

ORIGINAL ARTICLE

Comparative Evaluation of *Aloe vera* Gel and Conventional Denture Cleansers on Color Stability and Translucency of Acrylic Resin Teeth: An *In Vitro* Study

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Abstract

Introduction: This *in vitro* study aimed to evaluate and compare the stain removal efficacy and translucency effects of different denture cleansers, including *Aloe vera* (AV) gel, on coffee-stained acrylic resin teeth.

Methods: Fifty maxillary right central incisor acrylic teeth (shade A2) were stained with a coffee solution and then divided into five groups (n=10): Corega Cleaner-C, Corega Whiteness (CW), Protefix-P, AV gel, and distilled water-D. Each group underwent six 90-min immersion cycles simulating 6 months of clinical use. Color changes (ΔE_{00}) and translucency parameters (TP) were measured using a spectrophotometer. Data were analyzed using one-way analysis of variance (ANOVA), Tukey's honestly significant difference, and paired t-tests.

Results: Color stability and the TP were calculated. ANOVA revealed no statistically significant difference in color stability between the groups ($p=0.367$). For TP analyses, while no significant difference was observed among TP1 groups ($p=0.565$), a statistically significant difference was found among TP2 groups ($p<0.05$). The AV group differed significantly from the other groups in TP2. Paired t-tests showed a significant difference in translucency values, with a decrease in the CW group ($p=0.039$) and an increase in the AV group ($p=0.007$).

Discussion and Conclusion: AV gel was as effective as conventional denture cleansers in removing stains from acrylic resin teeth and was the only agent that preserved or enhanced translucency. Given its natural composition, biocompatibility, and minimal effect on optical properties, AV gel may be considered a clinically valuable alternative, especially for patients with high aesthetic expectations or sensitivity to chemical agents.

Keywords: *Aloe vera* gel; Artificial teeth; Color stability; Denture cleansers; Translucency

With the global increase in life expectancy, the proportion of elderly individuals has risen significantly. Consequently, the prevalence of edentulism and the use of complete dentures have also increased.

^[1] This trend has led to heightened aesthetic demands

and expectations across all areas of dentistry, including removable prosthodontics. In this context, the selection of artificial teeth is of critical importance, as their stain resistance and color stability significantly influence the overall aesthetics of prosthetic appliances.^[2] Acrylic resin

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teeth offer several advantages, such as reduced weight, superior chemical bonding with the denture base, and enhanced fracture resistance.^[3,4] However, they are also more susceptible to wear and discoloration.^[2] Among the key factors affecting patient satisfaction with removable dentures is the color stability of artificial teeth. A noticeable color mismatch between artificial and natural teeth can result in an unsatisfactory aesthetic outcome, particularly in cases involving removable partial dentures.^[5]

Discoloration of artificial teeth may result from inadequate oral hygiene and exposure to staining agents. Previous studies have demonstrated that artificial teeth exposed to commonly consumed staining substances, such as coffee, red wine, and tea, exhibit varying degrees of color change, ranging from subtle to significant.^[2,3] To address extrinsic staining on dentures and artificial teeth, both mechanical and chemical cleaning methods can be employed.^[6] A variety of chemical denture cleansers are available, including sodium perborate, alkaline hypochlorites, alkaline peroxides, chlorhexidine gluconate, acids, enzymes, and other disinfectants.^[7] Several studies have evaluated the effectiveness of different denture cleaning agents in removing stains from acrylic resin materials by measuring changes in optical density.^[8,9] Although findings suggest that most denture cleansers possess stain-removing capabilities, the efficacy of a given product largely depends on its chemical formulation.^[9]

Aloe vera (AV) is an herbal substance traditionally used for various medicinal purposes. It is environmentally friendly, biodegradable, cost-effective, and readily available. Due to these advantages, AV has found widespread application in dentistry. Its potential use as a disinfectant and anti-plaque agent – with minimal or no reported side effects – along with its anti-candidal properties and effectiveness in preventing denture stomatitis, makes it a promising alternative in prosthetic dentistry.^[10] However, there is limited information regarding the effects of AV gel on the color stability of acrylic resin teeth in comparison to conventional denture cleansers.^[11] Furthermore, to date, no studies have been identified in the literature that evaluate the stain removal efficacy of AV gel on discolored acrylic teeth.

Color stability is a critical property of many dental materials and can be quantitatively assessed using spectrophotometry or digital colorimetry. The American Dental Association recommends the use of the CIE L*, a*, and b* color system for such digital evaluations.^[12] In addition to color stability, translucency is another essential

parameter influencing the aesthetic performance of dental materials. Translucency refers to the ability of a material to transmit light while simultaneously scattering it, thereby preventing clear visualization of objects through the material. Like color stability, translucency can be measured using spectrophotometric and colorimetric methods.^[13,14] Despite the significance of these properties, there is limited data available on how denture cleansers affect the translucency of acrylic resin teeth. Therefore, the aim of this study is to investigate the effects of various denture cleansers on both the color stability and translucency of colored acrylic teeth. The null hypothesis of this study is that there are no statistically significant differences in color stability and translucency among the tested denture cleansers.

Materials and Methods

This study was conducted at Giresun University Faculty of Dentistry, Department of Prosthodontics, and as this was an *in vitro* investigation, no ethical committee approval was necessary. In the study, maxillary right central incisor acrylic teeth (shade A2) were used, along with three commercially available denture cleansers. Details of the materials used in this study are given in Table 1. Each acrylic tooth was individually numbered, and initial color measurements were obtained before immersion (T_0). These baseline color values were recorded against grey, black, and white backgrounds under standardized D65 illumination using a spectrophotometer (Vita Easyshade, Vita Zahnfabrik, Bad Säckingen, Germany). All measurements were performed on the middle third of the labial surface of each specimen, as this region provides the most representative optical characteristics of anterior acrylic teeth.

The coffee staining solution was prepared by dissolving one tablespoon of granulated coffee (Tchibo, Hamburg, Germany) in 200 mL of water, following the manufacturer's instructions. The acrylic specimens were then immersed in the coffee solution and placed in an incubator (Nuve EN 55, Esetron, Ankara, Türkiye) for 6 days to simulate a 1-month daily exposure period (1 month=1 day).^[15] During the 6-day staining period, the coffee solution was periodically mixed to maintain homogeneity and prevent sedimentation of pigments. Following the staining process, the specimens were removed from the coffee solution, rinsed thoroughly with distilled water, and air-dried. Subsequent color measurements (T_1) were performed under the same standardized conditions as the baseline. For each specimen, color readings were taken three times, and the average values of L1*, a1*, and b1* were calculated.

Table 1. Materials evaluated in the present study

Material	Product	Manufacturer	Active ingredients
Acrylic denture teeth	NT Optima-A2	Toros Dental, Antalya, Türkiye	Polymethyl methacrylate
Coffee solution	Coffee	Tchibo, Hamburg, Germany	Granulated coffee
Denture cleanser	Corega tooth cleanser (Group 1)	Stafford Miller Ltd., Waterford, Ireland	Potassium monopersulfate, sodium bicarbonate, sodium carbonate, sodium carbonate peroxide, TAED, sodium benzoate, polyethylene Glycol-180, sodium lauryl sulfoacetate, polyvinylpyrrolidone/vinyl acetate copolymer, sodium, aroma, colorants
	Corega whitening tooth cleanser (Group 2)	Stafford Miller Ltd., Waterford, Ireland	Sodium bicarbonate, citric acid, potassium caroate, sodium carbonate peroxide, sodium carbonate, TAED, sodium benzoate, polyethylene glycol-180, sodium lauryl sulfoacetate, polyvinylpyrrolidone/vinyl acetate copolymer, CI 42090, CI 73015.
	Protefix tooth cleanser (Group 3)	Helago-Pharma GmbH, Erfstadt, Germany	Sodium bicarbonate, citric acid, potassium caroate, sodium carbonate, sodium carbonate peroxide, TAED, sodium benzoate, poly ethylene glycol-180, sodium lauryl sulfate, Polyvinylpyrrolidone/Vinyl Acetate copolymer, aroma, cellulose gum, colorants
Aloe Vera gel	Ekel Natural (Group 4)	Newyork, Paris	Aloe vera leaf extract, glycerin, water
Distilled water	Distilled water (Group 5)	–	H ₂ O

CI: Colour index; TAED: Tetraacetythylenediamine.

The acrylic teeth were randomly assigned to five groups (n=10) based on the cleansing method used: Corega (Cleaner) [C], Corega (Whiteness) [CW], Protefix [P], AV, and distilled water [D]. For Groups C, CW, and P, effervescent cleansing solutions were prepared according to the manufacturers' instructions by dissolving one tablet in 200 mL of warm tap water (40°C). Each specimen underwent six immersion cycles, each lasting 90 min, to simulate 6 months of use (total immersion time: 9 h). Similarly, specimens in the AV and D groups were subjected to six 90-min immersion cycles under the same simulated time frame. After each cycle, the cleansing solutions were discarded, and the specimens were rinsed thoroughly under running water. At the conclusion of the final cycle, all specimens were rinsed with distilled water for 3 min, air-dried, and immediately assessed for color stability to prevent dehydration. Final color measurements (T2) were obtained using a spectrophotometer on grey, black, and white backgrounds, under standardized conditions.

The color differences of the specimens were calculated using the following formula CIEDE2000 (2:1:1) (ΔE_{00}):

$$\Delta E_{00} = [(\Delta L' / K_L S_L)^2 + (\Delta C' / K_C S_C)^2 + (\Delta H' / K_H S_H)^2 + R_T (\Delta C' / K_C S_C) (\Delta H' / K_H S_H)]^{1/2}$$

Where ΔL_0 , ΔC_0 , and ΔH_0 are the differences in lightness, chroma, and hue between the two specimens that were compared. S_L , S_C , and S_H are the weighting functions for the lightness, chroma, and hue components, respectively.

K_L , K_C , and K_H are the parametric factors to be adjusted according to different viewing parameters. In the current study, $K_L=2$, K_C , and K_H were set to 1.^[16]

The translucency differences of the specimens were calculated using the following translucency parameter (TP):

$$TP = [(L_b - L_w)^2 + (a_b - a_w)^2 + (b_b - b_w)^2]^{1/2}$$

Where L, a, and b are the color space indicators. The b and w denote black- and- white backgrounds.^[16]

Data were analyzed using the Statistical Package for the Social Sciences (SPSS Inc., Version 23, Chicago, IL, USA). The Shapiro–Wilk test was used to assess the normality of the data distribution for color difference (ΔE_{00}) and TP values within each group. For intergroup comparisons of color changes (ΔE_1 and ΔE_2) and translucency values (TP₁ and TP₂), one-way analysis of variance (ANOVA) was employed. When statistically significant differences were detected among the groups, Tukey's honestly significant difference (HSD) *post hoc* test was applied to identify specific group differences. In addition, paired sample t-tests were conducted to compare intra-group translucency changes before and after the cleaning procedures (TP₁ vs. TP₂). All data were reported as means±standard deviations.

Results

A total of fifty maxillary right central incisor acrylic teeth (shade A2) were used, along with three commercially

Table 2. The means and standard deviations of color differences

Groups	C	CW	p	AV	D
ΔE_1	1.83±0.55	1.81±0.55	1.95±0.63	1.80±0.39	1.96±0.47
ΔE_2	0.94±0.39	0.95±0.41	0.87±0.46	1.02±0.35	0.67±0.21

CW: Corega whiteness; AV: *Aloe vera*.

Table 3. The means and standard deviations of translucency parameters

Groups	C	CW	P	AV	D
TP ₁	0.87±0.30 ^{Aa}	0.82±0.18 ^{Aa}	0.94±0.26 ^{Aa}	0.78±0.21 ^{Aa}	0.79±0.13 ^{Aa}
TP ₂	0.77±0.29 ^{Aa}	0.61±0.20 ^{Ab}	0.72±0.25 ^{Aa}	1.15±0.21 ^{Bb}	0.71±0.19 ^{Aa}

Superscript uppercase letters in rows show differences between dental cleaners. Superscript lowercase letters in the column show differences between the Translucency Parameters. No significant differences were found between groups with the same letter ($p < 0.05$). CW: Corega whiteness; AV: *Aloe vera*.

available denture cleansers, AV gel, and distilled water, as outlined in Table 1. Table 2 presents the mean and standard deviation values for the color differences between baseline and post-staining measurements (ΔE_1 : T_0-T_1), and between post-staining and post-cleaning measurements (ΔE_2 : T_1-T_2) for all test groups.

Following immersion in the coffee solution, all groups exhibited color changes exceeding the clinically acceptable threshold ($\Delta E_{00} > 1.8$), indicating perceptible discoloration. After application of the cleansing methods, a visually perceptible improvement in color ($\Delta E_{00} > 0.8$) was observed in all groups except for the distilled water group.^[17]

The Shapiro–Wilk test confirmed that the data were normally distributed. One-way ANOVA was conducted to assess differences in color stability (ΔE values) among the groups, revealing no statistically significant differences ($p = 0.367$).

For translucency analysis, Shapiro–Wilk test results indicated that both TP₁ (translucency after staining) and TP₂ (translucency after cleaning) values were normally distributed. One-way ANOVA showed no statistically significant differences among TP₁ values ($p = 0.565$). However, a statistically significant difference was observed among the TP₂ groups ($p < 0.05$). Tukey's HSD *post hoc* test identified the AV group as being significantly different from the other groups.

A paired t-test was used to evaluate intra-group differences in translucency before and after cleansing. Statistically significant changes in translucency were found in the Corega Whiteness (CW) group ($p = 0.039$) and the AV group ($p = 0.007$). No significant differences were observed in the remaining groups ($p > 0.05$).

The means and standard deviations for TP₁ and TP₂ values are summarized in Table 3.

Discussion

In the present study, acrylic resin teeth were stained using a coffee solution and subsequently subjected to cleaning protocols involving various commercial denture cleansers, distilled water, and AV gel. The effectiveness of each cleansing method was evaluated by assessing color differences (ΔE) and changes in TP. Based on the results, the null hypothesis – stating that there would be no significant differences in color stability and translucency among the tested denture cleansers – was partially rejected. Although no statistically significant differences were found among the groups in color stability (ΔE), significant differences were observed in translucency changes, TP, particularly following the use of AV gel and CW. These findings suggest that while most cleansing agents performed similarly in stain removal, their impact on the translucency of acrylic resin teeth may vary significantly. These findings indicate that AV gel is not only a natural and biocompatible alternative to chemical cleansers but also comparable in terms of color stability. The highest ΔE_2 value observed in the AV group supports its potential as an effective stain-removing agent. This may encourage the broader use of plant-based products in prosthetic hygiene, particularly among patients who prefer biocompatible options or exhibit sensitivity to chemical agents.

Extrinsic factors, such as the absorption and the absorption of stains from external sources, continue to present significant challenges to the aesthetic longevity of dental restorations. Numerous studies have evaluated the discoloration of acrylic denture teeth when exposed to various staining agents, including beverages such as coffee, cola, black tea, orange juice, and red wine, as well as food colorants like tartrazine and erythrosine.^[18–21] Among these, coffee has been consistently identified as the most

potent staining agent. Due to its strong chromogenic potential and widespread consumption in daily life, the coffee solution was selected as the staining medium in the present study.^[22] In this study, all groups exhibited ΔE values exceeding the clinically acceptable threshold following coffee immersion, reaffirming the high staining potential of coffee on acrylic teeth. This emphasizes the importance of using effective cleansers for patients who consume chromogenic beverages frequently.

Patients have access to a variety of agents for cleaning dentures, including effervescent cleansing tablets, chlorhexidine gluconate, glutaraldehyde, sodium perborate, povidone-iodine, and neutral soap, which can be used either after each removal or as part of a daily hygiene routine.^[23,24] In addition to these conventional options, natural products such as AV gel, white vinegar, coconut oil, and olive oil have also been suggested as economical alternatives for denture hygiene.^[25,26] Mahboub et al.^[11] evaluated the discoloration effects of chlorhexidine and AV gel on acrylic teeth and concluded that AV gel was an acceptable agent for denture cleaning. However, there is still a lack of studies specifically investigating the stain-removal efficacy of AV gel. The stain-removal effectiveness of Corega tablets has been documented, although prior research primarily compared chemical and mechanical cleaning methods.^[27] In the present study, three types of effervescent denture cleansers with different active ingredients, AV gel – known for its disinfectant properties and minimal reported side effects – and distilled water as a control group were evaluated. An immersion technique was applied uniformly across all groups to assess their effects on stained acrylic denture teeth. Notably, in addition to the color change observed in the AV group, an increase in translucency following cleaning was also detected. While other groups demonstrated a decrease in TP values, the AV group showed improved translucency. This suggests that AV may possess surface-preserving or even optical-enhancing properties. Such an effect could be particularly advantageous when treating patients with high aesthetic expectations. Moreover, AV gel may be more suitable for patients with chemical sensitivities, xerostomia, or systemic conditions in which mucosal tolerance and material biocompatibility are important.

Researchers have reported that the CIEDE2000 (ΔE_{00}) formula offers improved accuracy and sensitivity in evaluating color differences compared to the older CIELAB system.^[16] Therefore, in the present study, color differences (ΔE_{00}) were calculated using the CIEDE2000 formula. According to established thresholds, the perceptibility

threshold and acceptability threshold for CIEDE2000 are $\Delta E_{00}=0.8$ and $\Delta E_{00}=1.8$, respectively.^[28] Among the groups tested, the AV group demonstrated the highest stain removal efficacy. This effect may be attributed to the presence of saponin, a high-molecular-weight glycoside found in AV gel, known for its cleansing and surfactant properties.^[29] Although saponins appear to play a major role, other constituents of the gel may also have minor supporting effects. Moreover, the ability of AV gel to remove stains effectively without compromising – and even enhancing – translucency supports its aesthetic advantages in removable prosthodontics. For long-term clinical success, cleansing agents must not only be effective but also preserve the optical properties of dental materials. AV appears to meet both criteria.

Translucency plays a critical role in the aesthetic and natural appearance of artificial teeth; therefore, clinicians should consider this parameter alongside color stability when selecting or evaluating dental materials. A higher TP value indicates greater translucency and reduced opacity. For tooth-colored restorative materials, TP₀₀ values of ≤ 2.6 are considered clinically acceptable.^[30] In the present study, TP₀₀ values decreased in all groups following the cleaning procedures, with the exception of the AV group, which showed no reduction in translucency. Notably, the CW group exhibited a significantly greater decrease in TP compared to the other groups. The notable drop in translucency observed in the CW group may be due to the abrasive or acidic components, such as citric acid and sodium carbonate peroxide, in its formula, which might have altered the surface integrity of the acrylic teeth. The cleansing ability of AV gel is primarily attributed to its natural surfactant content. These components may also contribute to maintaining surface gloss and integrity, explaining the increased translucency observed in this group. This result underlines the need to balance cleaning power with preservation of material aesthetics, especially in patients requiring long-term prosthetic use. Despite these differences, all groups remained within the acceptable translucency threshold.

A limitation of this study is the absence of thermal aging, which could potentially influence both stain-removal efficacy and translucency outcomes. Moreover, the antimicrobial or plaque-removal efficacy of the cleansing agents, particularly AV gel, was not assessed. Additionally, this *in vitro* study did not simulate the mechanical forces or dynamic oral conditions such as brushing, salivary enzymes, temperature fluctuations, or dietary variations, all of which may influence the long-term optical properties of acrylic

resin teeth. The study also focused solely on a single tooth shade (A2) and one type of acrylic resin tooth, which limits the generalizability of the findings across other materials, shades, or denture tooth brands. Differences in polymer composition, cross-linking density, and surface finish among manufacturers may influence optical outcomes such as color stability and translucency, and similar findings may not be directly extrapolated to other brands. Moreover, variations among different shade scales or systems may also influence the optical outcomes. Further research is warranted to explore the long-term optical, antibacterial, and microbiological effects of AV gel on denture materials under simulated or real-life oral conditions.

Conclusion

Within the limitations of this *in vitro* study, all tested denture cleansers removed more stains from acrylic resin teeth than distilled water, with AV gel showing the highest level of color improvement, although the differences were not statistically significant. Only AV gel preserved or slightly increased translucency, while all other cleansers caused a decrease, most notably with CW. Clinically, these findings highlight AV gel as a biocompatible, cost-effective, and esthetically favorable denture-cleansing option, especially for patients with high aesthetic demands or sensitivities to chemical agents. Its ability to effectively remove stains while maintaining the optical properties of acrylic teeth supports its inclusion in daily denture hygiene protocols.

Given its demonstrated biocompatibility and cleaning efficacy, AV gel holds potential for incorporation into future denture cleanser formulations. However, additional studies on formulation optimization, product stability, and antimicrobial performance are necessary before commercial application.

Ethics Committee Approval: As this study was an *in vitro* investigation conducted in the field of prosthodontics, ethics committee approval was not required.

Informed Consent: Informed consent was not required because this was an *in vitro* study and did not involve human participants.

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