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ORIGINAL ARTICLE

# A comparison of the effect of soaking in 75% pomegranate peel and pulp extract versus sodium hypochlorite on the surface roughness of heat-cured acrylic resin denture bases

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**ABSTRACT**

Heat-cured acrylic resin is the most common material used for denture bases; however, it has limitations such as susceptibility to fluid absorption and abrasion, which can increase surface roughness. This roughness has the potential to become a site for the colonisation of microorganisms such as *Candida albicans*. Sodium hypochlorite is frequently used as a denture disinfectant, but its corrosive properties can exacerbate surface roughness. Therefore, alternative natural materials such as pomegranate (both peel and pulp) extracts have become a focus of research. Aim: This study aimed to determine the comparative effects of immersion in 75% pomegranate peel extract and 75% pomegranate pulp extract versus sodium hypochlorite on the surface roughness of heat-cured acrylic resin. Method: This study employed a pre- and post-test control group experimental laboratory design, with three treatment groups of nine samples each. Acrylic resin samples were immersed for 7 days and 14.5 hours in the treatment solutions, and their surface roughness was measured using a surface roughness tester before and after immersion. Data analysis was performed using the Shapiro-Wilk test, One-Way ANOVA, and Post Hoc Tukey test. Results: This study found no significant difference between the treatment groups regarding the surface roughness of heat-cured acrylic resin ($p = 0.718$). However, only the sodium hypochlorite group showed a significant change in surface roughness before and after immersion ($p = 0.003$), whereas the pomegranate peel and pulp extract groups did not show significant changes ($p = 0.099$ and $p = 0.065$, respectively). Conclusion: 75% pomegranate peel and pulp extracts did not cause significant changes to the surface roughness of heat-cured acrylic resin and may represent safer natural alternatives to sodium hypochlorite as denture soaking solutions.

**Keywords:** denture base, heat-cured acrylic resin, surface roughness, pomegranate, surface roughness tester

## Introduction

The denture base is a component of a dental prosthesis that provides support and good adaptation to the underlying oral tissues.[1] Denture base materials are broadly classified into three types: thermoplastic, acrylic, and metallic.[2] In Indonesia, the most commonly used base material is heat-polymerised acrylic resin

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(HPAR), which undergoes polymerisation through the application of heat. This polymerisation process is achieved by immersion in hot water or using microwave irradiation.[3]

Poly(methyl methacrylate) (PMMA) denture bases offer advantages such as affordability, ease of fabrication and repair, simple equipment requirements, colour stability resembling the gingiva, and ease of polishing.[4] However, heat-cured base materials have limitations, including lower mechanical strength, residual monomer, poor thermal conductivity, porosity, water sorption, and susceptibility to abrasion during cleaning, which can negatively affect the surface roughness of the base.[5]

The low abrasion resistance and colour instability of acrylic resin can lead to occlusal imbalance and aesthetic compromise. Degradation of acrylic resin can result from daily denture brushing, occlusal contacts, and the side effects of mouthwash solutions, as well as the consumption of beverages like coffee, tea, soda, and wine, which can influence colour and surface roughness.[6] Gaps between polymer chains facilitate water molecule ingress into the acrylic resin, potentially causing porosity and polymer chain scission, leading to increased surface roughness and subsequently promoting the adhesion of microorganisms such as *Candida albicans*. An increased colonisation of *Candida albicans* can cause inflammation of the palatal mucosa, a condition known as denture stomatitis.[7-10]

Recommended methods for removing plaque and debris from dentures include mechanical and chemical cleaning.[11] The most common mechanical cleaning method involves a toothbrush and toothpaste; however, toothbrush bristles and abrasive particles in toothpaste can cause wear and potentially damage the material surface through friction during brushing, leading to increased surface roughness compared to the initial polished and smooth state.[6,12] Chemical cleaning is performed by immersion in denture cleaning solutions and is an effective, efficient, and relatively simple method, particularly for elderly denture wearers.[4] The American Dental Association (ADA) recommends denture cleaning and disinfection with agents such as sodium hypochlorite solution, a chlorine ($Cl_2$) based disinfectant effective against a broad spectrum of bacteria, viruses, and fungi.[13,14] A common preparation for sodium hypochlorite denture cleaning solution involves diluting household bleach containing 5% active sodium hypochlorite with sterile distilled water (1:3) for a 10-minute daily immersion.[15] Sodium hypochlorite can increase the surface roughness of heat-cured acrylic resin. This is attributed to hypochlorous acid ($HOCl^-$), which consists of ($H^+$) and ($OCl^-$), both potent oxidising agents and free radicals. Heat-cured acrylic resin is hydrophilic due to its ester groups (R-COOR'), which can cause the polymer chains to separate, leading to porosity. The increased number of voids in heat-cured acrylic resin can elevate surface roughness.[1]

Indonesia possesses a variety of herbal plants that can be used as alternative chemical agents, one of which is the red pomegranate fruit. The red pomegranate (*Punica granatum* L.) is a fruit with diverse applications, and all its parts are frequently used in traditional medicine. It can grow in almost any climate.[16,17] The peel of the red pomegranate (Punica granatum L.) contains compounds with antifungal properties.[18] Furthermore, extracts from pomegranate seeds contain ellagitannins and punicalagin, which are effective against microorganisms (*Candida* sp.) and anti-pathogenic agents (bacteria and fungi) such as *E. coli* and *Salmonella*.[19] Based on this research, red pomegranate exhibits antimicrobial properties and could serve as an alternative denture cleanser.

Surface roughness parameters are developed and standardised based on the American National Standard Institute (ANSI) and the International Organization for Standardization (ISO). Dentures should have a smooth surface, ideally established at 0.2 μm. Guidelines and procedures for surface texture assessment are available in ISO 4288:1996.[20,21] The standard method for determining surface roughness involves using a surface roughness tester/profilometer.[22] A profilometer/surface roughness tester measures surface roughness based on recorded surface height variations. These height variations are converted into electrical signals, and the operation involves a diamond stylus in contact with the surface. The measurement results obtained are only two-dimensional (2D) because the movement is limited to vertical and horizontal directions along a centre line.[20] This study aims to to compare the effectiveness of a natural disinfectant (75% pomegranate peel and pulp extract) against a conventional chemical disinfectant (sodium hypochlorite) in terms of their impact on the surface roughness of heat-cured acrylic resin used for denture bases.

## Method

This research employed an experimental laboratory study design, specifically a pre- and post-test control group design. The preparation of heat-cured acrylic resin plate samples was conducted at the Dental Testing Laboratory, Faculty of Dentistry, Universitas Sumatera Utara. The extraction of pomegranate peel and fruit pulp was performed at the Herbal Plant Testing Laboratory (ASPETRI), Medan. Immersion testing of the heat-cured acrylic resin plate samples took place at the machine testing laboratory of Universitas Harapan, Medan, as did the surface roughness measurements of the heat-cured acrylic resin plate samples. This research was carried out from February to March 2025. Heat-cured acrylic resin plate samples with rectangular dimensions of 10 x 10 x 2 mm, adhering to ISO/DIS 1567:1997 guidelines, were used in this study. The research involved three sample groups: a 75% red pomegranate peel extract group, a 75% red pomegranate fruit pulp extract group, and a sodium hypochlorite solution group. Consequently, the total sample size for the three groups was 27, with 9 samples per group.

The sampling technique employed was purposive sampling, where samples were selected based on the following inclusion criteria: intact red pomegranates without any signs of damage such as mould, bruising, or decay; heat-cured acrylic resin samples measuring 10 x 10 x 2 mm and polished to a uniform surface roughness (< 0.2 µm). The exclusion criteria were: red pomegranates that were either too young or overripe; acrylic resin surfaces with visible defects such as cracks, flaws, and porosity; and acrylic resin samples that had been previously used or immersed in chemical substances for other research.

The equipment used in this study included: cuvettes, a rubber bowl, a spatula, a master metal model, a water bath, a vibrator, an autoclave, a weighing scale, a hydraulic press, a micromotor, a handpiece, a polishing motor, a rag wheel, beakers, dappen dishes, a cement spatula, Fraser burs, a brush, a LeCron carver, a wax knife, tweezers, a face mask, gloves, tissue paper, label paper, a marker pen, test tubes (27 units), a surface roughness tester, a rotary evaporator, an oven, a blender, a stirring rod, and a vortex mixer. The materials used were red pomegranate peel and fruit pulp, distilled water, 5% sodium hypochlorite, cold mould seal, Vaseline, type II gypsum, sandpaper of grades 40, 800, and 1200, cellophane film, acrylic resin monomer and polymer, and 96% ethanol.

The procedure for preparing the heat-cured acrylic resin samples involved first preparing the upper and lower cuvettes and applying Vaseline. Type II gypsum was mixed with water at a ratio of 150 ml to 250 g in a rubber bowl and stirred with a spatula. The gypsum mixture was poured into the lower cuvette and vibrated to remove air bubbles. The master metal model was placed in the gypsum up to the surface level, and the gypsum was allowed to set. After setting, Vaseline was applied, the upper part of the cuvette was assembled and filled completely with a gypsum mixture (100 ml water : 200 g powder), and this was allowed to set. Once set, the master model was removed from the cuvette to create the mould, and the cuvette was cleaned with hot water to remove any residual Vaseline from the gypsum surface. Cold mould seal (CMS) was applied to the gypsum surface of the mould with a brush and allowed to dry for 15 minutes. The acrylic resin powder and liquid were mixed at a ratio of 2.4 g to 2 ml using a dappen dish and a cement spatula until the dough stage was reached. The acrylic dough was placed into the mould and covered with cellophane film. The opposing cuvette was assembled and compressed using a hydraulic press. The cuvette and cellophane were opened, excess acrylic was trimmed, and the cuvette was reclosed. The curing process was performed for 20 minutes at 70°C, followed by a temperature increase to 100°C for 90 minutes, and then allowed to cool to room temperature. The acrylic resin plate was removed from the cuvette, excess acrylic was trimmed and smoothed using a handpiece and carbide bur, followed by finishing and polishing.

The preparation of the pomegranate peel and fruit pulp extracts involved cleaning the red pomegranates and separating the peel and pulp. The peel and pulp were dried at 60°C for 24 hours, cut into small pieces, and blended. The blended material was then sieved to obtain a fine powder. This powder was macerated in 96% ethanol in a closed jar for 72 hours, with stirring every 24 hours. The mixture was filtered using filter paper, and the extract was concentrated using a rotary evaporator. The extract was diluted by mixing 7.5 ml of the concentrated extract with 2.5 ml of distilled water to a final volume of 10 ml. The same procedure was followed for the preparation of the red pomegranate peel extract.

The preparation of the sodium hypochlorite solution involved diluting a 5% sodium hypochlorite solution at a ratio of one part sodium hypochlorite to three parts water (1:3). Specifically, 25 ml of 5% sodium hypochlorite was mixed with 75 ml of distilled water and stirred until homogeneous, resulting in a 1.25% sodium hypochlorite solution. Following the preparation of the test plates, the pomegranate peel and fruit pulp extracts, and the sodium hypochlorite solution, the samples were divided into three groups, each containing 9 samples: Group A (red pomegranate peel extract), Group B (red pomegranate fruit pulp extract), and Group C (sodium hypochlorite). Before immersion, the surface roughness of each sample was measured using a surface roughness tester. Subsequently, each heat-cured acrylic resin test plate was immersed in 10 ml of the respective solutions in 9 small bottles per group: 75% red pomegranate peel extract, 75% red pomegranate fruit pulp extract, and 1.25% sodium hypochlorite. The immersion period was 7 days and 14.5

hours, simulating approximately 3 years of denture use. This duration was chosen because the lifespan of dentures can exceed 15 years, and the researchers opted for a shorter timeframe representing less than 5 years of usage. After immersion in the treatment solutions, the test plates were retrieved using sterile tweezers, rinsed with distilled water, and dried with tissue paper. Post-immersion surface roughness was then measured using a surface roughness tester.

After sample allocation, each polished sample was marked on one side with a permanent marker before the initial roughness test. Prior to immersion, the baseline surface roughness of each sample was measured in micrometres (µm) using a surface roughness tester. Samples from each group were then immersed for 7 days and 14.5 hours in the respective solutions: 75% red pomegranate peel extract, 75% red pomegranate fruit pulp extract, and 1.25% sodium hypochlorite solution. Following immersion, the surface roughness was measured again using the surface roughness tester. Samples were rinsed with sterile distilled water and dried. For measurement, each sample was placed on a smooth, flat glass surface, and the stylus of the measuring device was positioned to be parallel and in contact with the sample surface. Measurement was initiated by clicking "play" on the monitor, and the stylus moved across the desired surface area of the sample. Once the stylus stopped, a graph of the measurement results was automatically displayed on the monitor, and the pre- and post-treatment values were compared.

The collected research data were then analysed using SPSS software. Normality was assessed using the Shapiro-Wilk test due to the sample size being less than 50. Homogeneity of variance was then evaluated using Levene's test. If the data were normally distributed, a parametric one-way ANOVA test would be conducted to determine if there were significant differences between the groups. Subsequently, a post-hoc Tukey HSD test would be performed to identify which specific groups exhibited significant differences. If the data were not normally distributed, the non-parametric Kruskal-Wallis test would be used as an alternative.

## Results

Table 1 presents the mean changes in surface roughness for the 75% red pomegranate peel extract group, the 75% red pomegranate fruit extract group, and the sodium hypochlorite group, which were 0.042±0.067 µm, 0.062±0.088 µm, and 0.067±0.047 µm, respectively, on heat-cured acrylic resin. Overall, the sample group immersed in the sodium hypochlorite solution exhibited the highest mean change in surface roughness among the three groups. Conversely, the sample group immersed in the 75% red pomegranate peel extract demonstrated the lowest mean change among the three groups.

Table 1. Comparison of the effect of 75% pomegranate peel and pulp extract immersion versus sodium hypochlorite on the surface roughness of heat-cured acrylic resin denture bases

| Kelompok | Surface Roughness (µm) Mean ± SD | | Δ Surface Roughness (Mean ± SD) |
|---|---|---|---|
| | Before | After | |
| 75% Pomegranate peel extract | 0,198 ± 0,039 | 0,240 ± 0,052 | 0,042 ± 0,067 |
| 75% Pomegranate pulp extract | 0,180 ± 0,051 | 0,243 ± 0,086 | 0,062 ± 0,088 |
| Sodium Hypochlorite | 0,156 ± 0,053 | 0,222 ± 0,036 | 0,067 ± 0,047 |

The Shapiro-Wilk normality test was conducted prior to statistical data analysis. The results of the Shapiro-Wilk normality test indicated that the surface roughness change data for the 75% red pomegranate peel extract group, the 75% red pomegranate fruit extract group, and the sodium hypochlorite group were normally distributed ($p>0.05$), as shown in Table 2.

Table 2. Shapiro-Wilk normality test results

| | Group | *P-Value* (*Shapiro-Wilk*) |
|---|---|---|
| Δ Surface Roughness | 75% Red Pomegranate peel extract | 0,341 |
| | 75% Red Pomegranate Pulp Extract | 0,057 |
| | Sodium Hypochlorite | 0,438 |

A paired t-test was conducted to examine whether there was a significant change in surface roughness between the baseline and following immersion of samples in 75% pomegranate peel extract, 75% pomegranate flesh extract, and sodium hypochlorite. The results of the paired t-tests for the 75%

pomegranate peel extract group, the 75% pomegranate flesh extract group, and the sodium hypochlorite group yielded p-values of 0.099, 0.065, and 0.003, respectively (see Table 3).

Table 3. Effect of immersion in 75% pomegranate peel and pulp extracts compared to sodium hypochlorite on the surface roughness of heat-cured acrylic resin denture bases

| Group | Surface Roughness (µm) Mean ± SD | | *p-value (paired t-test)* |
|---|---|---|---|
| | Baseline ± SD | Post-Immersion ± SD | |
| 75% Pomegranate peel extract | 0,198 ± 0,039 | 0,240 ± 0,052 | 0,099 |
| 75% Pomegranate pulp extract | 0,180 ± 0,051 | 0,243 ± 0,086 | 0,065 |
| Sodium Hypochlorite | 0,156 ± 0,053 | 0,222 ± 0,036 | 0,003* |

ANOVA was employed to assess the comparative effects of immersion in 75% pomegranate peel and pulp extract and sodium hypochlorite on the surface roughness of heat-cured acrylic resin denture bases. The results yielded a p-value of 0.718 (refer to Table 4). Subsequently, a Post Hoc Tukey analysis was conducted to statistically evaluate pairwise comparisons between the groups. The significance values (p-values) for these inter-group comparisons are presented in Table 5.

Table 4. Comparison of the mean surface roughness difference of heat-cured acrylic resin between the group immersed in 75% red pomegranate peel and pulp extract and the sodium hypochlorite group

| Group | Δ Surface Roughness (µm) Mean ± SD | p *value* |
|---|---|---|
| 75% Pomegranate peel extract | 0,042 ± 0,067 | |
| 75% Pomegranate pulp extract | 0,062 ± 0,088 | 0,718 |
| Sodium Hypochlorite | 0,067 ± 0,047 | |

Table 5. Comparison of immersion effects between two treatment groups

| Kelompok | 75% Pomegranate peel extract | 75% Pomegranate pulp extract | Sodium Hypochlorite |
|---|---|---|---|
| 75% Pomegranate peel extract | | 0,797 | 0,730 |
| 75% Pomegranate pulp extract | 0,797 | | 0,993 |
| Sodium Hypochlorite | 0,730 | 0,993 | |

## Discussion

This study investigated the comparative effects of immersion in 75% pomegranate (Punica granatum) peel and fruit extracts versus sodium hypochlorite on the surface roughness of heat-cured acrylic denture base resin. One-way ANOVA revealed no significant difference in surface roughness changes between the three groups ($p = 0.718$, $p > 0.05$). This indicates that immersion in any of the tested solutions can induce surface roughness in heat-cured acrylic denture base resin, thus supporting the null hypothesis (H0). Alterations in acrylic resin surface roughness are influenced by several factors, including the duration of immersion during disinfection procedures. In this study, heat-cured acrylic resin specimens were immersed in the treatment solutions for a total of 168 hours, simulating a daily 10-minute immersion over a three-year average denture use period. Heat-cured acrylic resin exhibits high permeability, absorbing up to 0.69 $mg/cm^2$ of water, which can consequently affect the roughness of the acrylic resin base upon prolonged immersion. This fluid absorption occurs over time.[23]

The findings of this research demonstrate that immersion of heat-cured acrylic denture base resin in 75% pomegranate peel and fruit extracts did not result in significant changes in surface roughness. Paired t-tests yielded p-values of 0.099 and 0.065 respectively ($p > 0.05$) for the peel and fruit extract groups. Conversely, a significant increase in surface roughness was observed in heat-cured acrylic resin immersed in sodium hypochlorite (paired t-test, $p = 0.003$, $p < 0.05$). This is likely attributable to the oxidative and corrosive chemical properties of sodium hypochlorite, which can degrade the acrylic resin surface structure and increase its roughness. In contrast, pomegranate peel and fruit extracts, containing polyphenols and tannins, primarily function as antibacterials and antioxidants and did not significantly alter surface roughness after the specified immersion period.[24] hese results align with the findings of Fadriyanti et al[25], who reported a significant increase in acrylic resin surface roughness following immersion in sodium hypochlorite.

Furthermore, this study showed no significant difference in surface roughness changes of heat-cured acrylic denture base resin between immersion in 75% pomegranate peel extract and 75% pomegranate fruit extract, as determined by a post-hoc Tukey test ($p = 0.797$, $p > 0.05$). The mean surface roughness changes observed in the peel and fruit extract groups were 0.042 ± 0.067 µm and 0.062 ± 0.088 µm, respectively. This is attributed to the presence of polyphenolic compounds, such as tannins, flavonoids, gallic acid, ellagic acid, and punicalagin, in both pomegranate peel and fruit.[26] On the other hand, heat-cured acrylic resin contains ester groups (R-COOR') within its polymethyl methacrylate structure. If these ester groups react with the phenols present in pomegranate peel and fruit, the H+ ion from the phenol will be released and bond with the CH3O- group detached from the ester. This ion exchange reaction can destabilise the chemical bonds of the acrylic resin, potentially leading to the formation of numerous porosities on the resin surface. An increased number of porosities on the acrylic resin surface results in increased surface roughness.[3,27] The lower surface roughness change observed in the 75% pomegranate peel extract group may be due to the presence of active compounds, such as alkaloids, in the peel extract that are absent in the fruit.[28] Alkaloid compounds have a basic pH, which may contribute to the lower surface roughness compared to the fruit extract group.[29]

No significant difference was found in the surface roughness changes of heat-cured acrylic resin between the 75% pomegranate peel extract group and the sodium hypochlorite group (post-hoc Tukey test, $p = 0.730$, $p > 0.05$). This finding may be influenced by the presence of phenolic compounds in pomegranate peel, which can cause chemical degradation and consequently affect the surface roughness of the acrylic resin, similar to the strong oxidising effect of sodium hypochlorite. Other chemical damage may include cracking, and a reduction in the hardness and strength of the acrylic.[30] Additionally, paired t-test analysis revealed no significant change in the surface roughness of heat-cured acrylic resin after immersion in 75% pomegranate peel extract ($p = 0.099$, $p > 0.05$). However, a significant increase in surface roughness was observed after immersion in sodium hypochlorite ($p = 0.003$, $p < 0.05$). This can be attributed to the hydrophilic nature of acrylic resin, making it susceptible to the absorption of sodium hypochlorite solution, a strong oxidising agent capable of degrading the interstitial matrix of the acrylic resin, ultimately leading to increased surface roughness.[1,31]

This study also demonstrated no significant difference in the surface roughness of heat-cured acrylic resin after immersion in 75% pomegranate fruit extract compared to sodium hypochlorite (post-hoc Tukey test, $p = 0.993$, $p > 0.05$). The surface roughness changes in both groups might be influenced by the acidic nature of the phenolic compounds in the 75% pomegranate fruit extract and the formation of weak hypochlorous acid (HClO) when sodium hypochlorite is diluted with distilled water ($H_2O$).[27,32] The 75% concentration of the pomegranate fruit extract used in this study implies a higher concentration of acidic substances in contact with the heat-cured acrylic resin surface, potentially leading to increased chemical bond degradation and consequently higher surface roughness values.[33] However, statistical analysis using a paired t-test revealed that the surface roughness change was not significant in the 75% pomegranate fruit extract group ($p = 0.065$, $p > 0.05$), whereas a significant increase was observed in the sodium hypochlorite group ($p = 0.003$, $p < 0.05$). This suggests that while the concentration of the pomegranate fruit extract used may not have been sufficiently high to cause a statistically significant change, it still possesses the potential to alter the surface roughness of denture bases due to the presence of acidic phenolic compounds.[27] These findings are consistent with the research by Zulkarnain and Daniel (2014), which reported higher surface roughness values in the sodium hypochlorite immersion group compared to vinegar and distilled water immersion groups.[31] Furthermore, the study by Rifdayanti et al.[4] demonstrated that natural materials have a lower impact on the surface roughness of heat-cured acrylic resin compared to chemical agents.

A limitation of this study was the uncontrolled variability in the surface roughness of the heat-cured acrylic resin samples during the polishing process. The initial surface roughness values before immersion varied, depending on the polishing technique and materials used. However, to enhance the validity of the results, the initial surface roughness was standardised to a range of < 0.2 µm, in accordance with the International Organization for Standardization (ISO) and the American National Standard Institute (ANSI).[20] Additionally, negative values were observed in the calculated difference of surface roughness measurements (after immersion minus before immersion) for some samples in each group. This could be attributed to inconsistencies in the measurement positions on the heat-cured acrylic resin samples before and after immersion. The stylus of the surface roughness tester operates automatically upon contact with the surface of the heat-cured acrylic resin plate placed on a flat glass. However, the researchers did not mark the edges of the acrylic resin plate on the glass, potentially leading to variations in the measurement positions by the surface roughness tester between pre- and post-immersion assessments.[34]

## Conclusion

The research findings indicate that there was no statistically significant difference in the effect of immersion in 75% pomegranate peel extract and 75% pomegranate flesh extract compared to sodium hypochlorite on the surface roughness of heat-cured acrylic resin denture bases ($p=0.718$; $p>0.05$). The mean changes in surface roughness of the heat-cured acrylic resin denture bases after immersion were 0.042±0.067 µm for 75% pomegranate peel extract, 0.062±0.088 µm for 75% pomegranate flesh extract, and 0.067±0.047 µm for sodium hypochlorite. Furthermore, analysis revealed no significant change in surface roughness before and after immersion using either 75% pomegranate peel extract ($p=0.099$; $p>0.05$) or 75% pomegranate flesh extract ($p=0.065$; $p>0.05$). In contrast, immersion in sodium hypochlorite resulted in a significant change in surface roughness ($p=0.003$; $p<0.05$). Additionally, no significant differences were found in the effect of immersion between 75% pomegranate peel extract and 75% pomegranate flesh extract ($p=0.797$; $p>0.05$), 75% pomegranate peel extract and sodium hypochlorite ($p=0.730$; $p>0.05$), or 75% pomegranate flesh extract and sodium hypochlorite ($p=0.993$; $p>0.05$) on the surface roughness of heat-cured acrylic resin denture bases.

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