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ORIGINAL ARTICLE

Effect of Herbal Extracts and Commercial Denture Cleansers on Color Stability of Heat-Polymerized Acrylic Denture Base Resin: An In-Vitro Study

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ABSTRACT

Background: Color stability of denture base resins is critical for long-term esthetics and patient satisfaction. Commercial denture cleansers are effective but may affect the color stability of acrylic resins. Herbal alternatives offer potential advantages with fewer side effects.

Aim: To evaluate and compare the effect of herbal extracts and commercial denture cleansers on the color stability of heat-polymerized acrylic denture base resin.

Materials and Methods: A total of 36 acrylic resin specimens were fabricated and divided into four groups (n=9) based on cleansing solution: Group I – Clinsodent, Group II – Distilled Water, Group III – Oradox, and Group IV – Origanum Oil. All samples were stained with turmeric, tea, and coffee solutions, then subjected to respective cleansing agents for 10 days. Color changes were measured at baseline, post-staining, and post-cleansing using a UV-VIS spectrophotometer and analyzed via CIELAB parameters (ΔE). Data were statistically analyzed using ANOVA and Tukey's post hoc test.

Results: Origanum oil (Group IV) demonstrated the highest color stability (ΔE = 77.91 ± 0.13), followed by Oradox (76.01 ± 0.13), Clinsodent (75.35 ± 0.16), and distilled water (72.83 ± 0.20). Statistically significant differences were observed

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between all groups ($p < 0.001$).

Conclusion: Origanum oil exhibited superior performance in maintaining color stability of acrylic resins and can serve as an effective herbal alternative to commercial denture cleansers.

KEYWORDS:

• Denture cleanser • Color stability • Acrylic resin • Origanum oil • Herbal extract • Spectrophotometer

INTRODUCTION

India has one of the largest populations in the world, and the number of elderly people is increasing rapidly. The elderly, or people aged 60 years and above, are growing in numbers due to better health care and longer life expectancy. According to the 2011 Census, 8.6% of India's population were senior citizens, and this number is expected to rise to 20% by 2050. This demographic shift brings new challenges, especially in healthcare, with oral health being one of the most pressing issues.

Unfortunately, oral health is often neglected in India, especially in rural areas where access to dental care is limited.[1] Many elderly people in these areas face significant oral health challenges, including tooth loss, which can severely impact their ability to chew food, speak properly, and communicate effectively.

In addition to functional impairment, poor oral health contributes to systemic health risks. Studies have shown that inadequate denture hygiene can lead to the colonization of microorganisms, such as Candida albicans, which is associated with denture-induced stomatitis. The porous nature and hydrophobic surface of denture base resins like PMMA allow rapid microbial adherence, further emphasizing the importance of maintaining denture hygiene. Poor denture hygiene not only exacerbates local infections but may also increase the risk for aspiration pneumonia in vulnerable elderly patients.[2] Regular and effective cleaning of dentures is, therefore, essential to preserve both oral and general health among older adults.[4]

Moreover, certain traditional habits and cultural practices, such as the heavy consumption of certain spices and betel nuts, further contribute to oral health problems. Poverty and lack of education prevent many elderly people from seeking timely dental care, and in many rural areas, dental services are scarce or non-existent. This results in a cycle where untreated oral health problems lead to more severe health issues over time.

Maintaining good hygiene is crucial to the longevity and effectiveness of dentures. Regular cleaning helps remove food particles, stains, and bacteria, preventing the development of gum infections, bad breath, and other oral health issues. Brushing dentures with a soft brush and using non-abrasive cleaners also helps maintain their smooth surface and prevent damage. Additionally, specialized denture cleansers, available in the form of tablets, powders, and liquids, are designed to remove stains and food particles without harming the denture material.

There are two main categories of chemical denture cleansers: alkaline peroxide and sodium hypochlorite-based agents. Alkaline peroxide cleansers work through effervescent action to dislodge debris, while sodium hypochlorite solutions have potent bactericidal and fungicidal properties.[4] However, prolonged exposure to chemical cleansers can lead to adverse changes in the denture base, including color instability, surface roughness, and reduced mechanical strength.[5,6,7]

While traditional cleansers often contain chemicals like sodium perborate or hypochlorite, which can be effective at cleaning but may damage the material over time, herbal cleansers offer a gentler, more natural alternative. Natural products, particularly plant-derived essential oils such as thyme oil and origanum oil, have demonstrated significant antimicrobial and antifungal activities.[1,2]

These herbal products are often free from harsh chemicals and are less likely to cause side effects, making them a valuable option for seniors who want to care for their dentures while minimizing the risk of adverse effects.

This study aims to compare the effects of herbal extracts and commercial denture cleansers on the color stability of heat polymerized acrylic denture base resin. By focusing on herbal cleansers, the study hopes to find safer and more effective ways to maintain dentures, improving oral health and quality of life for elderly patients in India.

MATERIALS AND METHODS

The study was conducted in the Department of Prosthodontics at I.T.S Dental College, Ghaziabad. Ethical approval was obtained from the Institutional Ethical Committee. A total of 36 acrylic specimens (10mm x 10mm x 2mm) were fabricated using a standard heat-polymerization technique. These were finished and polished to a high gloss using pumice slurry and polishing brushes.

Sample Preparation

Specimens with the dimensions of 10mm×10mm×2 mm were obtained from the modeling wax. Wax patterns were invested into the flask and dewaxing was performed conventionally. Acrylic resin (DPI Heat-cure Improved; DPI India, India) was then packed and trial closure and final closures were done traditionally. Bench curing was done for 30 minutes and polymerization was carried out according to the manufacturer's instruction. Finishing was carried out using fine-grit sandpaper following wet sandpapering and polishing was done on a wet felt cone and rag wheel with pumice slurry to obtain a well-polished surface.

After finishing and polishing of the specimens, initial color measurements were made using UVVIS spectrophotometer.

Application of stains to the specimens

The specimens were stained by immersing them in a turmeric, tea, and coffee solution prepared by dissolving 3 g of powder in 100 ml of distilled water for 7 days to simulate weekly exposure to beverages or food in the oral cavity (2 h × 7 days = 14 h). Second color measurements of stained specimens were made using UV-VIS spectrophotometer.

Removal of stains using denture cleanser All the stained specimens were randomly divided into four groups containing 9 specimens each (n = 9) for the removal of stains using three different denture cleansers and distilled water as control group.

- Group 1 – Clinsodent
- Group 2 – Distilled water
- Group 3 − Oradox
- Group 4 – Origanum Oil

Denture cleansing solution was prepared by dissolving one tablet of denture cleanser or one teaspoon of denture cleanser powder in 150 ml of warm water (45°C). All the specimens in Groups 1, 2, 3 and 4 were immersed in their respective denture cleansing solution for 10 days to simulate the denture cleansing action of 1 month (8 h/ day for 30 days = 240 h).

Third color measurements of cleansed specimens were made using UVVIS spectrophotometer after 10 days.

Color Analysis

For evaluating color difference, the spectrophotometric readings were converted to International Commission on Illumination system (CIELAB).

This system was based on three parameters for defining color: L, a, and b, they represented lightness redgreen component, and yellowblue component of color, respectively.

The color change (ΔE) of each specimen was calculated using the following equation:

$$\Delta E = [(\Delta L)2 + (\Delta a)2 + (\Delta b)2]½$$

Where ΔE was color change, +a represented red and −a represented green, while yellow corresponded to +b and blue to −b. ΔL, Δa, and Δb represented the color differences measured in L, a, and b values before and after immersion of specimens.

The color measurements (ΔE) values of four groups: Group 1 – Clinsodent, Group 2 – Distilled Water, Group 3 − Oradox and Group 4 - Origanum Oil were arranged in the following categories:

Category a unstained

Category b stained

Category c cleansed were collected and data was analysed

Statistical Analysis:

Data were analyzed using SPSS v23. One-way ANOVA was used to compare means across groups, and post hoc Tukey HSD test determined intergroup significance. A p-value < 0.05 was considered statistically significant.

Figure 1: Mold for fabrication of samples

Figure 2: Cured acrylic samples

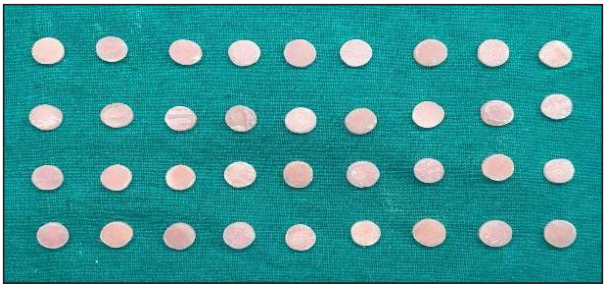

Figure 4: Finished and polished acrylic samples

Figure 4: Origanum Oil, Oradox Denture Cleansing Tablets, Clinsodent Denture Cleansing Tablets

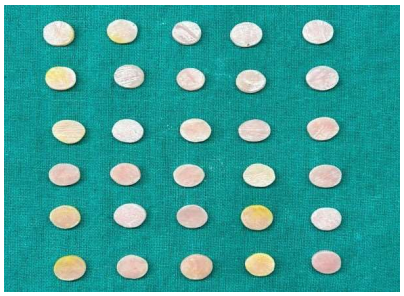

Figure 5: Stained samples in organic stains (tea, coffee and turmeric)

Figure 6: Samples In Origanum Oil, Distilled Water, Clinsodent Tablet and Oradox Tablet

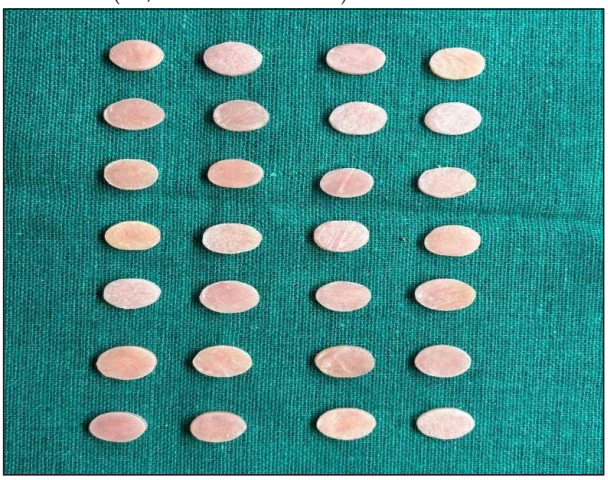

Figure 6: Acrylic disks after cleansing using denture cleansers

Figure 7: UV-VIS Spectrophotometer

RESULTS

Group IV (Origanum oil) exhibited the highest color stability (ΔE = 77.91 ± 0.13), followed by Group III (Oradox) at 76.01 ± 0.13, Group I (Clinsodent) at 75.35 ± 0.16, and Group II (Distilled water) at 72.83 ± 0.20. ANOVA revealed statistically significant differences among all groups ($F = 1620$, $p < 0.001$).

Tukey's post hoc analysis showed significant differences between all group pairs. The highest mean difference was observed between Group IV and Group II (mean diff = 5.08, $p < 0.001$), indicating superior performance of Origanum oil over distilled water.

These findings were supported by consistent standard deviations and narrow confidence intervals, reinforcing the reliability of the results. Group II demonstrated the poorest performance, validating its role as a negative control.

DISCUSSION

This in-vitro experimental study was designed to evaluate and compare the effect of herbal and commercial denture cleansers on the color stability of heat-polymerized acrylic denture base resin. A total of 36 acrylic specimens were fabricated using standardized procedures and divided equally into four groups (n = 9) based on the cleansing agent used: Clinsodent (Group I), Distilled Water (Group II – Control), Oradox (Group III), and Origanum oil (Group IV).

All specimens were stained using turmeric, tea, and coffee solutions, selected because they represent commonly consumed Indian dietary substances known to cause significant staining due to their high content of chromogenic compounds like curcumin (in turmeric) and tannins (in tea and coffee). These stains were chosen to simulate real-life oral conditions and mimic long-term discoloration effects on denture base materials.[16,13,19]

After staining, each group was immersed in its respective denture cleanser for a period simulating one month of clinical use (8 hours/day for 10 days).[4,6] Clinsodent and Oradox were selected because they are widely used commercial denture cleansers with different formulations. Clinsodent contains sodium perborate, which releases hydrogen peroxide and has effervescent and oxidizing properties, allowing effective stain removal but potentially altering the denture surface with prolonged use.[5,21] Oradox, which combines sodium bicarbonate and sodium perborate, offers a milder alternative, providing buffering and gentle abrasive action for cleansing.[21]

Origanum oil was included as a herbal test agent due to its documented antimicrobial, antifungal, and antioxidant properties[1]. It contains carvacrol and thymol, phenolic compounds that exhibit potent antimicrobial activity while being gentle on acrylic materials. Its inclusion aimed to assess the potential of a natural, biocompatible alternative to conventional chemical cleansers, which could be particularly beneficial for elderly or sensitive patients.[1,2,17]

Color stability was assessed using a UV-VIS spectrophotometer, a reliable and standardized instrument for evaluating color changes in dental materials. The results were interpreted using the CIELAB color system, and the color difference (ΔE) values were calculated to objectively quantify changes in shade before and after staining and cleansing.[4,6,22]

Clinsodent's composition includes sodium perborate monohydrate, which releases hydrogen peroxide upon dissolution in water. The resultant effervescence enhances mechanical cleaning. Additional components like potassium persulfate and sodium lauryl sulfate further its oxidizing and foaming capabilities, while trisodium phosphate contributes to its alkaline environment, aiding in organic stain breakdown. However, this potent chemical activity may, over time, adversely affect the resin matrix. Oradox leverages the alkalizing and mild abrasive effect of sodium bicarbonate, coupled with the oxidizing action of sodium perborate. This combination facilitates effective stain removal while being less aggressive than formulations containing higher concentrations of oxidants. The intermediate performance of Oradox reflects this balance it is efficient in cleansing without severely compromising the denture material. However, Clinsodent's marginally lower performance in maintaining color stability may stem from prolonged exposure to strong oxidizing agents, as corroborated by Shah et al., who reported more significant color change with Clinsodent compared to other cleansers over time.[5]

The mechanism of denture staining is both chemical and physical. Chromogenic

substances such as tannins and polyphenols from tea and coffee adhere to the porous surface of acrylic resins via adsorption and absorption. Over time, these pigments penetrate deeper layers of the resin, making removal more challenging. Chemical cleansers act primarily through oxidation, breaking down organic molecules into water-soluble by-products. However, repeated use of such agents may alter the surface chemistry, increasing surface roughness and promoting re-staining. In contrast, herbal cleansers like Origanum oil employ milder mechanisms, utilizing antimicrobial and antioxidant properties to inhibit microbial colonization and stain adherence without compromising surface integrity.

The study demonstrated statistically significant differences ($p < 0.001$) in color stability among the groups after cleansing. Group IV (Origanum oil) recorded the highest mean color stability (77.911 ± 0.1269), indicating the least change in color post-treatment. This was followed by Group III (Oradox) at 76.011 ± 0.1269, Group I (Clinsodent) at 75.350 ± 0.1604, and finally Group II (Distilled Water) at 72.833 ± 0.2000, which showed the least effectiveness. The superior outcome for Origanum oil highlights its effective cleansing mechanism, preserving esthetic qualities without degrading the denture surface.

These findings are consistent with prior literature. Anjum et al. reported favorable cleansing outcomes using herbal extracts compared to conventional agents.[20] Similarly, Namala and Hegde found that thyme extract preserved surface integrity and color better than commercial chemical cleansers, attributing its benefits to its non-corrosive and antimicrobial nature.[2]

Further support for the statistical significance of these differences was obtained from the post hoc Tukey HSD test, which showed significant mean differences between all group pairs. Notably, the largest difference was observed between Group IV and Group II (mean difference = 5.0778, $p < 0.001$). This emphasizes the limited cleansing capacity of plain distilled water, as also observed by Sato et al. and Paranhos et al., who concluded that water lacks the chemical potency to counter chromogenic discoloration.[4,11]

When comparing Origanum oil to the commercial denture cleansers, it exhibited superior color stability outcomes. This result is likely due to the herb's milder action on denture materials. Unlike peroxide-based cleansers, Origanum does not cause surface abrasion or microstructural damage. Its active compounds carvacrol and thymol exert natural antimicrobial and cleansing effects while preserving surface morphology, offering an advantage in long-term usage scenarios.

A direct comparison between the two commercial cleansers revealed that Clinsodent showed slightly better color stability than Oradox. This could be related to the differences in chemical formulation. Clinsodent contains alkaline peroxides, which release oxygen to dislodge stains and debris. In contrast, Oradox contains a combination of sodium bicarbonate and sodium perborate, which provides a balanced cleansing effect through mild abrasion and oxidation. While effective, both agents caused greater color changes than Origanum, underscoring the trade-off between stain removal strength and esthetic preservation.

The outcomes of this study underscore the importance of choosing denture cleansers that balance cleansing efficiency with material preservation. Herbal alternatives such as Origanum oil provide effective stain removal with reduced risk of long-term material degradation. Namala and Hegde's work further reinforces this, demonstrating that plant extracts like Thymus vulgaris maintained surface smoothness and mechanical strength better than chemical cleansers. Additionally, Origanum is biodegradable, readily available, economical, and aligns well with the increasing demand for biocompatible and eco-friendly dental products. Unlike peroxide-based cleansers, it does not induce surface corrosion or esthetic deterioration. Its anti-inflammatory and antioxidant properties may even benefit the underlying oral tissues in clinical settings.[2]

Nonetheless, as this is an in-vitro study, the findings should be interpreted within the context of its limitations. Laboratory conditions cannot fully replicate the dynamic environment of the oral cavity, where salivary enzymes, temperature variations, food particles, and masticatory forces can influence material behavior. Hence, future in-vivo studies are warranted to evaluate the long-term

effects of both herbal and chemical cleansers on denture base resins. Further investigations should also examine their impact on other physical properties such as surface roughness, flexural strength, and microbial resistance, for a more holistic understanding of their clinical suitability.

CONCLUSION

The study concludes that Origanum oil is the most effective among the tested cleansers for maintaining color stability of heat-polymerized PMMA denture base resins. Its natural, non-abrasive action preserves esthetics without compromising material integrity. Oradox and Clinsodent, though effective, showed comparatively higher color change. Distilled water was least effective.

Further clinical studies are recommended to evaluate the long-term effects of herbal cleansers on physical, mechanical, and biological properties of denture materials in the oral environment.

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