

## ORIGINAL ARTICLE

### Heat-Cured Acrylic Resin Plates on Surface Roughness in A 6.25% Siwak (Salvadora Persica) Effervescent Tablet Solution

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#### ABSTRACT

**Keywords:** Heat-cured acrylic resin, Siwak effervescent tablet (Salvadora persica), Surface roughness

Heat-cured acrylic resin is widely used as a denture base material due to its favorable aesthetic and biocompatible properties; however, denture hygiene must be maintained using cleaning agents that do not adversely affect surface characteristics. Siwak (*Salvadora persica*) contains antibacterial and antifungal compounds and has demonstrated inhibitory effects against *Candida albicans* at a concentration of 6.25%, indicating its potential as a natural denture cleanser. This study aimed to evaluate the effect of immersing heat-cured acrylic resin plates in a 6.25% siwak effervescent tablet solution on surface roughness. A true experimental study was conducted using 27 heat-cured acrylic resin plates (65 × 10 × 3.3 mm), divided into three groups: alkaline peroxide solution, 6.25% siwak effervescent tablet solution, and effervescent tablet solution without siwak. Immersion was performed for 15 minutes daily over an 8-day period at 37°C. Surface roughness was measured using a Surface Roughness Tester, and data were analyzed using Welch ANOVA. All groups exhibited an increase in surface roughness after immersion. However, statistical analysis showed no significant difference among the three groups ( $p > 0.05$ ). Immersion in a 6.25% siwak effervescent tablet solution did not significantly affect the surface roughness of heat-cured acrylic resin and can be considered safe for use as a denture cleaning agent. (IJP 2025;7(1):90-93)

#### Introduction

Oral health is an integral component of general health and plays a crucial role in mastication, speech, facial aesthetics, and overall quality of life. Tooth loss remains a prevalent oral health problem worldwide and is associated with functional impairment, reduced self-confidence, and diminished social interaction.<sup>1</sup> Removable prosthodontic treatment is commonly used to restore lost teeth and rehabilitate oral function while maintaining the health of surrounding tissues.<sup>2</sup>

Heat-cured acrylic resin is the most widely used denture base material because of its favorable physical properties, acceptable aesthetics, ease of manipulation, and relatively low cost.<sup>3</sup> However, acrylic resin is susceptible to surface alterations when exposed to the oral environment. Factors such as water sorption, chemical exposure, and routine cleansing procedures may alter surface characteristics, particularly surface roughness.<sup>4</sup>

Surface roughness is a critical property of denture base materials, as increased roughness facilitates plaque accumulation, microbial adhesion, and staining.<sup>5</sup> A rough denture surface has been strongly associated with colonization by *Candida albicans*, a major etiological factor in denture stomatitis.<sup>6</sup> Consequently, denture hygiene must be maintained using cleaning agents that are both effective against microorganisms and safe for denture materials. Chemical denture cleansers, including alkaline peroxide

solutions, are widely recommended due to their ability to remove biofilm and stains.<sup>7</sup> However, repeated exposure to these agents may negatively affect the surface integrity of heat-cured acrylic resin and increase surface roughness.<sup>8</sup> This limitation has encouraged the exploration of natural or herbal-based denture cleansers with antimicrobial activity and minimal adverse effects on denture materials.

Siwak (*Salvadora persica*) is a traditional herbal material known for its antibacterial, antifungal, antiplaque, and antioxidant properties.<sup>9</sup> Phytochemical studies have identified bioactive compounds such as flavonoids, tannins, alkaloids, and terpenoids that contribute to its antimicrobial mechanisms.<sup>10</sup> Experimental evidence indicates that siwak extract at a concentration of 6.25% can inhibit the growth of *Candida albicans*, suggesting its potential as a natural denture cleanser.<sup>11</sup> Effervescent tablet formulations further offer practical advantages for denture hygiene, including ease of use, rapid dissolution, and consistent dosing.<sup>12</sup>

Despite these promising properties, limited studies have evaluated the effect of siwak-based effervescent denture cleansers on the surface characteristics of heat-cured acrylic resin. Therefore, this study aimed to evaluate the effect of immersing heat-cured acrylic resin plates in a 6.25% siwak (*Salvadora persica*) effervescent tablet solution on surface roughness, compared with alkaline peroxide solution and effervescent tablets without siwak.

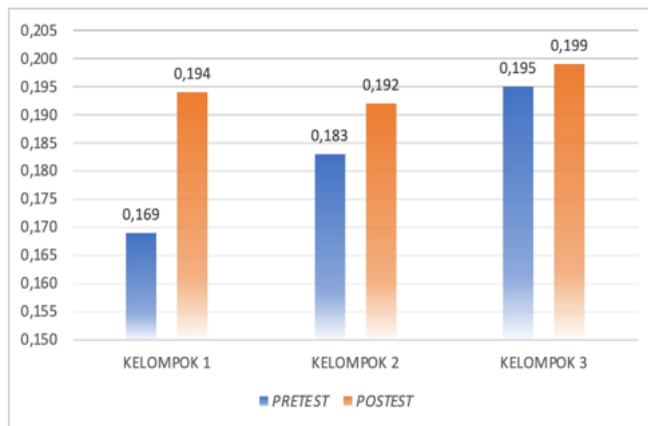
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**Table 1. Average Measurements.**

Group	Pre-test	Posttest	Difference
Group 1 (Alkaline Peroxide)	0,169	0,194	0,025
Group 2 (Effervescent Effervescent Siwak Wood)	0,183	0,192	0,009
Group 3 (Effervescent Tablet Effervescent Without Siwak)	0,195	0,199	0,004

**Figure 1. Bar Chart of Average Measurement Results.**

## Material and Methods

This study employed a true experimental design with a pretest–posttest control group approach. The research was conducted from July to October 2025 at the Fisheries Product Technology Laboratory, Faculty of Science and Fisheries, Hasanuddin University, and the Makassar Vocational Training and Productivity Center.

A total of 27 heat-cured acrylic resin plates measuring 65×10×3.3 mm were prepared and allocated into three groups ( $n = 9$  per group): immersion in alkaline peroxide solution (control group), immersion in a 6.25% siwak (*Salvadora persica*) effervescent tablet solution, and immersion in an effervescent tablet solution without siwak. The acrylic resin plates were fabricated using the conventional heat-curing technique and polished according to standardized procedures to obtain uniform surfaces prior to testing.

Siwak effervescent tablets were formulated using a 6.25% concentration of *Salvadora persica* extract combined with excipients including polyvinylpyrrolidone (PVP K30), citric acid, tartaric acid, and sodium bicarbonate. Effervescent tablets without siwak served as a comparative control to evaluate the effect of the herbal extract. Alkaline peroxide solution was prepared according to the manufacturer's instructions.

All specimens were initially rinsed with distilled water to eliminate residual monomers and debris. Baseline surface roughness measurements (pretest) were obtained for each specimen using a Surface Roughness Tester. Subsequently, the

specimens were immersed in their respective solutions for 15 minutes daily at 37°C for a total duration equivalent to 8 days of cumulative immersion. After completion of the immersion protocol, final surface roughness measurements (posttest) were recorded using the same instrument and measurement parameters.

Surface roughness values were expressed in micrometers ( $\mu\text{m}$ ). Statistical analysis was performed using SPSS software. Data normality was assessed using the Shapiro–Wilk test, and homogeneity of variance was evaluated using the Levene test. Due to non-homogeneous variance, differences in surface roughness among groups were analyzed using Welch analysis of variance (ANOVA). A  $p$ -value of less than 0.05 was considered statistically significant.

## Results

This study aimed to determine the effect of immersing heat-cured acrylic resin plates in a solution of siwak (*Salvadora persica*) effervescent tablets on surface roughness. The study was conducted at the Fisheries Product Technology Laboratory (THP) of the Faculty of Science and Fisheries, Hasanuddin University, and the Makassar Vocational Training and Productivity Center from July to October 2025. The research subjects were siwak (*Salvadora persica*) effervescent tablets, with a sample size of 27 heat-cured acrylic resin plates. The study used a pre-post test design with a control group, with data collection before and after immersion for 8 days. Surface roughness measurements were carried out using a Surface Roughness Tester at the Makassar Vocational Training and Productivity Center. The results of the average surface roughness measurements of heat-cured acrylic resin plates in groups 1, 2, and 3 are presented in the table.

Based on the table, all treatment groups showed an increase in surface roughness values after immersion. The largest increase occurred in the alkaline peroxide group at 0.025  $\mu\text{m}$ , while the smallest increase was in the effervescent tablet without siwak group at 0.004  $\mu\text{m}$ .

This increase indicates a change in the surface of the acrylic resin due to exposure to the cleaning solution. However, all roughness values are still below the ISO 1567 safety limit ( $<0.2 \mu\text{m}$ ), so it can be concluded that all immersion solutions do not cause excessive surface changes or damage to the acrylic resin structure. The Levene test results showed a significance value (Sig) of 0.039, which means that the data between groups is not homogeneous ( $p < 0.05$ ). Nevertheless, the analysis can still be continued using the Welch ANOVA test to determine the differences in means between treatment groups.

Based on the Welch ANOVA test results, a significance value of 0.673 ( $p > 0.05$ ) was obtained. These results show that there are no significant differences between the three treatment groups in terms of chang-

es in the surface roughness of heat-cured acrylic resin. Therefore, the hypothesis zero ( $H_0$ ) is accepted, which means that the effervescent siwak tablet solution (6.25%) does not have a significant effect on the surface roughness of acrylic resin compared to alkaline peroxide and effervescent tablets without siwak.

## Discussion

The present study evaluated the effect of immersing heat-cured acrylic resin plates in a 6.25% siwak (*Salvadora persica*) effervescent tablet solution on surface roughness, compared with alkaline peroxide and effervescent tablets without siwak. The results demonstrated that all immersion solutions produced an increase in surface roughness; however, no statistically significant differences were observed among the three groups. Similar findings have been reported in previous studies evaluating the influence of chemical denture cleansers on acrylic resin surface properties.<sup>8</sup> This finding indicates that the incorporation of siwak extract at a concentration of 6.25% in an effervescent tablet formulation does not adversely affect the surface integrity of heat-cured acrylic resin.

The observed increase in surface roughness across all groups may be attributed to the hydrophilic nature of polymethyl methacrylate (PMMA), which allows water absorption and facilitates diffusion of cleaning solution components into the polymer matrix.<sup>4</sup> Water sorption can induce plasticization of the resin, weakening intermolecular forces and resulting in minor surface alterations. Similar mechanisms have been described in studies examining hydrolytic degradation and hygroscopic behavior of dental polymer networks.

The alkaline peroxide group exhibited the greatest increase in surface roughness among the tested solutions. This outcome may be explained by the oxidative mechanism of alkaline peroxide cleansers, which generate reactive oxygen species capable of disrupting polymer chains within acrylic resin materials.<sup>13</sup> Although alkaline peroxide solutions are effective in removing stains and biofilm, repeated exposure has been associated with increased surface roughness and material degradation, potentially compromising long-term denture performance.<sup>8</sup>

In contrast, immersion in the 6.25% siwak effervescent tablet solution resulted in a relatively small increase in surface roughness. The bioactive compounds present in siwak, including flavonoids, tannins, alkaloids, and terpenoids, exhibit antimicrobial activity without strong oxidative or abrasive effects on polymer surfaces.<sup>14</sup> Experimental evidence indicates that siwak extract at a concentration of 6.25% is effective in inhibiting *Candida albicans*, supporting its use as a natural denture cleanser with minimal impact on acrylic resin surface integrity.<sup>11</sup>

The effervescent tablet solution without siwak produced the smallest change in surface roughness.

The cleansing action of this formulation is primarily mechanical, driven by the release of carbon dioxide bubbles that assist in detaching debris and plaque from denture surfaces.<sup>12</sup> However, the absence of bioactive antimicrobial compounds may limit its effectiveness in controlling microbial colonization compared with herbal-based formulations containing siwak.<sup>11</sup>

Importantly, although surface roughness increased in all groups, the post-immersion values remained below the clinically accepted threshold for acrylic resin materials, which is considered critical for preventing bacterial plaque retention and denture-related stomatitis.<sup>15</sup> This finding indicates that none of the tested solutions caused surface changes likely to compromise denture hygiene or clinical performance.

This study has several limitations. Only one physical property, surface roughness, was evaluated, and the immersion protocol simulated cumulative short-term use rather than long-term clinical conditions. In addition, microstructural changes were not assessed using advanced imaging techniques such as scanning electron microscopy, which may provide further insight into surface degradation mechanisms.<sup>8</sup> Future studies should investigate additional physical and mechanical properties, evaluate different concentrations of siwak extract, and incorporate longer immersion periods to better represent clinical denture use.

Overall, the findings of this study support the potential use of siwak-based effervescent tablets as a natural denture cleaning agent that does not significantly alter the surface roughness of heat-cured acrylic resin.

## Conclusion

Immersion of heat-cured acrylic resin plates in a 6.25% siwak (*Salvadora persica*) effervescent tablet solution resulted in a slight increase in surface roughness; however, the change was not statistically significant when compared with alkaline peroxide solution and effervescent tablets without siwak. All post-immersion surface roughness values remained within clinically acceptable limits. These findings indicate that siwak-based effervescent tablets can be considered a safe alternative denture cleaning agent for heat-cured acrylic resin with respect to surface roughness.

## References

1. Petersen, P.E. The World Oral Health Report 2003: continuous improvement of oral health in the 21st century. *Community Dent. Oral Epidemiol.* 31, 3–24 (2003).
2. Carlsson, G.E. & Omar, R. The future of complete dentures in oral rehabilitation. *J. Oral Rehabil.* 37, 143–156 (2010).
3. Anusavice, K.J., Shen, C. & Rawls, H.R. *Phillips' Science of Dental Materials*. 12th edn (Elsevier, 2013).
4. Ferracane, J.L. Hygroscopic and hydrolytic effects in dental polymer networks. *Dent. Mater.* 22, 211–222 (2006).
5. Bollen, C.M.L., Lambrechts, P. & Quirynen, M. Comparison of surface roughness of oral hard materials to the threshold surface roughness for bacterial plaque retention. *Dent. Mater.* 13, 258–269 (1997).

6. Budtz-Jørgensen, E. The significance of *Candida albicans* in denture stomatitis. *Scand. J. Dent. Res.* 82, 151–190 (1974).
7. Nikawa, H. et al. Denture plaque—past and recent concerns. *J. Dent.* 26, 299–304 (1998).
8. Peracini, A. et al. Effect of denture cleansers on physical properties of heat-polymerized acrylic resin. *J. Prosthodont. Res.* 54, 78–83 (2010).
9. Almas, K. The antimicrobial effects of extracts of *Salvadora persica* (miswak). *Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod.* 91, 657–660 (2001).
10. Niazi, F., Naseem, M., Khurshid, Z., Zafar, M.S. & Almas, K. Role of *Salvadora persica* chewing stick (miswak): a natural toothbrush for holistic oral health. *Eur. J. Dent.* 10, 301–308 (2016).
11. Rizki, A., Munawir, A. & Dewi, R. Antifungal effect of ethanolic extract of *Salvadora persica* against *Candida albicans*. *J. Dent. Sci.* 15, 45–50 (2020).
12. Allen, L.V. Pharmaceutical considerations in effervescent tablet formulation. *Int. J. Pharm. Compd.* 12, 20–24 (2008).
13. Goiato, M.C. et al. Effect of chemical disinfectants on surface roughness and hardness of acrylic resin denture base. *Gerodontology* 29, e483–e489 (2012).
14. Paranhos, H.F.O. et al. Effect of denture cleansers on physical properties of acrylic resin: a systematic review. *J. Prosthodont.* 22, 451–458 (2013).
15. Zafar, M.S. Prosthodontic applications of polymethyl methacrylate (PMMA): an update. *Polymers* 12, 2299 (2020).