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Evaluate the Effectiveness of DENTE91 DB toothpaste: Results from *In Vitro* Studies

Harsh Shah[1]*, Jacky Pariyani[1], Ankit Singh[2]

*[1]Medical affairs, La Renon Healthcare Pvt Ltd, Ahmedabad, India
Email: harsh.shah@larenon.com
Orcid ID: 0009-0008-6865-1770
[1]Medical affairs, La Renon Healthcare Pvt Ltd, Ahmedabad, India
Email: ankit.singh@larenon.com
Orcid ID: 0009-0006-0656-8424
[2]Business development, La Renon Healthcare Pvt Ltd, Ahmedabad, India
Email: jacky.pariyani@larenon.com
Orcid ID: 0009-0009-2587-8059

*Corresponding author

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Abstract

Background: Dental problems are common in patients with diabetes. Patients who have poor glycemic control are more likely to have the oral problems such as salivary gland dysfunction, burning mouth feeling, periodontal disease, sluggish wound healing, and increased susceptibility to infections. DENTE91 DB toothpaste is developed to offer beneficial effects in patients with diabetes. **Material & Methods:** *In vitro* studies were conducted to evaluate the effects of DENTE91 DB toothpaste on salivary glucose levels and prevention of dryness of mouth. Also, the antimicrobial activity, effects on good oral microorganisms, remineralization, healing, hypersensitivity, and protection against dental caries/tooth decay were evaluated. The major components of DENTE19 DB toothpaste include sorbitol, silica, xylitol, nano hydroxyapatite (nano hydroxyapatite dispersion), cocamidopropyl betaine, sodium methyl cocoyl taurate, xanthane, and PEGB. **Results:** The percent improvement in reduction of glucose, based on the glucose oxidase enzyme's enzymatic activity on the glucose, was greater (average 11%) with DENTE91 DB toothpaste versus control. Additionally, a 29% decrease in dryness of mouth was seen when using it. Significant antibacterial action was also shown by DENTE91 DB toothpaste against gram-negative, gram-positive bacteria, and fungi. Additional positive effects included: i) high survival rates of good oral microorganism; ii) significantly reduced lesions of teeth surface and enhanced remineralization process; iii) significantly increased NIH/3T3 cell proliferation and healing activity on dental cavities; iv) greater control of hypersensitivity through significant coverage of the lesions on dentine discs; and v) less mineral loss compared to controls. **Conclusion:** DENTE19 DB toothpaste demonstrated a significant decrease in salivary glucose levels and prevention of dryness of mouth, and hence, can be used in patients with diabetes. Additionally, it exerted beneficial effects in terms of antimicrobial activity, survival of good oral microorganisms, accelerated remineralization and healing, decreased hypersensitivity, and protection against dental caries/tooth decay.

Keywords:- DENTE19 DB toothpaste, diabetes, hypersensitivity, antimicrobial, healing, dental caries, dryness of mouth.

INTRODUCTION

Dental problems are common in patients with diabetes. Patients who have poor glycemic control are more likely to have the oral problems such as salivary gland dysfunction, burning mouth feeling, periodontal disease, sluggish wound healing, and increased susceptibility to infections.[1,2] The oral manifestations in diabetic patients increases

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with an increase in glucose level. Salivary gland dysfunction is amongst the most common dental complication, which is observed in approximately 68% of the patients with diabetes.[3] The mechanism of hyposalivation remains to be investigated, however, a few reports have suggested its relation with polydipsia and polyuria, which are common characteristics of diabetic patients.[4] Xerostomia (dry mouth) is a sensation of oral dryness, which can result from diminished saliva production in a diabetic patient. It may cause halitosis, taste disturbances, exacerbated periodontal disturbance, dental caries and tooth loss.[5] Further, elevated glucose level in saliva could lead to saccharolytic bacterial induction, which increases the concentration of organic acids in saliva due to the glucose metabolism ultimately causing dental diseases or infections.[6]

For oral health and aesthetics, toothpaste is routinely used by one and all with the help of toothbrush.[7] Over the past few decades, toothpastes have become an essential part of everyday oral hygiene.8 Generally, toothpastes are made of compounds to fight dental caries, gum disease, malodor, calculus, erosion and dentin hypersensitivity, and to clean and whiten teeth, breath freshening and provide visual appeal.[7] Further, the fundamental uses of toothpaste are to provide antimicrobial effects in addition to the eliminating the pathogenic dental biofilm as well as to facilitate a better protective barrier to teeth. These effects lead to increase in the resistance to future dental and periodontal diseases.[7,8,9] Furthermore, the effects of toothpaste on salivary components have also been reported.[10] The modern lifestyle and unhealthy eating habits such as sugar rich, poor dietetic, high calorie fast foods etc further necessitates the use of toothpaste that has properties to combat several dental conditions such as bacterial infection, demineralization, hypersensitivity, dental caries/tooth decay, dental stain, and increased salivary glucose levels.[11,12,13]

Because of the persistent oral diseases and conditions, there is a need for modern toothpastes to be multi-functional to combat these clinical situations,[14] particularly the increase in salivary glucose and associated dryness of mouth in diabetic patients. An oral DENTE91 DB toothpaste is developed that can exert properties such as decrease in salivary glucose level, prevent the dryness of mouth, exert antimicrobial activity, beneficial effects on good oral microorganisms, promote remineralization and healing, decrease hypersensitivity, and protect against dental caries/tooth decay. DENTE91 DB toothpaste contains (>1% component) sorbitol, silica, xylitol, nano hydroxyapatite (nano hydroxyapatite dispersion), cocamidopropyl betaine, sodium methyl cocoyl taurate, xanthane, and PEGB, which are known to exert the aforementioned effects. These effects of DENTE91 DB toothpaste were evaluated in several *in vitro* studies in comparison with other marketed products. In this report, we present the outcomes of these studies to support the use of DENTE91 DB toothpaste in patients with diabetes for the prevention and management of several dental problems.

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MATERIAL AND METHODS

A total of eight *in vitro* studies were conducted to evaluate the effects of DENTE91 DB toothpaste on decrease in salivary glucose level, prevention of dryness of mouth, antimicrobial activity, effects on good oral microorganisms, remineralization, healing, hypersensitivity, and protection against dental caries/tooth decay. These studies were conducted between November 2022 and May 2023. This report summarizes the findings of these studies to understand the effectiveness of DENTE91 DB toothpaste on the aforementioned parameters.

Effects on Salivary Glucose[15,16]

The effect of DENTE91 DB toothpaste on salivary glucose was evaluated using glucose oxidase activity test in toothpaste by the U.V. spectroscopic method. The method used the following steps:

- Preparation of papain solution of concentration: 1000 mg in 10 ml 3.5 pH NaAc–Hac Buffer.
- Preparation of 3,3,5,5,-tetramethylbenzidine (TMB) solution of concentration: 5.0 mM in DMF solvent.
- Phosphate Buffer 7 pH: (0.50 gm of anhydrous Disodium Hydrogen Orthophosphate and 0.301 gm of Potassium dihydrogen orthophosphate and volume make up to 1000 by water).
- 0.1M sodium acetate-acetic acid buffer pH 3.5: (8.2 gm of sodium acetate in 1000 ml volumetric flask and volume make up to 1000 ml by water, adjust pH 3.5 by acetic acid).
- Glucose solution: 18 mg in 100 ml phosphate buffer.
- H_2O_2 stock solution: 1000 ppm stock solution.
- The above solutions were incubated for 60 min at 37°C then filtered by 0.45 µm filter and the filtrate was used for further test preparation.
- Preparation of blank: 3 ml saliva, 100 µL papain, 1 ml phosphate buffer and 1 ml TMB. After preparation of all the solutions, it was incubated overnight and read absorbance at 652 nm.

Detection of Glucose

The standard stock solution was prepared using about 20.0 mg of D-glucose, which was transferred in 200 mL volumetric flask, and 100 mL of water was added and sonicated to dissolve. Once it came to room temperature, it was diluted up to mark with water. The 5% w/v) solution was prepared with about 5.0 gm of phenol added in 100 mL volumetric flask, and 50 mL of water was added and sonicated to dissolve. Once it came to room temperature, it was diluted up to mark with water. Blank preparation was made with 1 ml of water, 1 ml of phenol (5% w/v), and 3 ml concentrated H_2SO_4 and then absorbance was read at 482 nm. The final test and marketed solutions for glucose detection are presented in [Table 1].

Lubricating properties to prevent dryness of mouth[17]

The lubricating properties of DENTE91 DB toothpaste were evaluated on Capra Aegagrus Hircus tongue in dry mouth condition using universal tensile machine (UTM). Fresh Capra aegagrus hircus (Goat) tongues were rinsed with tap water to wash of coarse waste and put in a bath of ice water for ten minutes, then rinsed with demineralized water for 15 seconds. Excess water was removed by dabbing the

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tongue with paper towel and tongues were wrapped in cling film. The box was filled with duplicating silicone and hardened for 20 minutes. To achieve a similar hydration state of all tongues, the tongues were submerged in adhesion buffer for 30 minutes after opening the cling film and rinsing with demineralized water for 15 sec. Human teeth were shaped to fit in a stainless-steel holder by grinding its sides. The teeth were glued to the stainless-steel holder from the posterior side and stored overnight at room temperature.

Coefficient of Friction (COF) Estimation Dry Tongue

Dry tongue was placed over the tongue cell, which was subjected for the COF estimation with 10 cycles of reading with the teeth enamel fixture.

Coefficient of Friction Estimation Sample Toothpaste Lubricated Tongue

Dry tongue was place over the tongue cell. 1 mL of sample toothpaste between the tongue and teeth enamel fixture was subjected for the COF estimation with 10 cycles of reading with the teeth enamel fixture.

Coefficient of Friction Estimation Marketed Toothpaste Lubricated Tongue

Dry tongue was place over the tongue cell. 1 mL of marketed toothpaste between the tongue and teeth enamel fixture was subjected for the COF estimation with 10 cycles of reading with the teeth enamel fixture.

Calculation of COF (Coefficient of friction):

1. COF (Dry - Control) = Friction Force / Pinch Force
2. COF (Test Sample) = Friction Force / Pinch Force
3. COF (Marketed Sample) = Friction Force / Pinch Force

Antimicrobial Activity[18,19]

The antimicrobial activity of DENTE91 DB toothpaste was evaluated in a microbiological laboratory *in vitro* study on four standard microbial strains including *Candida albicans*, *Streptococcus mutans*, *Porphyromonas gingivalis* and *Pseudomonas aeruginosa*. The efficacy (%) or germ killing (%) rate were calculated using following formula:

% Survival =	CFU of sample x 100 CFU of positive control
% Efficacy or % Germ Killing= 100 - % Survival	

The acceptance criteria for the efficacy of DENTE91 DB toothpaste was considered if survival rate (%) was ≤0.1% for 2 minutes exposure and ≤0.01% for 5 minutes exposure. The efficiency of DENTE91 DB toothpaste for killing organisms were required to be ≥99.9%.

Effects on Good Oral Microorganisms

The effect of DENTE91 DB toothpaste on good oral microorganisms was evaluated on lactobacillus rhamnosus, bifidobacetrium longum, and streptococcus salivarius against a marketed product. The efficacy of DENTE91 DB toothpaste on good oral microorganisms was considered if survival rate (%) of these microorganisms was more than that reported with comparative marketed product.

Remineralization effect[20,21]

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The remineralization effects of DENTE91 DB toothpaste were evaluated in a two 2-minute toothpaste treatment periods, one 6-h acid challenge, and then storage in remineralizing solution for the rest of the time, even during the night. The specimens were treated with freshly prepared slurries of toothpaste twice daily. The demineralization and remineralization solutions were stirred, while the toothpaste slurry was static. Specimens was treated individually or collectively as treatment groups. Artificial carious lesions were produced using demineralizing solutions during this study. The treatment procedure to assess the remineralization effect included:

- For 96 h - Demineralization

Day 1 was all-day storage in remineralization solution. Then, subsequent days' treatments were as follows:

- 2 min - tooth paste treatment, and then rinse with deionized distilled water
- 6 h - acid challenge (demineralization), and then rinse with deionized distilled water
- 2 min - toothpaste treatment, and then rinse with deionized distilled water
- 16 h - storage in remineralization solution

This procedure was repeated for 8 additional days. Only demineralization and remineralization treatment were given to control group.

Effect on Healing Activity of Dental Cavities[22]

The effect of DENTE91 DB toothpaste on healing activity of dental cavities was evaluated by performing cell proliferation assay using NIH/3T3 cell line. NIH/3T3 cells were cultured in α-minimum essential medium (MEM) containing 10% FBS at 37°C in humidified CO_2 incubator and confluent culture was used for testing. For cell number measurement, cells were seeded (2x105) in 48-well plate and incubated in CO_2 incubator for 3 h. After incubation, initial medium was aspirated and 300 µL of statin free medium and 50 µL of MTT (1 mg/mL) was added to each well. Plate was further incubated for 2 h. After incubation, 100 µL of mixture was transferred to 96-well plate and reaction was stopped by adding 20 µL of isopropanol. Optical density was measured at 570 nm in microplate reader. This reading was used as baseline data for further experiment. Cell proliferation assay was performed using this baseline data. Cells in each well were cultured for 12 h under the presence of test sample at concentrations 0.1%, 0.05% and 0.01%.

Effects on Hypersensitivity[23]

The reduction in hypersensitivity effects on teeth with DENTE91 DB toothpaste was evaluated against marketed product. In the test procedure, teeth were taken and cleaned with deionised water. The tooth was cut in longitudinal section and a dentine disc was formed, which was divided in test sample, marketed sample and control groups. It was treated by immersing the disc in lemon juice for 30 seconds, and the toothpaste Dilution was 1:3 (toothpaste/water). Post this, the disc was placed on a plate and treated with toothpaste by brushing for continuously for 2 hrs. A tooth brushing time of six months was simulated (2 hrs of continuous brushing, assuming 28 teeth in an oral cavity and 2 - 3 min tooth brushing per day). Later, the dentine disc was washed using deionised water. The control disc was

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treated with lemon juice and washed with deionized water, and no toothpaste treatment was given. Dentine disc was stored in deionized water and observed it under scanning electron microscope (SEM).

Dental Caries/Tooth Decay[21,24]

Another *in vitro* study was conducted to evaluate the effects of DENTE91 DB toothpaste on protection against dental caries/tooth decay and compared these effects with a marketed product. The cyclic treatment regimen consisted of two 2-min toothpaste treatment periods, one 6-h acid challenge, and then storage in remineralizing solution for the rest of the time, including night. Freshly prepared slurries of toothpaste were used for specimen treatment two times per day; the demineralization and remineralization solutions were magnetically stirred, while the toothpaste slurry was static. Specimens were treated individually or collectively as treatment groups. The procedure to evaluate the effects of DENTE91 DB toothpaste on dental caries/tooth decay were as follows:

- For 96 h - Demineralization

Day 1 was all-day storage in remineralization solution. Then, subsequent days' treatments were as follows:

- 2 min - tooth paste treatment, and then rinse with deionized distilled water
- 6 h - acid challenge (demineralization), and then rinse with deionized distilled water
- 2 min - toothpaste treatment, and then rinse with deionized distilled water
- 16 h - storage in remineralization solution

This procedure was repeated for 8 additional days. Only demineralization and remineralization treatment were given to control group.

RESULTS

Salivary Glucose

By determining the glucose conversion through enzymatic activity of the glucose oxidase on the glucose, the highest amount of glucose converted in the test sample estimating almost 11% compared to the control. The percent reduction in salivary glucose is presented in [Table 2].

Dry Mouth

DENTE 19 DB toothpaste resulted in ~29% decrease in the dryness of mouth [Table 3].

Antimicrobial Efficacy

DENTE91 DB toothpaste demonstrated significant antimicrobial activity against Gram positive bacteria (*S. mutans*), Gram negative bacteria (*P. aeruginosa*, *Porphyromonas gingivalis*) and Fungi (*C. albicans*) [Table 4]. DENTE91 DB toothpaste also demonstrated antimicrobial properties on microorganisms known to cause dental problems such as formation of dental plaque, dental caries and periodontal diseases.

Effects on Good Oral Microorganisms

The observed survival rate (%) was higher for DENTE91 DB toothpaste versus comparative marketed products for *Streptococcus salivarius* (84.66% vs. 45.45%), *Lactobacillus rhamnosus* (73.64% vs. 54.55%) and *Bifidobacetrium longum* (59.52% vs 26.19%) [Table 5].

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Remineralization effects

The surface scan of teeth demonstrated irregular coverage of the dentine surface. The initial teeth were found with more lesions on the surface. After DENTE91 DB toothpaste treatment, the lesions were decreased significantly as compared with control teeth and teeth treated with marketed toothpaste [Figure 1].

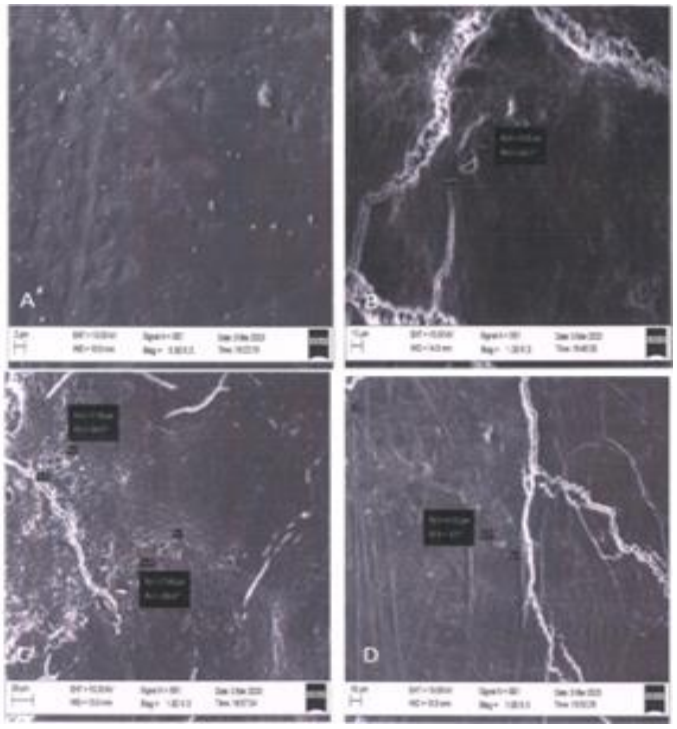

Figure 1: Remineralization effects. (A) Initial teeth result under scanning electron microscopy (SEM) before treatment, (B) control teeth without any toothpaste treatment, (C) teeth treated with marketed product, and (D) teeth treated with DENTE91 DB toothpaste

Healing Activity

After incubation for 12 h, the cell proliferation of NIH/3T3 was significantly promoted by DENTE91 DB toothpaste at dosages of 0.01% [Table 6]. Data obtained from the test sample were comparable with baseline data.

Hypersensitivity

The surface scan of dentine discs demonstrated significant lesions in control dentine discs but treated dentine discs showed significant coverage of the lesions compared to the control dentine discs [Figure 2]. There were less lesions observed in dentine discs treated with DENTE91 DB toothpaste versus the marketed product.

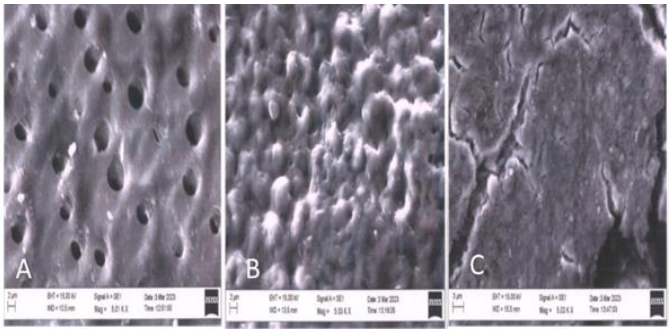

Figure 2: Hypersensitivity. (A) control dentine disc at 5.01 KX, (B) dentine disc treated with DENTE91 DB toothpaste at at 5.03 KX, (C) dentine disc treated with marketed product at at 5.03 KX

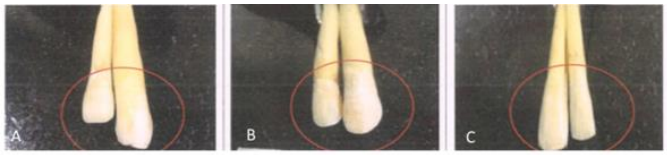

Figure 3: Effects on dental caries/tooth decay. (A) Control sample, (B) DENTE 91 DB toothpaste, (C) Marketed product

Dental Caries/Tooth Decay

After completion of all the treatments, there was a change in color. After demineralization,

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control group teeth were found to be white transparent. After demineralization and brushing, DENTE91 DB teeth and marketed product teeth showed significant color difference as compared with control group [Figure 3].

Control teeth showed loss of minerals as compared with DENTE91 DB toothpaste [Table 7].

Table 1: Final test and marketed solutions for glucose detection

Final preparation of test solution for glucose detection					
S. No.	**Mixture**	**mL taken from Test Stock solution**	**Phenol solution (5% w/v)**	**Add. Conc. H_2SO_4**	**Final volume of test mixture**
1	Test mixture 1	1	1 ml	3 ml	5 ml
2	Test mixture 2	1	1 ml	3 ml	5 ml
3	Test mixture 3	1	1 ml	3 ml	5 ml
Final preparation of marketed solution for glucose detection					
1	Marketed mixture 1	1	1 ml	3 ml	5 ml
2	Marketed mixture 2	1	1 ml	3 ml	5 ml
3	Marketed mixture 3	1	1 ml	3 ml	5 ml

Table 2: Percent reduction in salivary glucose

S No	**% Glucose level (initial)**	**% Reduction in salivary glucose**		**% Improvement in reduction of glucose by DENTE91 DB toothpaste vs control**
		Control	**Test**	
1	100	86	92	6
2	100	74	84	10
3	100	45	60	15
Average %				11

Table 3: Percentage lubrication

Lubricating condition	**Average COF**	**Percentage (%) lubrication**
Dry condition	1.99	0%
DENTE19 DB toothpaste lubricated	1.41	28.96%
Marketed sample lubricated	1.47	26.25%

Table 4: Survival and Efficacy Results on Antimicrobial Effectiveness

Organism	**Avg. CFU**			**Survival (%)**	**Efficacy (%)**
	Positive control	**Exposure time**	**DENTE91 DB toothpaste**	**DENTE91 DB toothpaste**	**DENTE91 DB toothpaste**
S. mutans	8500000	2 mins	1500	0.0176	99.98
		5 mins	850	0.0100	99.99

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P. aeruginosa	3500000	2 mins	2800	0.0800	99.92
		5 mins	1300	0.0371	99.96
C. albicans	6500000	2 mins	1100	0.0169	99.98
		5 mins	250	0.0038	100
P. gingivalis	7000000	2 mins	1450	0.0207	99.98
		5 mins	700	0.0100	99.99

Table 5: Survival Results on Good Oral Microorganisms

Organism	**Survival (%)**	
	DENTE91 DB toothpaste	**Marketed product**
Streptococcus salivarius	84.66%	45.45%
Lactobacillus rhamnosus	73.64%	54.55%
Bifidobacetrium longum	59.52%	26.19%

Table 6: Healing activity of DENTE91 DB toothpaste

Concentration	**Comparison of % Improvement in Proliferation**	
	DENTE91 DB toothpaste	**Marketed product**
DI (I%)	-32.56	-67.36
D2 (0.1%)	-15.12	-29.01
D3 (0.05%)	-5.58	-7.58
D4 (0.01%)	11.01	6.39

Table 7: Effects on mineral components

Concentration of minerals (%)		
Treatment group	**Calcium**	**Phosphate**
Control teeth	13.196	6.539
DENTE91 DB toothpaste	26.233	12.929
Marketed product	23.968	12.122
Percent improvement of minerals		
Minerals	**Teeth treated with DENTE 91 DB toothpaste**	**Teeth treated with marketed product**
Calcium	98.80	81.63
Phosphate	97.72	85.38

DISCUSSION

Oral health issues are becoming a major concern globally with ~50% of the population suffering from an oral disease as per an estimate by the World Health Organization.[25] Oral manifestations are of particular concern in patients with diabetes that increases with elevated glucose levels.[3] Diabetes is amongst the most prevalent diseases with general as well as oral health manifestations such as periodontal, gingival and other oral problems including tooth loss, altered taste, periapical abscess, proneness to bacterial, viral and fungal

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infections, salivary gland disorder, which are related to poorly controlled glucose levels.[12,26] Studies have demonstrated an increase in the salivary glucose levels with an increase in the blood glucose levels.[27,28] Several toothpastes are available in market but the effectiveness of these toothpastes differ due to the different composition.[14,25] This report presents the effectiveness data of DENTE91 DB toothpaste on several oral diseases, especially on the decrease in salivary glucose levels and prevention of the dryness of mouth, which are of particular concern in patients with diabetes.

DENTE91 DB toothpaste effectively reduces the salivary glucose levels as evident in the in vitro study. These findings suggest that DENTE91 DB toothpaste can be effective in diabetic patients as it decreases the salivary glucose of oral cavity. DENTE91 DB toothpaste improves dryness of mouth and also reduces the complication associated with dryness of mouth.

It is evident from *in vitro* antimicrobial effectiveness study that DENTE91 DB toothpaste have less killing effects on good oral microorganisms such as *Streptococcus salivarius*, *Lactobacillus rhamnosus*, and *Bifidobacetrium longum*. Based on these antimicrobial properties, DENTE91 DB toothpaste can be effective for the prevention of several infections in diabetic patients such as Candidiasis (fungal infection), diabetic halitosis (bad breath), gingivitis (mild gum disease), and periodontis (serious gum infection/advanced stage of gingivitis). DENTE91 DB toothpaste has demonstrated the ability to reduce the progression of demineralization, while simultaneously enhancing remineralization process of artificial carious lesions. DENTE91 DB toothpaste can also prevent caries by enhancing the remineralization process and simultaneously providing protection against the inevitable acid attack. DENTE91 DB toothpaste can achieve prevention of caries development (net demineralization) as well as net remineralization of early caries lesions.

Accelerated epithelialization of the tooth extraction socket may have some impact on the prevention of the oral cavity.[29] *In vitro* study demonstrated that proliferation of NIH/3T3 cells were promoted by DENTE91 DB toothpaste. These findings indicate that the treatment of toothpaste activates the proliferation of cells and subsequent healing of dental cavity. DENTE91 DB toothpaste has the ability to occlude the lesions of dentine disc and thereby reducing the hypersensitivity. Furthermore, the SEM observation and mineral profile showed that DENTE91 DB toothpaste could ensure a mineral regain for demineralized enamel thereby it protects against dental caries/tooth decay.

CONCLUSIONS

DENTE19 DB toothpaste offers beneficial effects in diabetic patients with a significant decrease in salivary glucose levels and prevention of dryness of mouth, and hence, could be used in patients with diabetes. Additionally, it exerted beneficial effects in terms of antimicrobial activity, survival of good oral microorganisms, accelerated remineralization and healing, decreased hypersensitivity, and protection against dental caries/tooth decay.

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REFERENCES

1. Miller A, Ouanounou A. Diagnosis, Management, and Dental Considerations for the Diabetic Patient. J Can Dent Assoc. 2020;86:k8.
2. Al-Maskari AY, Al-Maskari MY, Al-Sudairy S. Oral Manifestations and Complications of Diabetes Mellitus: A review. Sultan Qaboos Univ Med J. 2011;11(2):179-86.
3. Indurkar MS, Maurya AS, Indurkar S. Oral Manifestations of Diabetes. Clin Diabetes. 2016;34(1):54-7.
4. López-Pintor RM, Casañas E, González-Serrano J, Serrano J, Ramírez L, de Arriba L, et al. Xerostomia, Hyposalivation, and Salivary Flow in Diabetes Patients. J Diabetes Res. 2016;2016:4372852.
5. Khovidhunkit SO, Suwantuntula T, Thaweboon S, Mitrirattanakul S, Chomkhakhai U, Khovidhunkit W. Xerostomia, hyposalivation, and oral microbiota in type 2 diabetic patients: a preliminary study. J Med Assoc Thai. 2009;92(9):1220-8.
6. Hintao J, Teanpaisan R, Chongsuvivatwong V, Ratarasan C, Dahlen G. The microbiological profiles of saliva, supragingival and subgingival plaque and dental caries in adults with and without type 2 diabetes mellitus. Oral Microbiol Immunol. 2007;22(3):175-81.
7. Lippert F. An introduction to toothpaste - its purpose, history and ingredients. Monogr Oral Sci. 2013;23:1-14.
8. Aspinall SR, Parker JK, Khutoryanskiy VV. Oral care product formulations, properties and challenges. Colloids Surf B Biointerfaces. 2021;200:111567.
9. Walsh T, Worthington HV, Glenny AM, Marinho VC, Jeroncic A. Fluoride toothpastes of different concentrations for preventing dental caries. Cochrane Database Syst Rev. 2019;3(3):Cd007868.
10. George J, Hegde S, Rajesh KS, Kumar A. The efficacy of a herbal-based toothpaste in the control of plaque and gingivitis: a clinico-biochemical study. Indian J Dent Res. 2009;20(4):480-2.
11. Shah H, A. S. Efficacy Evaluation of DENTE91 Anti-Stain Toothpaste: Review of In-Vitro Studies. Ann Int Med Dent Res. 2023;9(3):211-219.
12. Kapadia J, Dodamani A, Baviskar P, Karibasappa GN, Pathak P, Bezalwar A. Effect of Sugar-Free and Regular Toothpaste on Salivary Glucose and pH among Type 2 Diabetes- A Randomized Crossover Trial. J Clin Diagn Res. 2017;11(7):Zc71-zc75.
13. Ahmed F, Prashanth S, Sindhu K, Nayak A, Chaturvedi S. Antimicrobial efficacy of nanosilver and chitosan against Streptococcus mutans, as an ingredient of toothpaste formulation: An: in vitro: study. J Indian Soc Pedod Prev Dent. 2019;37(1):46-54.
14. Yano Y, Vogtmann E, Shreves AH, Weinstein SJ, Black A, Diaz-Mayoral N, et al. Evaluation of alcohol-free mouthwash for studies of the oral microbiome. PLoS One. 2023;18(4):e0284956.
15. Ali Mohammed ZM, Baydaa J, Hassan A. The effect of Glucoamylase and Glucose oxidase from the Aspergillus niger and Penicillium notatum respectively on inhibition of Streptococcus mutans causes the Dental caries. Research J Pharm Tech. 2018;11(8): 3419-3422.
16. Chen Y, Zhong Q, Wang Y, Yuan C, Qin X, Xu Y. Colorimetric detection of hydrogen peroxide and glucose by exploiting the peroxidase-like activity of papain. RSC Advances. 2019;9:16566-16570.
17. Vinke J, Kaper HJ, Vissink A, Sharma PK. An ex vivo salivary lubrication system to mimic xerostomic conditions and to predict the lubricating properties of xerostomia relieving agents. Scientific Reports. 2018;8(1):9087.
18. Prasanth M. Antimicrobial efficacy of different toothpastes and mouthrinses: an in vitro study. Dent Res J (Isfahan). 2011;8(2):85-94.
19. Haerian-Ardakani A, Rezaei M, Talebi-Ardakani M, Keshavarz Valian N, Amid R, Meimandi M, et al. Comparison of Antimicrobial Effects of Three Different Mouthwashes. Iran J Public Health. 2015 Jul;44(7):997-1003.
20. Amaechi BT. Protocols to Study Dental Caries In Vitro: pH Cycling Models. Methods Mol Biol. 2019;1922:379-392.
21. Manchery N, John J, Nagappan N, Subbiah GK, Premnath P. Remineralization potential of dentifrice containing nanohydroxyapatite on artificial carious lesions of enamel: A comparative in vitro study. Dent Res J (Isfahan). 2019;16(5):310-317.
22. Yasunami N, Ayukawa Y, Furuhashi A, Atsuta I, Rakhmatia YD, Moriyama Y, et al. Acceleration of hard and soft tissue healing in the oral cavity by a single transmucosal injection of fluvastatin-impregnated poly (lactic-co-glycolic acid)

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microspheres. An in vitro and rodent in vivo study. Biomed Mater. 2015;11(1):015001.
23. Arnold WH, Prange M, Naumova EA. Effectiveness of various toothpastes on dentine tubule occlusion. J Dent. 2015;43(4):440-9.
24. Muntean A, Sava S, Delean AG, Mihailescu AM, Dumitrescu LS, Moldovan M, et al. Toothpaste Composition Effect on Enamel Chromatic and Morphological Characteristics: In Vitro Analysis. Materials (Basel). 2019;12(16).
25. Jain N, Dutt U, Radenkov I, Jain S. WHO's global oral health status report 2022: Actions, discussion and implementation. Oral Dis. 2023 Jan 20. doi: 10.1111/odi.14516. Online ahead of print.
26. Hegde A, Shenoy R, D'Mello P, Smitha A, Tintu A, Manjrekar P. Alternative markers of glycemic status in diabetes mellitus. Biomed Res. 2010;21(3):252-256.
27. Vasconcelos AC, Soares MS, Almeida PC, Soares TC. Comparative study of the concentration of salivary and blood glucose in type 2 diabetic patients. J Oral Sci. 2010;52(2):293-8.
28. Aydin S. A comparison of ghrelin, glucose, alpha-amylase and protein levels in saliva from diabetics. J Biochem Mol Biol. 2007;40(1):29-35.
29. de Sousa Gomes P, Daugela P, Poskevicius L, Mariano L, Fernandes MH. Molecular and Cellular Aspects of Socket Healing in the Absence and Presence of Graft Materials and Autologous Platelet Concentrates: a Focused Review. J Oral Maxillofac Res. 2019;10(3):e2.

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