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RESEARCH ARTICLE

Effect of immersion in effervescent granules of watermelon rind (*Citrullus lanatus*) extract on the surface roughness of artificial teeth

Aria Fransiska*✉, Alifia Sabilla, Desy Purnama Sari***, Fidya Meditia Putri******

*Department of Dental Materials, Faculty of Dentistry, Universitas Andalas, Padang, West Sumatra, Indonesia
**Faculty of Dentistry, Universitas Andalas, Padang, West Sumatra, Indonesia
***Department of Public Health, Universitas Andalas, Padang, West Sumatra, Indonesia
****Department of Dental Public Health, Faculty of Dentistry, Universitas Padjadjaran, Bandung, West Java, Indonesia
*Jl Perintis Kemerdekaan No 77, Padang, West Sumatra, Indonesia; ✉ correspondence: aria.fransiska@dent.unand.ac.id

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ABSTRACT

Artificial teeth elements are essential components of removable dentures. Inadequate cleaning can lead to the accumulation of microorganisms, which may cause denture stomatitis. Alkaline peroxide effervescent tablets are commonly used denture cleansers. However, prolonged use may increase the surface roughness of artificial teeth. To address this, an alternative natural-based cleanser has been formulated using red watermelon (*Citrullus lanatus*) rind extract in effervescent granule form. Effervescent granules of watermelon rind extract have potential as an alternative denture cleanser due to their antibacterial properties. The effervescent reaction helps mechanically remove plaque and debris while inhibiting the growth of microorganisms that cause odor and infection. This formulation is practical, natural, and economical. The study aims to evaluate the effect of immersion in effervescent granules containing watermelon rind extract on the surface roughness of artificial teeth. This was a laboratory experimental study using acrylic resin-based artificial teeth. Samples were divided into three treatment groups: aquadest, alkaline peroxide effervescent solution, and watermelon rind effervescent granule solution (n = 5). Surface roughness was measured using a Surface Roughness Tester, and data were analyzed with the Kruskal–Wallis test ($p < 0.05$). The mean surface roughness values after immersion in aquadest, alkaline peroxide solution, and watermelon rind effervescent granules were 0.140 ± 0.026 µm, 0.616 ± 0.213 µm, and 0.670 ± 0.041 µm, respectively. The findings demonstrate that immersion in effervescent granules containing watermelon rind extract significantly increases the surface roughness of artificial teeth. Further formulation development is recommended to optimize its potential as a natural denture cleanser.

Keywords: acrylic; artificial teeth; effervescent granule; watermelon rind extract; surface roughness

INTRODUCTION

Tooth loss is one of the most common oral health problems in Indonesia, with a prevalence of 21%.[1] Dentures are a common alternative to replace missing teeth, helping to restore masticatory function, improve speech, and enhance facial aesthetics.[2,3] The primary components of a denture are the artificial teeth and the denture base.[4] Artificial teeth made of acrylic resin remain widely used due to their ease of manipulation, non-abrasive nature to remaining or opposing teeth, and their strong adhesion to acrylic-based denture bases. However, a major drawback of this material is its porosity, which makes acrylic resin susceptible to fluid absorption.[5,6] This condition facilitates the accumulation of plaque and food debris, which in turn promotes the growth of microorganisms such as *Candida albicans*, leading to denture stomatitis.[6,7] Poor denture hygiene can exacerbate this condition, highlighting the need for effective and proper denture cleaning methods.[8]

Denture cleaning can be performed through mechanical or chemical methods.[9] Mechanical cleaning involves the use of toothbrushes and toothpaste, whereas chemical cleaning utilizes agents such as alkaline peroxide and sodium

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hypochlorite.[9,10] Among chemical cleaning formulations, effervescent preparations are widely used due to their ease of use and relatively shorter cleaning time.[6] However, chemical-based effervescent tablets have been shown to increase the surface roughness of acrylic resin; therefore, natural-based alternatives for effervescent formulations are being explored.[6,11]

One of the natural ingredients that can be used for effervescent granule formulation is the white rind of red watermelon (*Citrullus lanatus*).[12,13] A study by Susanti et al demonstrated that watermelon rind extract at concentrations of 20% and 40% was effective in inhibiting the growth of *Candida albicans* and *Bacillus subtilis* at a strong inhibition level. This antimicrobial effect is attributed to the active compounds present in the rind extract, including flavonoids, tannins, alkaloids, saponins, and terpenoids.[12] The active compounds in watermelon rind, such as flavonoids and tannins, belong to the phenolic group.[13] Phenolic compounds are acidic (approximately pH 4) and can contribute to surface erosion of artificial teeth, thereby increasing porosity and allowing water molecules to penetrate, which ultimately leads to an increase in surface roughness.[14]

Studies using effervescent preparations containing phenolic compounds have been previously conducted. For instance, a study by Fathoni et al reported that 75% tobacco leaf effervescent tablets increased the surface roughness of heat-polymerized acrylic resin, although the roughness remained below the ISO 1567 threshold for acrylic resin surface roughness, which is 0.2 µm.[6] Leal et al (2023) further stated that the phenolic content in tobacco leaf extract was higher (2.7 mg GAE/g) compared to that in red watermelon rind extract (2.4 mg GAE/g).[15,16] To date, there have been no studies using red watermelon rind extract as the base ingredient for effervescent granules intended for denture cleaning. Therefore, this study aims to investigate the effect of immersion in effervescent granules containing red watermelon rind (*Citrullus lanatus*) extract on the surface roughness of artificial teeth.

MATERIALS AND METHODS

This study was an - laboratory experiment using a pre-test/post-test with control group design. The study was conducted across four locations: the Laboratory of Natural Organic Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Andalas; the Laboratory of Agricultural Product Technology and Engineering, Universitas Andalas; the Dental Laboratory, Faculty of Dentistry, Universitas Andalas; and the Industrial Metrology Laboratory, Faculty of Engineering, Universitas Andalas. The Research Ethics Committee Faculty of Medicine Andalas University approved the research protocol with No. 65/UN.16.2/KEP-FK/2025. The aim of this study was to determine the effect of immersion in effervescent granules containing 40% red watermelon rind (*Citrullus lanatus*) extract on the surface roughness of artificial teeth. The samples used in this study were artificial upper central incisor teeth (tooth 11).

The watermelon species used in this study was *Citrullus lanatus*. The extraction of the watermelon rind was performed using the maceration method. The powdered simplicia was immersed in 96% ethanol for 72 hours in a closed container, followed by filtration to obtain the desired extract. The technique used in the preparation of effervescent granules from watermelon rind extract is the wet granulation method. This wet granulation technique involves mixing the active ingredients into larger particles by adding a binder to produce a moist mass that can be granulated. The concentrated extract was first mixed with maltodextrin at a ratio of 1 : 3 to obtain a powdered extract; at this stage, a 100% concentration of watermelon rind powder was obtained. A total of 800 mg of the red watermelon white rind extract powder was then mixed (this amount was based on the assumption of 40% content per effervescent tablet commonly available on the market), followed by the addition of 442 mg of tartaric acid, 148 mg of citric acid, 590 mg of sodium bicarbonate, and 20 mg of PVP, resulting in 2,000 mg of effervescent granules of red watermelon white rind extract.

Table 1. Mean and standard deviation of surface roughness of artificial teeth in control and experimental groups

Groups	Mean ± DS (µm)			
	n	Pre-test	Pos-test	Δ Ra
Aquadest	5	0.918 ± 0.100	1.058 ± 0.123	0.140 ± 0.026
Alkaline peroxide effervescent tablet solution	5	0.7400 ± 0.113	1.356 ± 0.221	0.616 ± 0.213
effervescent granule solution of red watermelon white rind extract 40%	5	0.838 ± 0.069	1.508 ± 0.078	0.670 ± 0.041

The samples were divided into three treatment groups: immersion in distilled water (Group A), immersion in an alkaline peroxide effervescent tablet solution (Group B), and immersion in a 40% red watermelon rind effervescent granule solution (Group C). The samples were immersed in the solution for two days. This duration was determined based on the immersion time of dentures in an alkaline peroxide cleanser (Polident®), which is approximately five minutes per day. Therefore, the immersion of samples for two days is considered equivalent to one year of actual use. The sample size for each group was determined using the Daniel and Cross formula and adjusted using a dropout correction formula to account for potential loss of experimental units. Based on the calculation, each group consisted of 5 samples, resulting in a total of 15 samples for the entire study. The type of data used in this study was primary data, obtained directly from measurements of the surface roughness of the artificial teeth before and after treatment. The data were analyzed using computer-assisted statistical software. The data were statistically analyzed by performing normality and homogeneity tests. The normality of the data in each group was assessed using the Shapiro–Wilk test with a significance value of ($p > 0.05$). The homogeneity test in this study was conducted using Levene's test with a significance value of ($p > 0.05$). Based on the data analysis, the distribution of the data was normal but not homogeneous; therefore, data transformation was performed and followed by non-parametric tests, namely the Kruskal–Wallis test and the Mann–Whitney test.

RESULTS

Surface roughness of the artificial teeth was assessed pre and post treatment using a surface roughness tester, and the values were recorded in micrometers (µm). Table 1 shows an increase in surface roughness after immersion in distilled water, alkaline peroxide effervescent tablet solution, and 40% effervescent granule solution of red watermelon white rind extract. The greatest difference in surface roughness of artificial teeth was observed in the group immersed in the alkaline peroxide solution, while the smallest difference was found in the group immersed in distilled water.

The data were analyzed statistically to determine the effect of immersion in the effervescent granule solution of watermelon rind extract on the surface roughness of artificial teeth.

Table 2. Kruskal-Wallis test of surface roughness of artificial teeth in control and experimental groups

Statistical test	Value
Kruskall-Wallis H	6.236
df	2
p	0.044

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Table 3. Mann-Whitney test of surface roughness of artificial teeth in control and experimental groups

Groups	Aquadest	Alkaline peroxide effervescent tablet solution	effervescent granule solution of red watermelon white rind extract 40%
Aquadest		0.112	0.009*
Alkaline peroxide effervescent tablet solution			0.917
effervescent granule solution of red watermelon white rind extract 40%			

Note: *p < 0.05 = significant

Normality testing using the Shapiro–Wilk test showed a p-value > 0.05, indicating that the data were normally distributed. However, the Levene's test for homogeneity revealed a p-value of 0.002, indicating that the data were not homogeneous. Therefore, data transformation was performed. After transformation, the data remained non-normally distributed, so non-parametric tests (Kruskal–Wallis and Mann–Whitney) were subsequently used.

The Kruskal–Wallis test results presented in Table 2 show a p-value < 0.05, indicating a statistically significant difference among the treatment groups. Therefore, the analysis was continued with the Mann–Whitney U test as a post hoc test. The Mann–Whitney U test results showed a statistically significant difference between the distilled water solution and the 40% effervescent granule solution of red watermelon white rind extract.

DISCUSSION

An increase in surface roughness of artificial teeth made from acrylic resin can occur due to the material's inherent property of water absorption. When water penetrates the porous structure, it can disrupt the polymer bonds within the resin.[17–19] Surface roughness may also be affected by the presence or absence of active compounds in the immersion solution used during the study. The alkaline peroxide effervescent tablet used in this research releases hydrogen peroxide (H_2O_2), which decomposes into water and oxygen. The resulting oxygen is unstable and generates free radicals that cause polymer chain scission in the acrylic resin through oxidation reactions.[6,20]

This finding aligns with the study by Dewi et al, which demonstrated that alkaline peroxide can increase the surface roughness of acrylic resin.[21] Immersion in distilled water (aquadest) also led to an increase in surface roughness. This is consistent with the findings of Rifdayanti et al, who reported that distilled water can increase the surface roughness of acrylic resin.[19] Although aquadest does not contain any active compounds, it can still penetrate the pores of the acrylic resin. The penetration of aquadest into the resin's micro-porosities can induce stretching between polymer chains, thereby increasing surface roughness.[21]

The increase in roughness in artificial teeth immersed in effervescent granule solutions containing watermelon rind extract may be attributed to the presence of phenolic compounds such as tannins and flavonoids.[12,13,22] Phenolic compounds react with water by releasing H^+ ions, forming phenolate ions. These phenolate ions then react with the ester groups in the acrylic resin of the artificial teeth. The released H^+ ions bond with CH_3O^- groups in the acrylic resin, while the remaining phenolate (phenoxide anion) interacts with the original ester functional groups. This leads to polymer degradation and chain cleavage, resulting in surface damage and increased roughness.[19,23,24]

A similar result was reported by Fathoni et al, who found that immersion of acrylic resin in a 75% tobacco leaf effervescent solution, which

also contains phenolic compounds, increased the surface roughness of the resin.[6] In this study, the greatest increase in surface roughness was observed in the group immersed in the effervescent granule solution of watermelon rind extract. This result contrasts with previous studies, which reported that the highest increase in surface roughness occurred with immersion in alkaline peroxide effervescent solutions.[6] This discrepancy may be explained by the direct exposure of active compound sediments from the watermelon rind extract to the artificial teeth, which may accelerate the degradation of polymer chains, thereby causing a more rapid increase in surface roughness. This is consistent with a study by Bitencourt et al, which stated that continuous exposure to solutions containing active substances can increase the surface roughness of artificial teeth.[25]

In the present study, immersion in an alkaline peroxide effervescent tablet solution also caused an increase in surface roughness, reaching 0.616 µm, which exceeds the clinically acceptable threshold. This may be attributed to the immersion method used in this study, which did not fully simulate real-world clinical conditions. A previous study by Pertiwisari et al immersed acrylic resin in alkaline peroxide effervescent tablet solution for 5 minutes over 7 cycles, with solution replacement after each cycle and rinsing with distilled water before measurement. That study aimed to simulate daily clinical use, and reported a surface roughness increase of only 0.004 µm, remaining below the threshold.[11] In contrast, the current study involved continuous two-day immersion with solution replacement every 24 hours and no rinsing prior to measurement. These procedural differences suggest that prolonged immersion and the absence of a rinsing step may lead to chemical residue buildup on the resin surface, potentially contributing to the increased surface roughness observed.

CONCLUSION

This study concludes that immersion of artificial teeth in effervescent granules containing watermelon rind extract results in a higher increase in surface roughness compared to immersion in alkaline peroxide effervescent tablets. Based on these findings, the watermelon rind extract effervescent granules cannot yet be recommended as an alternative denture cleanser. Further formulation development and evaluation are necessary to optimize the potential of active compounds in watermelon rind while minimizing adverse effects on denture base materials.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this paper.

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