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Research Article

Effect of Brushing Small White Ginger Extract Paste on Mechanical Strength of Heat-Cured Acrylic Resin Plates

[1]Debby Saputera, [2]Beta Widya Oktiani, [3]R. Harry Dharmawan Setyawardhana, [4]I Wayan Arya Krishnawan Firdaus, [1]Ririn Handayani, [1]Ade Nia Karlina, [1]Nor Najwa

[1]Department of Prosthodontics, Faculty of Dentistry, Lambung Mangkurat University, Banjarmasin, Indonesia
[2]Department of Periodontics, Faculty of Dentistry, Lambung Mangkurat University, Banjarmasin, Indonesia
[3]Department of Public Dental Health Science, Lambung Mangkurat University, Banjarmasin, Indonesia
[4]Department of Oral Biology, Faculty of Dentistry, Lambung Mangkurat University, Banjarmasin, Indonesia

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ABSTRACT

Introduction: Brushing dentures with conventional toothpaste may compromise the mechanical and physical properties of heat-cured acrylic resin because of its high abrasive content. Small white ginger extract paste, which contains phenolic compounds, presents potential as an alternative cleansing agent. The present study analyzes the effect of brushing with small white ginger extract paste on the surface hardness, impact strength, and flexural strength of heat-cured acrylic resin plates.
Materials and Methods: This study used heat-cured acrylic resin specimens (65 x 10 x 2,5 mm) and divided them into three brushing groups: small white ginger extract paste, placebo paste, and distilled water. These groups were evaluated to test surface hardness (12 specimens), impact strength (27 specimens), and flexural strength (24 specimens). Data were analyzed using the One-Way ANOVA test.
Results and Discussion: The mean decrease in hardness for the ginger, placebo, and distilled water groups was 1 VHN, 0.6 VHN, and 1.2 VHN, respectively, indicating no significant difference between the ginger and control groups ($p > 0.05$). The mean impact strength values for the ginger, placebo, and control groups were 55×10^3 J/mm², 50×10^3 J/mm², and 42×10^3 J/mm², respectively, demonstrating a significant difference($p<0,05$). The mean flexural strength values were 96.96 MPa (ginger), 97.97 MPa (placebo), and 96.22 MPa (control), with the One-Way ANOVA test showing no significant difference ($p>0,05$).
Conclusion: Brushing with small white ginger extract paste significantly increases impact strength without significantly reducing surface hardness or flexural strength compared to control groups.

Corresponding Author:
Debby Saputera
Department of Prosthodontics, Faculty of Dentistry
Lambung Mangkurat University, Banjarmasin, Indonesia
Email: debbysaputera@ulm.ac.id

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INTRODUCTION

Dentures are prostheses that replace missing natural teeth and mucosal tissues to restore masticatory, phonetic, and aesthetic functions, and to maintain the health of the supporting oral structures.[1,2] According to the 2018 Basic Health Research (Riskesdas) data, South Kalimantan Province has the highest prevalence of denture users in Indonesia at 3,3%, a figure that sits above the national average.[3] The use of acrylic resin removable dentures is a significant clinical risk, as the thin layer of saliva between the denture base and the mucosa creates an environment that is difficult to cleanse naturally.[4] This condition triggers the adherence of biofilm-forming microorganisms, particularly the fungus *Candida albicans*. Biofilm accumulation that is not properly cleaned becomes the primary etiology of denture stomatitis, an inflammatory condition affecting approximately 17% to 75% of the removable denture-wearing population.[5]

Denture stomatitis can be prevented through proper denture hygiene. Denture cleansing methods are generally classified into three types: mechanical, chemical, and a combination of both methods.[6] Chemical cleansing via immersion is often considered less effective in eliminating biofilms and requires a prolonged duration. Conversely, mechanical cleansing through brushing is more widely preferred by the public because it is fast, simple, and efficient in removing plaque.[7,8] However, the use of commercial toothpaste in the mechanical brushing method is not recommended for dentures.[9] Conventional toothpaste is formulated for natural teeth, which possess a high enamel hardness value of 350 VHN, whereas heat-polymerized acrylic resin has a hardness value of only approximately 20 VHN.[10] Consequently, the high abrasive content in commercial toothpaste can compromise the surface hardness, impact strength, and flexural strength of heat-cured acrylic resin plates.[8,11,12]

The use of natural ingredients as an innovation in denture toothpaste with lower abrasive content has been widely explored, as it is considered safer for long-term use. One potential natural ingredient is small white ginger (*Zingiber officinale* var. *amarum*). According to the 2021 Agricultural Data and Information System, South Kalimantan Province is one of the largest producers of ginger in Borneo.[12,13] Scientifically, a 100% concentration of small white ginger extract is optimal for inhibiting *Candida albicans growth*.[14] This antifungal and antibacterial effect is produced by the activity of phenolic secondary metabolite compounds contained within it, such as gingerol, shogaol, zingerone, and zingiberene, which are capable of denaturing fungal cell proteins.[15,16]

Although effective as antimicrobial agents, acrylic resin bases exposed to chemical compounds from plant extracts require careful structural consideration. Phenolic compounds in small white ginger extract are generally weakly acidic. Upon contact during brushing, the H^+ ions of the phenol group can be released and bind to the ester functional groups (CH_3O^-) on the acrylic resin polymer chain. This reaction triggers chemical degradation, weakening intermolecular bonds and causing swelling within the polymer matrix. It is hypothesized that this microscopic chemical damage could adversely affect the physical and mechanical properties of heat-polymerized acrylic resin plates, particularly when applied continuously as a brushing paste.[17,18]

Previous studies have explored the impact of various cleansing agents and methods on denture base materials, highlighting a critical balance between antimicrobial efficacy and structural preservation. Mylonas et al.[9] emphasized that conventional toothpaste is strictly not recommended for brushing dentures due to the stark contrast in substrate hardness. Natural tooth enamel and dentin possess hardness values of 350 VHN and 60 VHN, respectively, whereas acrylic resin measures only approximately 20 VHN. Consequently, high abrasive content in commercial paste induces surface roughness, although the brushing method itself holds an advantage in limiting the denture's exposure time to water.[8-10,19]

Regarding herbal alternatives, prior investigations have noted potential adverse effects of plant extracts on the mechanical properties of denture polymers. For instance, Kristiana et al.[20] demonstrated that increasing the concentration of tobacco leaf extract paste tended to lower the impact strength of thermoplastic nylon due to its phenol content and exposure duration, albeit not statistically significant. Furthermore, Islami[15] reported that the passive immersion of heat-cured acrylic resin plates in 100% small white ginger extract significantly reduced their flexural strength. This reduction was attributed to the diffusion of phenolic compounds into the acrylic resin, inducing chemical damage, weakening polymer chain bonds, and triggering matrix expansion that disrupts intermolecular bonds.[15,19,20]

Despite these findings, a significant gap remains in the literature. While the chemical degradation of acrylic resin by *Zingiber officinale var. amarum* has been observed under passive immersion and the abrasiveness of pastes has been noted broadly, no study has yet evaluated the combined dynamic effect of both mechanical friction and chemical interaction by formulating small white ginger extract into a dynamic brushing paste. This study addresses this gap by comprehensively analyzing the simultaneous effects of simulated brushing with this novel herbal paste on three critical mechanical vulnerabilities: surface hardness, flexural strength, and impact strength.[9,15]

The mechanical properties most susceptible to alteration due to polymer degradation are surface hardness, impact strength, and flexural strength. Flexural strength and surface hardness reflect the denture base's capacity to withstand excessive masticatory forces and to prevent wear or scratching from external abrasion.[10,12] Meanwhile, impact strength measured using the Izod method is crucial for assessing the base's resistance to sudden fracture if accidentally dropped outside the oral cavity during cleaning. A decline in these three mechanical values shortens the prosthesis's lifespan and increases surface roughness, inadvertently facilitating the recolonization of microorganisms. This risk is further heightened by the continuous application of the formulated brushing paste on heat-cured acrylic resins.[17,18] Based on this background, this study was conducted to analyze the effect of brushing with small white ginger extract paste on the surface hardness, impact strength, and flexural strength of heat-cured acrylic resin plates.

MATERIALS AND METHODS

This research is a true experimental study employing a pre-test and post-test with a control group design for the surface hardness test, and a post-test only with a control group design for the impact and flexural strength tests. The protocol of this study was approved by the Health Research Ethics Committee of the Faculty of Dentistry, Universitas Lambung Mangkurat, as evidenced by three Ethical Clearance certificates (No. 120-123/KEPKG-FKGULM/EC/XI/2023).

A total sample of 63 heat-cured acrylic resin plates (Yamahachi BASIS Heat Cured) was used, shaped into rectangular blocks with dimensions of (65 x 10 x 2,5) ± 0,03 mm in accordance with the American Dental Association (ADA) Specification No. 12 (1975). Sample selection was performed using simple random sampling. The total number of samples was distributed among three testing parameters: 12 samples for the surface hardness test, 27 for the impact strength test, and 24 for the flexural strength test. For each mechanical test, the samples were divided equally into three electric brushing intervention groups: Group 1 (intervention group) brushed with 50% small white ginger extract paste; Group 2 (positive control group) brushed with a placebo paste; and Group 3 (negative control group) brushed with distilled water.

The primary equipment utilized in this study included metal flasks, a hydraulic bench press, a hand press, an aluminum pot, a stove, a straight handpiece, a micromotor, a fraser bur, a stone bur, a felt cone bur, a cotton wheel bur, a caliper, a digital scale, a maceration apparatus, a rotary evaporator, a water bath, a mortar and pestle, an electric toothbrush conforming to ISO/DTS 14569-2 specifications (Formula Soft Platinum Protector Nano Charcoal; bristle diameter of 0.01 mm), a Vickers Hardness Tester, an Izod Impact Tester, and a Universal Testing Machine (UTM).

The materials used consisted of small white ginger rhizomes (*Zingiber officinale* var. *amarum*), heat-cured acrylic resin powder and liquid, type III dental stone, Cold Mold Seal (CMS), vaseline, distilled water, 70% ethanol, cellophane plastic, sandpaper (grit numbers 800, 1000, and 1200), pumice powder, chalk (kryt), and placebo paste raw materials (anise oil, menthol crystals, peppermint oil, magnesium carbonate, calcium carbonate, glycerin, polyethylene glycol, triethanolamine, and *oleum citri*).

The initial phase of the study began with the plant determination test of the small white ginger rhizomes (*Zingiber officinale* var. *amarum*) at the Basic Laboratory of the Faculty of Mathematics and Natural Sciences, Universitas Lambung Mangkurat, Banjarbaru, South Kalimantan. This test aimed to confirm the plant's taxonomy and prevent misidentification.

Sample fabrication was performed at the Dentier Laboratory in Banjarmasin. The mold space was fabricated using three master models made of metal plates measuring (65,5 x10,5 x 3) mm. This size was 0.5 mm oversized relative to the ADA specification to compensate for dimensional reduction after polishing. Vaseline was applied to all internal surfaces of the flask as a separator. Type III dental stone was mixed at the water-to-powder (W/P) ratio according to the manufacturer's instructions, utilizing a vibrator to prevent air entrapment, and then poured into the lower flask. The master models were invested up to half their thickness and allowed to set for 15–20 minutes. After applying Vaseline to the surface of the lower dental stone, the upper flask was positioned, filled with the type III dental stone mixture, and then tightly closed using a hand press for 60 minutes. The flask was subsequently opened to remove the master models, and the residual Vaseline was cleaned using hot water.[15]

The gypsum surface of the mold space was coated with a cold mold seal (CMS) and allowed to dry. The acrylic resin polymer and monomer were mixed in a mixing jar (Stellon pot) according to the manufacturer's recommended ratio until the dough stage was reached. The dough was then packed into the mold space, covered with a cellophane sheet, and subjected to an initial pressing using a hydraulic press at 1000 psi (70 kg/cm^2). The flask was opened to remove excess resin using a modeling knife, after which the cellophane sheet was removed. The flask was then reassembled and subjected to a final pressing at 2200 psi (154 kg/cm^2) before being transferred to a hand press.[15]

The flask, secured in the hand press, was immersed in boiling water (100 °C) and cured for the manufacturer-specified duration. After the polymerization was complete, the heat source was turned off, and the flask was allowed to cool in water until the temperature reached 37 °C. The acrylic specimens were then deflasked, and their sharp edges were smoothed using a tungsten carbide (fraser) bur and a stone bur. The specimen surfaces were sequentially ground using 800, 1000, and 1200 grit sandpaper under running water on a rotary grinding machine. Final polishing was performed using a mixture of pumice and water with a felt-cone bur, followed by high-shine polishing with a polishing compound (Kryt) and a cotton-wheel bur. The final dimensions of the specimens were verified to comply with the ADA Specification No. 12 using a caliper.[15]

The preparation of the extract-and-paste formulation was conducted in the Pharmacy Laboratory, Faculty of Pharmacy, Sari Mulia University, Banjarmasin. The ginger extract was prepared using the maceration method. Small white ginger rhizomes were washed under running water, thinly sliced, and air-dried away from direct sunlight to obtain the simplicia. The simplicia was ground into a fine powder, and a 200 g aliquot was weighed and transferred into a maceration vessel. A 70% ethanol solution was added at a powder-to-solvent ratio of 1:5 (w/v) until the solution reached a height of 1 cm above the powder surface. The mixture was periodically stirred, and the filtrate was filtered and replaced with fresh solvent every 24 hours until the supernatant became clear. All collected filtrates were pooled and evaporated using a rotary evaporator under reduced pressure at 40 °C over a water bath until a thick extract of constant weight was obtained.[14]

The placebo paste formulation was prepared step by step using a mortar and pestle. Mixture I consisted of 0.6 mL anise oil, 0.05 g menthol crystals, and 0.5 mL peppermint oil. Mixture II comprised 6.5 g of magnesium carbonate and 7.5 g of calcium carbonate. Mixture III contained 1.5 mL of glycerin, 10 mL of warm water, 2 g of polyethylene glycol, 0.75 mL of triethanolamine, and 0.5 mL of oleum citri. These three mixtures were subsequently combined and triturated until a smooth, homogeneous white paste was formed. The paste was then stored in a tightly closed container. To prepare the 50% small white ginger extract paste at a 1:1 ratio, 15 g each of the thick small white ginger extract and the placebo paste were weighed, mixed, and triturated in a mortar until homogeneous.[20]

The electric brushing simulation was performed using a brush stroke method compliant with ISO/DTS 14569-2 specifications. The acrylic resin sample was mounted on the sample holder, and a soft-bristled electric toothbrush was attached to the apparatus. For the toothpaste groups (P and K+), 3 mg of the formulation was applied evenly to the sample surface. The device was activated for 1 minute, then stopped automatically. The procedure of applying a new 3 mg dose of paste is repeated every minute. For the distilled water group (K-), distilled water is applied to the sample surface with a syringe at 1-minute intervals. The total brushing duration for all groups is 22 minutes without interruption. According to the literature, a cumulative brushing time of 22 minutes is equivalent to a 1-year clinical simulation of brushing a denture base. Upon completion, the samples were rinsed with clean water and dried.[7]

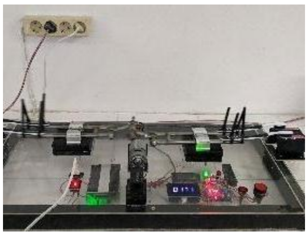

Figure 1. Brushing of an acrylic resin sample (Source: Personal Documentation)

Hardness measurements were taken before and after the brushing treatment using a Vickers Hardness Tester. The sample was placed horizontally on the stage, and the lens was adjusted to achieve optimal focus. Indentation was performed on a surface area away from the edge of the sample using a diamond pyramid indenter with a load (L) of 25 gf for a dwell time of 30 seconds. The diagonal length of the indentation (d) was measured, and the Vickers hardness value (HV) was calculated based on the standard formula:[23-25]

$HV = \frac{1{,}8544 \, x \, L}{d^2}$

Description:

HV = Hardness Vickers (Vickers hardness value) (kg/mm^2)

L = load used (kg)

d = diagonal length (mm) = $\frac{D1+D2}{2}$

1,8544 = 2 sin a/2

a = the angle formed by the tip of the tester (136^0)

Figure 2. Surface hardness testing on samples using a Vickers Hardness Tester (Source: Personal Documentation)

The impact strength testing was conducted at the Engineering Materials Laboratory, Department of Mechanical and Industrial Engineering, Faculty of Engineering, Universitas Gadjah Mada (UGM), Yogyakarta. The test was performed at room temperature using an Izod impact tester. The specimen was positioned vertically and securely clamped at one end. The pendulum was locked in its initial position and subsequently released to strike the free end of the specimen until fracture occurred. The energy absorbed during fracture was recorded, and the impact strength (J/mm2) was calculated using the following equation:[26]

$HI = \frac{EI}{A}$

Description:

E : Impact Energy (J)

A : Area (mm2)

Figure 3. Impact strength testing of samples using an impact tester with the Izod method (Source: Personal Documentation)

The flexural strength measurement was performed at the Engineering Materials Laboratory, Department of Mechanical and Industrial Engineering, Faculty of Engineering, Universitas Gadjah Mada (UGM), Yogyakarta, using a Universal Testing Machine (UTM). Each specimen was placed horizontally on two support spans separated by a specific distance (L). A vertical load (P) was continuously applied precisely at the midpoint of the specimen's upper surface at a constant rate until fracture occurred. The maximum load at fracture was recorded, and the flexural strength (S) was calculated using the following equation:[24]

$S = \frac{3PL}{2bd^2}$

Description :

S: Flexural strength (MPa = kg / mm2)

P: Fracture or load (N) or (kgf)

L: Length/width distance of the specimen (cm)

b: Specimen width (cm)

d: Thickness of the tested plate (cm)

Figure 4. Sample testing using the Universal Testing Machine 3-Point Bending technique. (Source: Personal Documentation)

RESULTS AND DISCUSSIONS

The results of the evaluation of the effect of brushing with small white ginger extract paste are presented sequentially according to surface hardness, impact strength, and flexural strength.

Table 1. Surface hardness (VHN) values before and after brushing the resin acrylic plate

Treatment Group	Mean Pre-Test (VHN)	Mean Post-Test (VHN)	Decrease Difference (VHN)	Significance Value (p)
Small White Ginger Extract Paste	13.9	12.9	1.0	0.007*
Placebo Paste	13.8	13.2	0.6	0.014*
Aquades	14.8	13.6	1.2	0.004*

*Significant at $p < 0.05$ based on the Paired T-Test

Based on the data in Table 1, the Paired T-Test showed a statistically significant decrease in surface hardness across all treatment groups after brushing ($p<0.05$). Furthermore, to compare the magnitude of the decrease in hardness between groups, a One-Way ANOVA was conducted on the differences in hardness decrease values across all samples. The analysis results showed a p-value of $0.024 < 0.05$, indicating a significant difference in the decrease in hardness in at least one group. Next, a Bonferroni post hoc test was conducted to identify the specific groups that differed. The results of the Bonferroni post hoc test are shown in Table 2.

Table 2. Results of the Bonferroni Post Hoc Comparison Test for the Decrease in Surface Hardness Values

Treatment Group	Small White Ginger Extract Paste	Placebo Paste	Aquades
Small White Ginger Extract Paste	-	0.167	0.825
Placebo Paste	-	-	0.025*
Aquades	-	-	-

*Significant at $p < 0.05$ based on the Bonferroni Post Hoc test.

The results of the Bonferroni Post Hoc test (Table 2) showed that there was no significant difference in the decrease in the hardness value of the acrylic plate in the small white ginger extract paste group when compared with the placebo paste group ($p = 0.825>0.05$) or with the aquadest group ($p = 0.167>0.05$).

The next evaluation assessed the impact strength of the acrylic resin plates after 22 minutes of brushing. The average value and standard deviation of the impact strength test results for the samples are presented in Table 3 below.

Table 3. Average Impact Strength Values of Acrylic Resin Plates After Brushing

Treatment Group	Number of Samples(N)	Mean Impact Strength ($\times 10^{-3}$ J/mm^2) ± SD
Small White Ginger Extract Paste	9	55 ± 4.13
Placebo Paste	9	50 ± 3.57
Aquades	9	42 ± 4.87

Based on Table 3, the acrylic resin group brushed with small white ginger extract paste had the highest impact strength, followed by the placebo paste group, and the lowest in the aqueous control. The results of the Shapiro-Wilk normality test indicated that the data were not normally distributed in one of the groups, so hypothesis testing was conducted using the nonparametric Kruskal-Wallis test. The significance value obtained from the Kruskal-Wallis test was $p = 0.000$ ($p < 0.05$), which means there was a statistically significant difference in impact strength values in at least one treatment group. Groups that had significant differences in values can be identified by continuing with the Mann-Whitney Post Hoc test (Table 4).

Table 4. Results of the Mann-Whitney Post Hoc comparison test of impact strength values

Treatment Group	Small White Ginger Extract Paste	Placebo Paste	Aquades
Small White Ginger Extract Paste	-	0.029*	0.000*
Placebo Paste	-	-	0.001*
Aquades	-	-	-

*The mean difference is statistically significant at the p < 0.05 level.

The results of the Mann-Whitney Post Hoc test in Table 4 show that all treatment groups had significant differences in impact strength values ($p < 0.05$).

The final mechanical property examined in this study was the flexural strength of acrylic resin after brushing, which was measured using the 3-point bending loading method. Quantitative data on the average flexural strength are presented in Table 5 below.

Table 5. Average flexural strength value of acrylic resin plates after treatment

Treatment Group	Number of Samples(N)	Mean Flexural Strength (MPa) ± SD
Small White Ginger Extract Paste	8	96.96 ± 17.42
Placebo Paste	8	97.97 ± 18.44
Aquades	8	96.22 ± 9.88

The average flexural strength of the acrylic resin plates after brushing ranged from 96.22 MPa to 97.97 MPa for the three groups. Hypothesis testing was conducted parametrically using the One-Way ANOVA test, which yielded a p-value > 0.05. These results indicate that there was no statistically significant difference in flexural strength between the three treatment groups after brushing.

Denture cleaning using the brushing method is generally chosen by patients because of its practicality. According to Mylonas et al. (2022), the choice of cleaning paste for brushing dentures must be appropriate.[6] The choice of denture cleaning paste will harm acrylic dentures due to the low hardness value of PMMA polymers compared to natural tooth tissue.[10] Innovation in paste preparations using the active ingredient, small white ginger extract (*Zingiber officinale var. amarum*), is intended as a safe alternative cleaner for dentures. Saputera et al.[14] reported that small white ginger extract inhibits oral microorganisms through active phenolic compounds, including gingerol, shogaol, and zingerone.[14-16] A comprehensive evaluation of the mechanical and chemical effects of this substance begins with the hardness properties of the denture base surface.

Based on the research data, all treatment groups experienced a significant decrease in hardness values after brushing ($p < 0.05$). Physically, after brushing, micro-scratches were formed due to the mechanical friction of the toothbrush bristles, in accordance with ISO/DTS 14569-2 specifications. In small white ginger paste, the decrease in hardness values was triggered by physical contact as well as chemical interactions of weak acid phenol compounds. Muchtar et al.[19] explained that weak-acid components in herbal plants can react with acrylic resin, thereby degrading superficial polymer bonds.[19] The results of the Bonferroni Post Hoc test showed that the magnitude of the decrease in hardness values in the small white ginger extract paste group did not have a significant difference with the Aquadest control (p 0.825 > 0.05). This indicates that the decrease in hardness values in the small white ginger extract, attributed to phenolic compounds, remains within acceptable limits and is considered safe, as it does not exceed that of Aquadest, the negative control.

Brushing with a small white ginger extract paste resulted in the highest impact strength (55 × 10^{-3} J/mm2), which differed significantly from the placebo and Aquadest ($p < 0.05$). The scientific explanation for this phenomenon lies in the molecular structure of the phenolic components of small white ginger. Phenolic compounds have a benzene ring bonded with a polar hydroxyl group, OH^-, which tends to release H^+ ions in an acidic atmosphere. During brushing, H^+ ions bind to the ester group CH_3O^- of the PMMA acrylic resin chain.[17,18] In line with the study of Savitri et al.[18] regarding exposure to organic chemicals on dental polymers, this ion exchange reaction disrupts the stability of polymer cross-links, which results in reduced rigidity of the acrylic resin matrix.[18] This decrease in rigidity linearly increases the flexibility and elasticity of the acrylic molecular chain. This more elastic material property is advantageous in impact tests because the plate can efficiently dampen and absorb impact energy before reaching the fracture threshold. On the other hand, the lowest impact strength in Aquadest is due to pure water penetrating the acrylic microporosity, triggering molecular hydrolysis without the damping effect of the paste preparation, thereby accelerating the propagation of internal cracks under sudden loads.

Despite the chemical interaction of the phenolic compounds in small white ginger, which decreased the hardness value and increased the flexibility of the polymer chain (thereby increasing impact strength), the flexural strength parameters showed that the main integrity of the denture base in resisting functional chewing loads was perfectly maintained. The results of the One-Way ANOVA test confirmed that there was no significant difference in flexural strength among the test groups ($p > 0.05$), with values consistently above 96 MPa. This finding strongly confirms that the interaction of the phenolic compounds in small white ginger paste occurs only locally in the superficial region of the acrylic plate and does not affect the deepest structural region of the polymer. The 22-minute brushing simulation did not provide sufficient time for the phenol molecules to diffuse into the core of the PMMA matrix. This result differs from the static immersion study by Islami,[15] in which long-term immersion of acrylic plates in small white ginger extract reduces flexural strength due to total penetrative diffusion, thereby damaging the main polymer bonds and triggering macrostructural expansion.[15] Thus, the dental cleaning preparation in the form of small white ginger paste is much safer than the immersion preparation because it is applied dynamically for a short duration, so that the polymer core bond in the center of the acrylic plate is not disturbed, and the mechanical capacity of the prosthesis for chewing remains clinically safe.

CONCLUSION

Brushing with a paste containing white ginger extract (*Zingiber officinale var. amarum*) did not significantly reduce the surface hardness and flexural strength of heat-cured acrylic resin plates compared to the placebo paste and distilled water groups. However, there were significant differences in the impact strength values among all treatment groups. The impact strength values of the acrylic resin plates after brushing with a paste containing white ginger extract were the highest, followed by the placebo paste group, and the lowest value was in the distilled water group. All impact strength values of the three treatment groups were declared safe and clinically acceptable because they were still above the standard mechanical strength limits required for denture bases. Future studies are required to evaluate the biocompatibility and cytotoxicity of the white ginger extract formulation on oral mucosal cells, ensuring its safety for clinical applications before full commercial development.

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REFERENCES

1. Annete J, Widaningsih, Prabowo PB. The difference in impact strength in acrylic resin self-cured with the addition of zirconium dioxide (ZrO2) nanoparticles. Denta J Kedokt Gigi. 2018;12(1):51-59. DOI: 10.30649/denta.v12i1.167
2. Anggraini TD, Adiran N. Pengaruh ekstrak biji Persea americana terhadap kekasaran gigi tiruan resin akrilik heat-cured (Laporan penelitian). J Kedokt Gigi Terpadu. 2022;4(2):150-152. DOI: 10.25105/jkgt.v4i2.15675
3. Kementerian Kesehatan Republik Indonesia. Laporan Nasional Riskesdas 2018. Jakarta: Badan Penelitian dan Pengembangan Kesehatan; 2018. p. 674.
4. Alvianita R, Utama MD, Jubhari EH. Utilization of herbal as a denture cleanser in inhibiting the growth of Candida albicans and Streptococcus mutans: A literature review. Makassar Dent J. 2021;10(2):194-200. DOI: 10.35856/mdj.v10i2.435
5. Abuhajar E, Ali K, Zulfiqar G, Al Ansari K, Raja HZ, Bishti S, et al. Management of chronic atrophic candidiasis (denture stomatitis)-A narrative review. Int J Environ Res Public Health. 2023;20(4):1-15. DOI: 10.3390/ijerph20043029
6. Costa RTF, Pellizzer EP, Vasconcelos BCE, Gomes JML, Lemos CAA, de Moraes SLD. Surface roughness of acrylic resins used for denture base after chemical disinfection: A systematic review and meta-analysis. Gerodontology. 2021;38(3):1-10. DOI: 10.1111/ger.12529
7. Noviyanti AM, Parnaadji R, Soesetijo FA. Efektivitas penggunaan pasta biji kopi robusta sebagai pembersih gigi tiruan terhadap kekasaran permukaan resin akrilik heat-cured. Pustaka Kesehatan. 2018;6(2):339. DOI: 10.19184/pk.v6i2.8653
8. Nugraha PW, Arifin R, Wardhana AS. Pengaruh pasta kelakai (Stenochlaena palustris) dengan konsentrasi 30% terhadap kekasaran permukaan acrylic heat-cured. Dentin. 2022;6(2):65-70. DOI: 10.20527/dentin.v6i2.6388
9. Mylonas P, Milward P, McAndrew R. Denture cleanliness and hygiene: An overview. Br Dent J. 2022;233(1):20-26. DOI: 10.1038/s41415-022-4411-6
10. McCabe JF, Walls AW. Applied Dental Materials. 9th ed. Blackwell Publishing; 2008.
11. Sari V, Ningsih D, Soraya N. Pengaruh konsentrasi ekstrak kayu manis (Cinnamomum burmannii) terhadap kekasaran permukaan resin akrilik heat cured. J Syiah Kuala Dent Soc. 2016;1(2):130-136.
12. Sundari I, Sofya PA, Hanifa M. Studi kekuatan fleksural antara resin akrilik heat cured dan termoplastik nilon setelah direndam dalam minuman kopi uleekareng (Coffea robusta). J Syiah Kuala Dent Soc. 2016;3(1):51-58.
13. Hadyprana S, Noer S, Supriyatin T. Uji daya hambat ekstrak jahe putih terhadap pertumbuhan Pseudomonas aeruginosa dan Candida albicans secara in vitro. EduBiologia Biol Sci Educ J. 2021;1(2):142. DOI: 10.30998/edubiologia.v1i2.10142
14. Saputera D, Nalar GA, Budiarti LY. Minimum inhibitory concentration of white ginger and chlorhexidine gluconate on acrylic plates toward Candida albicans. Dentino J Kedokt Gigi. 2017;2(1):6. DOI: 10.20527/dentino.v2i1.2591
15. Islami N, Saputera D, Arifin R. The soaking effect of 100% small white ginger extract on the value of the flexural strength of acrylic base (flexural strength value of acrylic base using acrylic resin heat cured type). Dentino J Kedokt Gigi. 2020;5(1):10. DOI: 10.20527/dentino.v5i1.8114
16. Santoso HD, Budiarti LY, Carabelly AN. Perbandingan aktivitas antijamur ekstrak etanol jahe putih kecil (Zingiber officinale var. amarum) 30% dengan chlorhexidine glukosa 0,2% terhadap Candida albicans in vitro. Dentino J Kedokt Gigi. 2014;2(2):125.
17. Hasran MAR, Imam DNA, Sunendar B. Addition of rice husk nanocellulose to the impact strength of resin-based heat-cured. J Voc Health Stud. 2021;4(3):119. DOI: 10.20473/jvhs.V4.I3.2021.119-123
18. Savitri RPA, Naini A, Parnaadji R, Kristiana D. Pengaruh lama perendaman resin akrilik heat-cured pada ekstrak daun tembakau (Nicotiana tabacum) 50% terhadap perubahan warna. Padjadjaran J Dent Res Stud. 2022;6(3):290. DOI: 10.24198/pjdrs.v6i3.38816
19. Dwimartha AJ, Saputera D, Wijayanti TF. Efek ekstrak jahe putih kecil 70% terhadap nilai kekerasan basis resin akrilik. Dentin J Kedokt Gigi. 2018;2(1):40-44. DOI: 10.20527/dentin.v2i1.407

20. Kristiana D, Novitasari FH, Naini A. Efek penggunaan pasta daun tembakau sebagai pembersih gigi tiruan terhadap kekuatan impak nilon termoplastik: Studi eksperimental laboratoris. Jurnal Kedokteran Gigi Universitas Padjadjaran. 2023;35(2):159. DOI: 10.24198/jkg.v35i2.47528
21. Muchtar AE, Widaningsih, Apsari A. Pengaruh perendaman resin akrilik heat cured dalam ekstrak Sargassum ilicifolium sebagai bahan pembersih gigi tiruan terhadap kekerasan permukaan. Denta. 2018;12(1):1-8. DOI: 10.30649/denta.v12i1.165
22. Setyorini D, Praharani D, Kurniawati HE. Pengaruh ekstrak daun teh (Camellia sinensis L.) terhadap jumlah koloni Streptococcus sp. pada permukaan gigi. Stomatognatic J Kedokt Gigi UNEJ. 2011;8(1):44-50.
23. Puspitasari D, Saputera D, Anisyah RN. Perbandingan kekerasan resin akrilik tipe heat cured pada perendaman larutan disinfektan alkalin peroksida dengan ekstrak seledri (Apium graveolens L.) 75%. ODONTO Dent J. 2016;3(1):34-41. DOI: 10.30659/odj.3.1.34-41
24. Rudi S. Kekuatan permukaan basis gigi tiruan resin akrilik heat cured pada perendaman teh hitam (Camellia sinensis) dengan kandungan fenol yang berbeda. Bhakta Dental Journal. 2023;1(1):19-24.
25. Praveen B, Babaji HV, Prasanna BG, Rajalbandi SK, Shreeharsha TV, Prashant GM. Comparison of impact strength and fracture morphology of different heat-cure denture acrylic resins: An in vitro study. Journal of International Oral Health-JIOH. 2014;6(5):12-16.
26. Nuhgraha Y, Rosa MKA, Agustian I. Perancangan alat uji impak digital dengan metode Charpy untuk mengukur kekuatan material polimer. Jurnal Amplifier: Jurnal Ilmiah Bidang Teknik Elektro dan Komputer. 2020;10(2):15-19. DOI: 10.33369/jamplifier.v10i2.15333