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Comparative effect of an Ayurvedic dentifrice and non-herbal dentifrice on salivary pH and its importance: Clinical study

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Abstract
This study aimed to evaluate the effect of ayurvedic toothpaste on salivary pH and buffer capacity.
Seventy individuals aged 25-50 years who fulfilled the inclusion criteria were enrolled. After a washout period of one week, the participants were grouped into two, one using ayurvedic toothpaste (n=35) and the other using control toothpaste (n=35). Unstimulated saliva sample was collected at two intervals, i.e., pre usage and post usage (4 weeks) of toothpaste. The salivary pH and buffer capacity were analyzed using GC Salivary Check kit (GC, Tokyo, Japan).
The mean salivary pH and buffer capacity were maintained at 7.103 and 10.69, respectively, in group using ayurvedic toothpaste containing potential herbs whereas the mean salivary pH and buffer capacity were decreased to 6.697 and 8.629 respectively in the group using control toothpaste.
The use of ayurvedic toothpaste helps in significantly improving oral health by increasing the salivary pH and buffer capacity.
Clinical Relevance: The use of ayurvedic toothpastes containing herbal products is beneficial in enhancing the oral health by maintaining healthy salivary pH and buffer capacity.

Keywords: Toothpaste, oral health, buffering capacity, salivary pH

Introduction
Saliva plays an essential role in the oral cavity, oropharyngeal region, and upper gastrointestinal tract's local and systemic defences. It contributes to the preservation of dental health by performing a variety of host defence tasks. It promotes and protects the soft and hard tissues of the mouth, as well as supports several important oral functions. It is the most important oral fluid and one of the most significant variables in oral health regulation. It is a necessary element to maintain the ecological balance of the oral cavity. It also aids in the preservation of oroesophageal mucosal integrity by lubricating, hydrating, clearing, buffering, and repairing the mucosa. Mineralization, taste facilitation, tissue coating, and antibacterial action are all significant activities of saliva. Saliva aids in Digestion too.
Saliva is a non-invasive diagnostic medium readily available for a growing number of diseases and clinical circumstances. Saliva has recently emerged as a viable option for diagnosing some disease and tracking the progression of certain pathologies or treatment dosages. Quantitative, biochemical assays housed in small, user-friendly equipment improve the likelihood of biochemical indicators being used routinely to supplement clinically reported symptoms, disease progression, and near-continuous therapeutic efficiency assessment. The major components of salivary defence properties are saliva flow rate, pH, and buffer capacity. Factors that affect the production, function, and differentiation state of salivary gland cells have an impact on an individual's general health and well-being [1].
Protective variables that aid the remineralization process include optimal salivary pH, buffering capabilities, lower salivary *Streptococcus mutans* counts noncariogenic sugar substrate in the diet, and so on. High sugar intake and low salivary pH induced by microbial degradation of the sugar substrate are two main mechanisms that destabilize the oral environment's equilibrium. *S. mutans* are considered as the predominant human type *S. mutans*, which is intimately connected to dental caries. By producing acids from sugar substrates, *S. mutans* levels in saliva promote demineralization. Furthermore, the organisms use carbohydrates to generate glucans, which enhances their capacity to adhere to the tooth structure. The *S. mutans* uses the fermentable sugar substrate as a reserve source of energy. As a result, a sensible approach would be to direct preventive actions toward lowering *S. mutans* levels, as well as improving salivary pH and buffering capacity [2].

Saliva flow, buffer capacity, and microbial content in saliva are all important aspects of dental health. Saliva's buffer systems are responsible for maintaining a proper acid-base balance. Buffer solutions, which are resistant to fluctuations in the oral pH, maintain a roughly constant pH even when modest amounts of acid or base are added or when saliva is diluted. The pH of resting saliva should be between 6.2 and 7.6. Saliva has three different buffer systems: protein buffer, phosphate buffer, and carbonic acid/bicarbonate buffer. Several studies looked into the relationship between saliva buffering capacity and caries activity.

Salivary buffers can invert the low pH of dental plaque, allowing oral clearance and preventing enamel demineralization. Saliva also plays an important role in maintaining tooth integrity by managing demineralization, promoting enamel remineralization, and providing the primary defence against tooth erosion and prosthetic restorations by preventing the apparition of dental alloys corrosion [3]. Thus, this study aimed to evaluate the effect of Ayurveda toothpaste on salivary pH and buffer capacity over a period of one month.

Materials and Methodology

Table 1: Classification of toothpaste

S. No.	Group of Toothpaste	Company of the Toothpaste	
1.	Experimental Toothpaste@ (Ayurvedic dentifrice)	Dabur Red Paste	Pipali, Tomar, Maricha, Sunthi, Kapur, Pudina, Clove Oil, Gairic in a Calcium Carbonate base
2.	Control Toothpaste# (Non-Herbal dentifrice)	Commercial toothpaste-Dental Cream	Sodium Monoflurophosphate, in Calcium carbonate base

@- Ayurvedic toothpaste
#- Non-herbal toothpaste

The present active control trial was conducted at A B Shetty Memorial Institute of Dental Sciences, NITTE, Dakshina Kannada District, Karnataka, India. The study protocol and procedures were accepted by the University Ethics Committee (NU/CEC/2020/0302) and the Clinical trial registered (CTRI/2020/06/026082). Seventy participants aged between 25-50 years fulfilling the following inclusion criteria were enrolled in this study after obtaining the written consent and followed up for 4 weeks.

Inclusion criteria

- Subjects with caries, gingivitis, and periodontal diseases.
- Subjects free from systemic diseases affecting salivary flow patterns.
- Subjects willing to give voluntary informed consent and available for the entire duration of the study

Exclusion criteria

- Subjects undergoing orthodontic treatment and edentulous.
- History of smoking and alcohol consumption.
- Subjects who are pregnant, lactating, or nursing.
- Subjects under continuous nutritional supplementation.
- Any underlying uncontrolled medical illness, including Hypertension, Diabetes mellitus, and Hepatitis.
- Subjects undergoing radiotherapy, chemotherapy, and under long-term medication.

Washout period (Run in period)

Participants were provided with commercially available non-herbal toothpaste (Colgate Cibaca) and an adult Colgate sensitive ultra-soft toothbrush to be used in place of their usual toothpaste and toothbrush. Subjects were advised to use the toothpaste and toothbrush for 2 minutes twice a day as directed on the toothpaste package for one week.

This reduces the residual effects of the subject's previous toothpaste use and allows all subjects to be on the same toothpaste background [4].

Participants

The participants were grouped into two; one using Ayurveda toothpaste and the other using control toothpaste (n=35). (Table 1) They were asked to use the allotted toothpaste for 2 minutes twice a day as directed on the toothpaste package for a period of one month. (Figure1)

Saliva collection and analysis

For two hours prior to the sample collection, subjects were advised to refrain from brushing their teeth, using mouthwash, and eating/drinking. The saliva samples were collected at two intervals: the first visit (pre usage of toothpaste) and the second visit (post usage of toothpaste, i.e., 4 weeks). 5 mL of unstimulated saliva was collected in a 15 mL Tarson centrifuge tube, salivary pH and buffer capacities were determined [5].

Salivary pH and Buffer capacity determination

Using the GC Salivary Check kit (GC, Tokyo, Japan), the salivary pH and buffer capacity were determined. This kit comprises 20 *in vitro* pH and buffer test strips. A salivary pH test strip was inserted into the vial containing saliva, and then the color obtained was compared with the testing chart included in the kit.

Three drops of saliva were applied to the test strip with a pipette/dropper, one drop to each of the three test pads, and the test strip was immediately rotated at 90 degrees to remove excess saliva, preventing the excess saliva from swelling on the test pad and possibly affecting the accuracy of the test result. The color guide included in the GC Salivary Check kit was used to determine the salivary buffer capacity.

2.1 Statistical analysis

The data acquired was entered into a Microsoft Excel spreadsheet. Descriptive statistics were reported in the form of mean and Standard Deviation (SD). Statistical significance was defined as a p-value of <0.05.

Results

Table 2: Descriptive analysis of salivary pH in experimental and control toothpaste

Group	Parameter	N	Minimum	Maximum	Mean	Std. Deviation
Experimental	Salivary pH (Pre usage)	35	6	7.6	6.811	0.3462
	Salivary pH (Post usage)	35	6.6	7.8	7.103	0.3642
Control	Salivary pH (Pre usage)	35	6	7.6	6.789	0.3066
	Salivary pH (Post usage)	35	6.2	7.4	6.697	0.2584

Seventy healthy subjects aged between 25 to 50 years with caries, gingivitis, and periodontal diseases were included in this study; they were followed up for 4 weeks and included in the analysis of salivary pH and buffer capacity.
In one month, follow-up, we observed that the mean salivary pH in groups using ayurvedic toothpaste had been increased to 7.103 from 6.811. Whereas in the control group, the mean salivary pH had been decreased to 6.697 from 6.789. (Table 2)

Table 3: Descriptive analysis of Salivary Buffer capacity in the experimental and control group

Group	Parameter	N	Minimum	Maximum	Mean	Std. Deviation
Experimental	Salivary buffer capacity (Pre usage)	35	8	12	9.371	1.352
	Salivary buffer capacity (Post usage)	35	8	12	10.69	1.367
Control	Salivary buffer capacity (Pre usage)	35	8	12	9.2	1.106
	Salivary buffer capacity (Post usage)	35	6	10	8.629	1.06

The buffer capacity had been increased from 9.371 to 10.67 on post usage (4 weeks) of ayurvedic toothpaste. In the control group, the buffer capacity had been decreased to 8.629 from 9.2 in one month follow-up period. (Table 3).

Table 4: Comparison of salivary pH using Paired t-test

Group	Mean Difference	95% CI	R squared (partial eta squared)	p-value
Experimental	0.2914	0.1720 to 0.4108	0.4199	<0.0001
Control	-0.09143	-0.1567 to -0.02616	0.1925	0.0074

(*p-value <0.05 statistically significant)

From table 4, it can be interpreted that post usage of Ayurveda toothpaste; there was an increase in mean salivary pH by 0.2914. Whereas in the control group, there was a decrease in mean salivary pH by 0.09143 values. The p-value for the experimental group and control group was <0.0001 and 0.0074, respectively, indicating that the results were statistically significant (p-value <0.05).

Table 5: Comparison of salivary Buffer capacity using Paired t-test

Group	Mean Difference	95% CI	R squared (partial eta squared)	p-value
Experimental	1.314	0.8160 to 1.813	0.458	<0.0001
Control	-0.5714	-1.030 to -0.1129	0.1587	0.0161

(*p-value <0.05 statistically significant)

In table 5, the mean buffer capacity in one-month follow-up has been increased by 1.314 in the experimental group and decreased by 0.5714 in the control group. The p-value for the experimental group and control group was <0.0001 and 0.0161, respectively, indicating that the results were statistically significant (p-value <0.05).

Discussion

In this study, we estimated salivary pH and buffer capacity, pre and post usage of Ayurveda toothpaste in comparison to a control toothpaste.
We found that those who used Dabur Red Paste had a higher salivary pH over a period of one month compared to control toothpaste. This could be due use of Ayurveda toothpaste contains rejuvenating herbs (Rasayanas like Pippali) and minerals like Gairic Powder which helps to maintain the overall health of mouth along with pH & buffering capacity. Tomar is well known herb for dental benefits & it helps to maintain health of teeth [6].
The use of Ayurveda toothpaste containing plant extracts resulted in a considerable increase in salivary pH. The salivary pH depends on the H+ ion concentration, which in turn is changed by food, beverages, intense exercise and enzymes in the oral cavity. Salivary Bicarbonate, phosphate, and protein buffer systems counteract acidity caused by bacterial activity in drinks and meals, preventing pathogenic microbe colonization. Hence the pH and buffer capacity have to be checked 2 hours prior to or after ingestion of food and brushing.
The differences in pH and buffering capacity found in other research could be attributed to differences in technique or extrinsic factors like food and dental hygiene habits, as well as internal factors like bicarbonate content. It is well known that enamel dissolution occurs when the pH falls below the critical pH, which is 5.5 [7]. The mean pH value obtained in our study is insufficient to cause demineralization of the tooth as both groups showed pH above the critical pH. In the Ayurvedic pharmacopoeia of India, ingredient like Gairica (Red ochre) is known for Pitta Nasaka (acidic neutralization) in Ayurveda, as well as Pippali & Karpura balance Tridoshas (Vata, Pitta, Kapha) [8]. Similar study shown that Ayurveda herbs like Pilu, Neem, and Cinnamon help to raise the salivary pH [9].
A study by Willershausen B *et al*., concluded that the use of

herbal products considerably shifted the pH of total saliva into the alkaline range, and the findings of this study suggest that herbal ingredients can be used as a supplement in the treatment of periodontal disorders and for routine prophylaxis [10].

Previous research by Celik, ZC, *et al.*, (2021) looked at the natural antibacterial, antifungal, and antioxidant activities of plant sources, such as ginger rhizome, and found considerable benefits, especially in the oral cavity. The remineralization potential of ginger has been studied, and it has been suggested that non-invasive treatment of artificially made early caries lesions with a ginger-containing solution resulted in improved remineralization, with the potential to yield clinical benefit in the management of oral health [11].

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Conclusion
After one month of follow-up, it can be concluded that Ayurvedic medicated toothpaste with herbal extracts and minerals enhanced the overall oral health by maintaining high salivary pH and buffer capacity, which was statistically significant.

Conflict of Interests
The authors declare no competing interests.

Data Sharing
De-identified patient datasets will be available upon written request to the corresponding author following publication.

Ethics Approval and Consent to Participate
After obtaining the Institutional Ethics clearance (NU/CEC/2020/0302), a written consent was obtained from the participants.

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Author Contributions
A. B. C. F. and G contributed to conception and design. A. B. and C contributed to acquisition. A. B. C. D. and E contributed to analysis. A. C. D and E drafted manuscript. A. B. C. D. E. F and G critically revised manuscript. All authors reviewed the manuscript.

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