperatures.

These findings align with prior research. Verma *et al.* reported panipuri masala as having the lowest pH and highest titratable acidity among commonly used spices, suggesting cautious consumption.[5] Similarly, Yuvaraj and Antony found turmeric powder to exhibit the highest erosive potential, while coriander powder had the least.[10] Studies on acidic beverages, including carbonated drinks, also highlight their significant erosive effects on dental enamel.[11-14] These comparisons reinforce the role of dietary acids, including spices, in dental erosion.

Table 3: pH of individual spices and spices mix at varying temperatures.

Spices and Masalas	pH at 40° C		pH at 50°C		pH at 60° C		pH at 70°C	
Cumin powder	5.5		5.4		5.4		5.4	
Coriander powder	4.3		4.2		4.2		4.1	
Turmeric powder	6.0		6.1		6.1		6.2	
Red chilli powder	4.3		4.2		4.2		4.1	
Black pepper	6.6		6.6		6.7		6.8	
	C-1	C-2	C-1	C-2	C-1	C-2	C-1	C-2
Garam masala	5.3	5.1	5.2	5.1	5.2	5.1	5.3	5.1
Pavbhaji masala	4.5	5.0	4.5	5.0	4.4	5.0	4.5	5.0
Sambhar masala	4.0	5.1	4.0	5.1	4.0	5.1	3.9	5.1
Chole masala	3.9	5.0	3.9	4.9	3.8	4.8	3.8	5.1
Panipuri masala	2.9	3.3	2.8	3.2	2.8	3.2	2.7	3.1
Biryani masala	5.5	5.0	5.5	4.9	5.5	4.9	5.5	5.0

Despite its contributions, this study highlights the limited research available on the erosive potential of spices on dentition, emphasizing the need for further investigations, such as *in vivo* studies and longitudinal observations, to confirm these findings.

Limitations

This study has several limitations. It focused on a limited selection of commonly used spices, potentially overlooking other spices with erosive potential. The temperature-dependent pH assessments were performed in a controlled laboratory environment, which may not fully represent real-world conditions. Furthermore, spice mixtures were sourced from only two brands, potentially limiting the diversity of compositions analyzed.

Future directions

Future research should expand the range of spices studied to include a broader variety representative of diverse cuisines. Investigations into specific compounds within spices, different cooking methods, and their interactions with dietary components would provide a more comprehensive understanding. Long-term and population-based studies, as well as *in vivo* assessments, are necessary to evaluate the real-world cumulative effects of spice consumption on dental health.

CONCLUSION

This study highlights the erosive potential of commonly used Indian spices and spice mixtures, particularly noting the impact of temperature on increasing acidity. Spice blends like panipuri masala exhibited a higher erosive potential compared to individual spices, posing potential risks to dental and gastric health. The findings emphasize the importance of moderating spice and masala consumption to mitigate these risks. This study contributes to the limited body of research on the erosive effects of spices and encourages further research through longitudinal and *in vivo* studies to better understand their impact on oral health. Public awareness of the influence of temperature on spice acidity and its implications can help promote healthier dietary practices and better oral health outcomes.

Ethical approval: The research/study approved by the Institutions Ethical committee at Government Dental College and Hospital, Mumbai, number 4128/2023, dated 07th November 2023.
Declaration of patient consent: Patient's consent not required as there are no patients in this study.
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Use of artificial intelligence (AI)-assisted technology for manuscript preparation: The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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