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Research Article

Comparative Evaluation of the Clinical Efficacy of Nigella Sativa (0.1%) Mouthwash and Chlorhexidine Gluconate (0.2%) in subjects with Gingivitis: A Randomised Control Trial

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Abstract

Gingivitis, the most common periodontal disease caused by plaque biofilm, often requires adjunctive chemotherapeutic agents alongside mechanical plaque control for effective management, and *Nigella sativa* (black seed) emerges as a promising natural option due to its wide range of therapeutic properties. The objectives were to evaluate and compare the anti-plaque and anti- inflammatory efficacy of *Nigella sativa* (0.1%) mouthwash on reactive oxygen metabolites levels in the saliva with chlorhexidine gluconate (0.2%) mouthwash in patient with gingivitis. In this randomized controlled clinical trial, 48 subjects were randomly assigned to two groups with 24 subjects in each group, Group I received Scaling + *Nigella sativa* (0.1%) mouthwash and Group II received Scaling + Chlorhexidine gluconate (0.2%) mouthwash. Clinical parameters Plaque index (PI), Gingival index (GI), collection of saliva samples was done at baseline and after four weeks. On Intergroup comparison, the mean PI, GI values exhibited no statistically significant difference [PI (P=0.93) and GI (P=0.89)]. Whereas On Intergroup comparison for the mean ROM levels, statistically significant difference [P= <0.001*] was noted between two groups. Thus *Nigella sativa* (0.1%) mouthwash, as a plaque control agent was found to be comparable in plaque reduction to that of chlorhexidine gluconate mouthwash (0.2%) and can be used for the treatment of gingivitis.

Keywords: Chlorhexidine gluconate, Gingivitis, *Nigella sativa*, Plaque control, Reactive oxygen metabolites, Saliva

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Introduction

The human oral cavity harbours various communities of microbes that reside in dental biofilm. Dental caries and periodontal disease are the most prevalent microbial mediated human oral diseases, worldwide (1) .These oral diseases are recognized to significantly burden the economic, psychological, and social development of communities across the globe (2).

Gingivitis is the most prevalent form of periodontal disease, characterised by inflammation and bleeding of the gingival tissue with the primary etiologic factor being plaque biofilm. Gingivitis has a direct association with dental plaque and affects oral health around 70%–100% of the population across the world (3). Gingivitis is a reversible process through meticulous plaque control. However, it may progress into periodontitis with inadequate oral care and eventually affects the entire periodontal attachment apparatus of the involved teeth, finally resulting in tooth loss (3).Therefore, elimination of plaque and its control plays a vital role in preventing and or arresting gingival inflammation and maintenance of good periodontal health.

Currently, toothbrushing is the most popular, self-performed oral hygiene method to mechanically remove dental plaque. However mechanical plaque control in most of the individuals is often not sufficiently effective because of time consumption, dexterity required and injury to the adjacent tissues (4).Thus it is important to supplement mechanical plaque removal with a chemotherapeutic agent so that they can inhibit bacterial colonization, growth, and metabolism, and consequently interrupt the formation of mature biofilm (5).The use of antimicrobial mouthwashes as an adjunct to mechanical oral hygiene has become well established in dental practice for the control of supra-gingival plaque and gingivitis (6).

Several agents such as chlorhexidine gluconate, essential oils, phenolic compounds, pyrimidines, quaternary ammonium compounds, oxygenating agents, and halogens are effective in reducing the plaque biofilm (5). Among these agents, chlorhexidine gluconate (CHX) is considered as the gold standard mouthwash in prevention and treatment of gingivitis, but its

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deleterious effects on the oral mucosa, staining properties, taste alterations and calculus formation discourage its usage and reduce acceptance (6) .Therefore, there is a constant quest for naturally occurring, indigenous and cost-effective oral hygiene products with similar positive effects and least adverse effects (7).

Herbal medicines, derived from botanical sources, have been used for various therapeutic benefits in periodontal therapy(3). The herbal mouthwashes are gaining popularity as they contain naturally occurring ingredients called as phytochemicals that achieve the desired antimicrobial and anti-inflammatory effect. It has been recently reported that a considerable number of herbal mouthwashes have achieved encouraging results in plaque control and treatment and/or prevention of gingivitis(8).

Nigella sativa (NS) is one such miracle herb with a rich historical and religious background belonging to the Ranunculaceae family, commonly known as 'black seed' or 'black cumin'. It is cultivated in countries bordering the Mediterranean Sea, Pakistan, India, and Iran. Major population from the Middle East and Southeast Asian countries use N. sativa seeds extensively to treat disorders, such as bronchitis, asthma, gastrointestinal diseases, and applied its oil to treat skin diseases such as boils and eczema (9). *Nigella sativa* is known to have antihypertensive, antidiabetic, anticancer, diuretic, analgesic, antimalarial effects. The major constituents are thymoquinone, dithymoquinone, thymol and thymo hydroquinone(10). The active ingredient being, Thymoquinone (TQ) which possesses anti-inflammatory and anti- oxidative properties has been reported to have an important role in the prevention of periodontal disease (11).

To the best of our knowledge the anti-plaque, anti-inflammatory and anti-oxidant effects of *Nigella sativa* mouthwash in the treatment of gingivitis has not been reported. Hence the aim of the study was to evaluate the antiplaque and anti- inflammatory efficacy of *Nigella sativa* (0.1%) mouthwash on reactive oxygen metabolites levels in the saliva with gingivitis subjects.

Methodology

The present double-blind, randomized controlled trial was conducted in the Department of Periodontology, Dayananda Sagar College of Dental Sciences, Bengaluru, and included male and female subjects aged between 20 to 50 years. Subjects diagnosed with dental biofilm- induced gingivitis and without any systemic illnesses were included in the study after obtaining informed written consent. Ethical clearance was obtained from the Institutional Ethical Committee. Participants were recruited based on defined inclusion and exclusion criteria. Those with systemic diseases (e.g., diabetes mellitus, hypertension, thyroid disorders), recent antibiotic or steroid use, prior dental treatment within the preceding 14 days, known allergies to oral hygiene products, or periodontal conditions beyond gingivitis were excluded.

A total of 48 eligible subjects were enrolled and randomly allocated into two groups using block randomization with allocation concealment. Group A (Experimental group) received a mouthwash containing 0.1% *Nigella sativa*, whereas Group B (Control group) received 0.2% chlorhexidine gluconate mouthwash. Blinding was ensured by labeling the mouthwash bottles as 'A' and 'B' by the dispensing pharmacist, with the code revealed to the investigator only after data analysis.

The *Nigella sativa* extract was prepared following standardized protocols as described in literature (12). Black seeds procured from an Ayurvedic vendor were dried, powdered, and subjected to ethanol extraction using Soxhlet apparatus. The extract was filtered and concentrated by evaporating the solvent, followed by drying in a water bath at 50°C until a consistent residue was obtained. The minimum inhibitory concentration (MIC) of *Nigella sativa* was determined using thioglycolate broth prior to the study, and 0.1% was selected as the effective concentration(13).An MTT assay was performed to assess cytotoxicity and cell viability of the extract on human gingival fibroblasts. Substantivity of the *Nigella sativa* mouthwash was analyzed spectrophotometrically in-vitro at intervals of 8 and 12 hours and compared to that of chlorhexidine gluconate(14)

Baseline clinical parameters , plaque index (Turesky-Gilmore-Glickman modification of Quigley-Hein Index) and gingival index (Löe and Silness) were recorded for all participants, and unstimulated saliva samples were collected to assess reactive oxygen metabolite (ROM) levels. Participants underwent thorough scaling and were instructed to follow their usual brushing habits, followed by twice-daily rinsing with the assigned mouthwash for one minute, over four weeks. Saliva and clinical assessments were repeated at the four-week follow-up. Adherence to the regimen was monitored weekly by evaluating the residual mouthwash volume in the bottles, and any adverse effects were documented.

Reactive Oxygen Metabolite (ROM) estimation involved spectrophotometric analysis, where 20 µl of saliva was combined with 1 ml of acetate buffer and 20 µl of the chromogenic substrate (N,N-diethyl-p- phenylenediamine), followed by incubation at 37°C for 5 minutes. Absorbance at 505 nm was recorded, and ROM levels were expressed in Carratelli units (CARRU), where 1 CARRU equates to 0.08 mg/dL of hydrogen peroxide(15).

Sample size was calculated a priori using G*Power 3.1.9.2 software, based on an effect size of 0.8, $\alpha = 0.05$, and power of 0.80, yielding a minimum of 42 subjects. Accounting for an anticipated 10% dropout rate, the final sample size was adjusted to 48, with 24 participants in each group.

All statistical analyses were conducted using SPSS version 22.0 (IBM Corp., Armonk, NY). Descriptive statistics included mean and standard deviation for each parameter. Inferential statistics involved the Mann–Whitney U test to compare intergroup differences in Plaque index, Gingival index, and ROM levels at baseline and after four weeks. The Wilcoxon signed-rank test was employed for intragroup comparisons across time points. Substantivity differences between groups at 8 and 12 hours were analysed using the Mann–Whitney U test, while Wilcoxon signed-rank test was used for intra-group comparisons across the two-time intervals. Statistical significance was set at $p < 0.05$. An odds ratio analysis was performed to evaluate the likelihood of achieving a ≥25% reduction in ROM levels between CHX and NS groups, establishing clinical significance.

Results

This study compared the anti-plaque, anti-inflammatory, and antioxidant effects of 0.1% *Nigella sativa* and 0.2% chlorhexidine mouthwashes in participants with gingivitis . Forty-eight participants (aged 20–50) underwent baseline assessments, including Plaque and Gingival Indices and salivary ROM levels. Following scaling, subjects were randomized to either group and instructed to rinse twice daily for four weeks. Post-treatment evaluations repeated clinical and biochemical measures, with data statistically analyzed.

Prior to clinical intervention, the antimicrobial potency of the *Nigella sativa* extract was gauged against four pertinent oral

pathogens: Streptococcus mitis, Streptococcus mutans, Fusobacterium nucleatum, and Prevotella intermedia. The Minimum Inhibitory Concentration (MIC) was determined to be 100 µg/mL, which corresponds to a 0.1% (w/v) concentration employed in the mouthwash formulation. Substantivity, reflecting the residual antimicrobial activity over time was assessed in vitro via spectrophotometric measurement at 8 hours and 12 hours post-application. The mean substantivity values (± SD) for NS (0.1%) and CHX (0.2%) are presented in Table 1.

Table 1: Comparison of Substantivity Values Between *Nigella sativa* (0.1%) and Chlorhexidine (0.2%) Mouthwash

Time Interval	Group	Mean ± SD	p-Value
8 hours	CHX (0.2%)	0.8019 ± 0.1300	0.08
	NS (0.1%)	0.9370 ± 0.1722	
12 hours	CHX (0.2%)	0.7903 ± 0.1487	0.19
	NS (0.1%)	0.8882 ± 0.0911	

An MTT assay was conducted to appraise the cytotoxic potential of the 0.1% *Nigella sativa* extract on human gingival fibroblasts (HGF). Findings confirmed that the selected concentration was non-cytotoxic, preserving viability of HGFs. No deleterious effects on cell proliferation or morphology were observed at 0.1% concentration, validating its safety for clinical application. (Graph-1).

This study compared the plaque index (PI) and gingival index (GI) between two groups: Chlorhexidine (CHX) and *Nigella sativa* (NS) at baseline and after 4 weeks. At baseline, both groups had similar PI (CHX: 1.63±0.41, NS: 1.65±0.32; p=0.86) and GI (CHX: 1.25±0.18, NS:1.33±0.13; p=0.27), showing no significant difference. After 4 weeks, both groups showed a significant intragroup reduction in PI (CHX: ↓1.22, NS: ↓1.22; p<0.001) and GI (CHX: ↓0.90, NS: ↓0.97; p<0.001), indicating effective plaque and gingival inflammation control. Intergroup differences at 4 weeks remained non-significant (PI p=0.93, GI p=0.89), suggesting both CHX and NS were similarly effective. (Table-2)

Graph 1: **Bar graph representing the MTT assay results for human gingival fibroblast (HGF) cell viability with 0.1% *Nigella sativa* extract.**

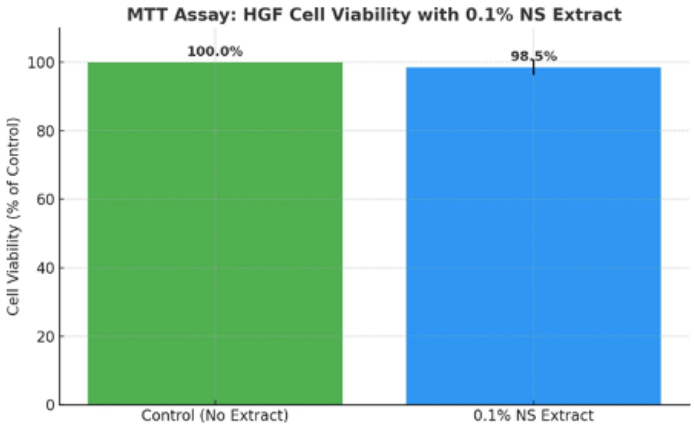


Table 2: Comparative Analysis of Plaque and Gingival Index (PI & GI) Between NS (0.1%) and CHX (0.2%) Groups

Parameter	Time Point	Group	Mean ± SD	Mean Difference	p-Value	Significance
PI	Baseline	CHX	1.630 ±0.409	–0.017	0.86	NS = CHX
		NS	1.647 ±0.317			
	4 Weeks	CHX	0.414 ±0.081	–0.009	0.93	NS = CHX
		NS	0.423 ±0.073			
	Intragroup (CHX)	Pre vs. Post	↓1.216	< 0.001*	Significant	
	Intragroup (NS)	Pre vs. Post	↓1.224	< 0.001*	Significant	
GI	Baseline	CHX	1.253 ±0.176	–0.076	0.27	NS = CHX
		NS	1.329 ±0.127			
	4 Weeks	CHX	0.355 ±0.057	–0.005	0.89	NS = CHX
		NS	0.360 ±0.062			
	Intragroup (CHX)	Pre vs. Post	↓0.898	< 0.001*	Significant	
	Intragroup (NS)	Pre vs. Post	↓0.968	< 0.001*	Significant	

Both CHX and NS groups showed a significant reduction in ROM levels after 4 weeks (CHX:↓78.4, NS: ↓115.95) ,($p < 0.001$). Although NS showed a greater intragroup drop, intergroup comparison favoured CHX at 4 weeks (CHX: 354.11 vs NS: 307.74; $p < 0.001$), indicating CHX maintained higher antioxidant status. (Table-3) (Graph-2)

Table 3: **Comparison of ROM Levels (CHX vs NS) at Baseline and 4 Weeks**

Group	Time Point	Mean ± SD	Intragroup Δ (↓)	p-Value (Intra)	Intergroup Δ	p-Value (Inter)
CHX (0.2%)	Baseline	432.51 ± 26.43			8.81	0.29
	4 Weeks	354.11 ± 34.67	↓78.40	< 0.001*	46.36	< 0.001*
NS (0.1%)	Baseline	423.69 ± 36.43				
	4 Weeks	307.74 ± 37.93 ±	↓115.95	< 0.001*		

While both CHX and NS significantly reduced oxidative stress levels over 4 weeks, CHX showed a 4.5 times higher likelihood of achieving a clinically meaningful ROM reduction (≥25%) compared to NS (OR = 4.53, $p < 0.01$). Although NS showed a greater mean drop in ROM values, CHX's more consistent individual response rate (92% vs. 71%) underscores its greater clinical reliability and superior antioxidant substantivity in managing gingivitis- associated oxidative stress. (Table-4) (Graph-3).

Graph 2: Bar graph comparing ROM levels in CHX and NS groups at baseline and after 4 weeks.

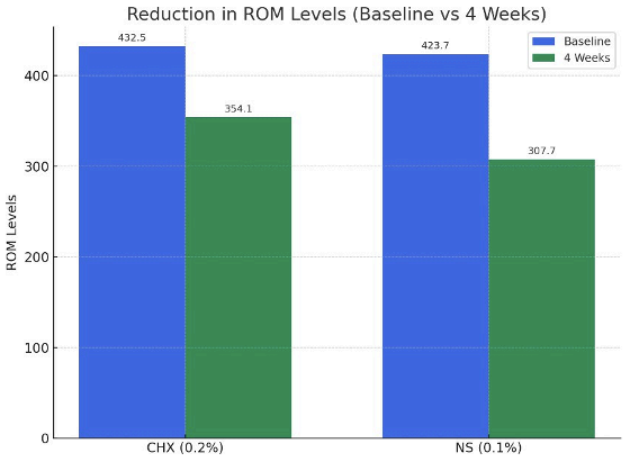
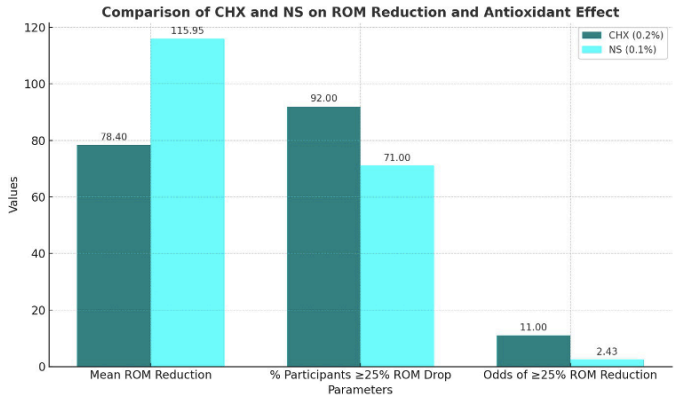


Table 4: Comparative Clinical Impact of CHX vs. NS on ROM Reduction in Gingivitis Subjects

Parameter	CHX (0.2%)	NS (0.1%)
Mean ROM Reduction (µmol H_2O_2 equiv./L)	↓78.4	↓115.95
% of Participants with ≥25% ROM Drop	92% (22/24)	71% (17/24)
Odds of ≥25% ROM Reduction	11.0	2.43
Odds Ratio (CHX vs. NS)	4.53	—
p-Value (Odds Ratio)	< 0.01	—

Graph 3: Differences between CHX (0.2%) and *Nigella sativa* (0.1%) mouthwashes in terms of ROM reduction and antioxidant efficacy



Discussion

This study evaluated the comparative efficacy of 0.1% *Nigella sativa* (NS) and 0.2% chlorhexidine (CHX) mouthwashes on plaque control, gingival inflammation, and oxidative stress in patients with biofilm-induced gingivitis. The findings align with established knowledge that dental plaque is the primary etiological factor in gingivitis and periodontitis, as microbial communities within plaque undergo complex structural changes transitioning from health to disease states(1). Gingival inflammation, a hallmark of periodontal disease, remains a global health challenge due to its prevalence and impact on quality of life (2). Conventional antiseptics like CHX have demonstrated robust antiplaque and anti-inflammatory effects (2-6) but are often limited by adverse effects such as tooth staining and mucosal irritation, prompting investigation into safer, plant-based alternatives (7-9).

Nigella sativa, rich in bioactive compounds such as thymoquinone, has garnered interest for its antimicrobial, anti-inflammatory, and antioxidant properties, making it a promising phytomedicine in oral care(1,16,17) .This study's demonstration of NS mouthwash achieving comparable reductions in plaque and gingival indices echoes prior clinical trials evaluating herbal mouthwashes including Ocimum sanctum and green tea, which showed efficacy on par with CHX (5,6,15).The substantial decrease in reactive oxygen metabolite (ROM) levels observed in the NS group further supports the antioxidant potential of NS in mitigating oxidative stress, a critical mediator of periodontal tissue destruction(18,19).

The non-cytotoxicity of NS extract on human gingival fibroblasts confirmed via MTT assay reinforces its safety and biocompatibility (8,20) Interestingly, NS exhibited greater substantivity at 8 and 12 hours compared to CHX, though without statistical significance, suggesting prolonged retention and potential sustained action in the oral cavity. The lower odds ratio for achieving ≥25% ROM reduction in the NS group relative to CHX may reflect variability in patient response or pharmacokinetics, indicating the need for optimization of formulation or dosage.

Mechanistically, NS's active constituents have been documented to disrupt bacterial biofilms, inhibit pro-inflammatory cytokines, and scavenge free radicals, thus addressing multiple pathogenic pathways in gingivitis(10,21,22).These multimodal actions may contribute to the observed clinical improvements and support the integration of NS as a complementary adjunct to mechanical plaque control(23,24).

Prior to clinical application, the antimicrobial efficacy of *Nigella sativa* (NS) extract was validated against key oral pathogens including Streptococcus mitis, Streptococcus mutans, Fusobacterium nucleatum, and Prevotella intermedia, with a Minimum Inhibitory Concentration (MIC) established at 100 µg/mL (0.1% w/v), which was the concentration incorporated into the mouthwash formulation.Substantivity, a critical factor reflecting the sustained antimicrobial action on the oral biofilm, was assessed spectrophotometrically at 8 and 12 hours post-application. The results demonstrated marginally higher substantivity for NS (0.1%) compared to chlorhexidine (CHX) (0.2%), though the differences were not statistically significant ($p > 0.05$), indicating comparable residual activity between the herbal and gold- standard agents(14).

Importantly, the cytotoxicity profile evaluated by MTT assay on human gingival fibroblasts confirmed that NS at 0.1% concentration maintained high cell viability and normal morphology, underscoring its biocompatibility and safety for clinical use(21,22,25,).This aligns with growing evidence supporting *Nigella sativa*'s role as a natural adjunct in oral care, combining antimicrobial potency with minimal adverse effects, offering a promising alternative to chemical antiseptics traditionally used for plaque and gingivitis control(2,7,10,). Given the multifactorial etiology of plaque-induced gingivitis and the increasing interest in plant-based therapeutics, NS mouthwash may contribute effectively to plaque management and inflammation reduction while circumventing common side effects

associated with CHX, such as mucosal irritation and staining(1,17,23).

The present study demonstrated significant reductions in both plaque index (PI) and gingival index (GI) within the Chlorhexidine (CHX) and Normal Saline (NS) groups over 4 weeks, confirming effective plaque and gingival inflammation control in both interventions. At baseline, comparable PI and GI values between groups indicated similar initial oral health status, supporting the reliability of the subsequent comparative analysis. Significant intragroup decreases in PI (CHX: ↓1.22; NS: ↓1.22) and GI (CHX: ↓0.90; NS: ↓0.97) align with existing evidence on the effectiveness of antimicrobial and mechanical plaque control methods in managing gingivitis.2,28,29 Notably, the absence of significant intergroup differences at 4 weeks (PI p=0.93; GI p=0.89) suggests that low-concentration NS may be nearly as effective as CHX in reducing plaque and gingival inflammation over the short term, corroborating findings from recent trials on alternative mouth rinses(26).

Chlorhexidine's broad-spectrum antimicrobial properties and substantivity are well- established, making it the gold standard in chemical plaque control(29). However, the comparable clinical outcomes observed with NS here might reflect its role as a mechanical rinsing agent aiding plaque removal and reducing bacterial load, particularly in mild to moderate gingivitis(7) .These results resonate with studies highlighting the potential of herbal and natural rinses with anti-inflammatory and antimicrobial activities comparable to CHX, including *Nigella sativa* and other botanical extracts(7,8,9). Moreover, the significant reduction in gingival inflammation observed supports the critical role of plaque control in preventing periodontal tissue breakdown. As gingivitis is a reversible condition primarily driven by dental biofilm accumulation, the effective reduction of plaque correlates directly with decreased inflammatory indices(1,17).CHX remains a highly effective agent for plaque and gingivitis control, the findings here contribute to a growing body of literature advocating for alternative or adjunctive therapies such as NS and herbal mouthwashes, which may offer similar clinical benefits with fewer side effects(3,23).

Both 0.2% chlorhexidine (CHX) and 0.1% *Nigella sativa* (NS) mouthwashes demonstrated a significant reduction in reactive oxygen metabolites (ROM) levels over the 4-week period (CHX: ↓78.4, NS: ↓115.95; $p < 0.001$), indicating their effectiveness in reducing oxidative stress associated with gingival inflammation. Although NS exhibited a greater intragroup reduction, the intergroup comparison revealed that CHX maintained a significantly higher antioxidant status at 4 weeks (354.11 vs 307.74; $p < 0.001$), underscoring CHX's sustained substantivity and efficacy in oral antioxidant defense. This aligns with prior evidence demonstrating CHX's robust antimicrobial and anti-plaque effects through disruption of dental biofilms and inhibition of microbial oxidative pathways(1,24,26) .Meanwhile, NS, rich in thymoquinone and other bioactive compounds, exhibits potent antioxidant and anti- inflammatory properties, supporting its adjunctive role in periodontal therapy(21,27,29).These findings suggest that while NS can serve as a natural alternative with considerable antioxidative benefits, CHX remains superior in maintaining prolonged oral antioxidant levels and controlling oxidative stress-induced periodontal damage(18,19,23).This study demonstrated that both chlorhexidine (CHX) 0.2% and *Nigella sativa* (NS) 0.1% mouthwashes significantly reduced oxidative stress levels, as measured by reactive oxygen metabolites (ROM), over 4 weeks in gingivitis patients. However, CHX showed a notably higher clinical reliability, with a 4.5-fold greater likelihood of achieving a clinically meaningful ROM reduction (≥25%) compared to NS (OR = 4.53, $p < 0.01$). Although NS yielded a larger mean decrease in ROM values, CHX's consistent individual response rate (92% vs. 71%) underscores its superior substantivity and antioxidant effect in managing gingivitis-associated oxidative stress. The superior clinical efficacy of CHX aligns with its well-established antimicrobial and anti- inflammatory properties, which have been extensively documented in controlling dental plaque biofilms and gingival inflammation(1,2,24). The substantivity of CHX allows prolonged antimicrobial activity. Conversely, *Nigella sativa*, a traditional herbal agent known for its active constituent thymoquinone, has shown promising antioxidant, anti-inflammatory, and antimicrobial effects in vitro and in vivo(8,9,10,21) in the oral cavity, contributing to its consistent performance across patients.

The present study findings corroborate previous randomized controlled trials reporting the potential of NS mouthwashes to reduce plaque and gingival inflammation(4,18) but also highlight some variability in patient response, which might be attributed to differences in formulation, bioavailability, or individual host factors(27,29).The greater mean ROM reduction observed with NS suggests a potent antioxidant effect possibly due to thymoquinone's free radical scavenging activity(21). However, the lower proportion of participants achieving the ≥25% ROM reduction threshold indicates less predictable clinical efficacy compared to CHX, underscoring the need for further optimization of dosage and delivery methods.

Future studies should explore synergistic formulations and long-term effects to harness the benefits of both agents in periodontal therapy. Clinically, the demonstrated superior consistency of chlorhexidine in reducing oxidative stress supports its continued use as a reliable first-line adjunct in managing gingivitis, while *Nigella sativa* offers a promising natural alternative that may benefit patients seeking herbal options or those intolerant to chemical mouthwashes. From a managerial perspective, incorporating evidence-based herbal formulations like *Nigella sativa* alongside chlorhexidine could enhance patient compliance and satisfaction, potentially reducing treatment costs and side effects associated with long-term chemical mouthwash use in periodontal care programs.

Limitation

The relatively small sample size and short intervention duration warrant caution in extrapolating these findings broadly.

Future Perspective: Longitudinal, large-scale studies are imperative to substantiate *Nigella sativa*'s therapeutic potential and optimize its clinical application in periodontal care.

Conclusion

The 0.1% *Nigella sativa* mouthwash demonstrates comparable anti-plaque and anti- inflammatory efficacy to 0.2% chlorhexidine, coupled with promising antioxidant properties and exceptional biocompatibility, positioning it as a viable natural adjunct in periodontal therapy. Despite chlorhexidine's superior consistency in oxidative stress reduction, *Nigella sativa* offers a safer, phytotherapeutic alternative that merits further exploration.

Ethical Clearance: The study was conducted following institutional ethical approval and in accordance with the Declaration of Helsinki.

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