



Potential of Coconut Shell Liquid Smoke as Acrylic Resin Removable Dentures Cleaner

(Study of Surface Roughness, Hardness of Acrylic Resin Plate, and Organoleptic Properties)

Sekar Diah Kumalasari¹, Windriyatna^{2,3}, Tyas Prihatiningsih^{2*}

¹ Graduate Dentistry Study Program, Faculty of Medicine, Diponegoro University, Indonesia

² Dentistry Study Program, Faculty of Medicine, Diponegoro University, Indonesia

³ Dr. Kariadi hospital, Semarang, Indonesia

Abstract: *The phenolic, acetic acid, and carbonyl components of coconut shell liquid smoke show promise as cleaning agents. However, they may negatively affect the surface roughness and hardness. The distinct color and odor of coconut shell liquid smoke may affect consumer acceptance of the product. This study aimed to evaluate the efficacy of coconut shell liquid smoke as a cleaning agent for acrylic resin removable dentures. In this study, 36 heat-cured acrylic resin cylinder samples were used. Each sample had a diameter of 30±1 mm and a height of 5±1 mm. The samples were divided into two groups: a control group immersed in 0.5% sodium hypochlorite solution and a treatment group immersed in a solution of 20% coconut shell liquid smoke and 0.5% peppermint oil. The immersion period was 92 hours. A hedonic test was administered to evaluate the color and odor of the solution. Results showed there was no statistically significant difference in surface roughness ($p=0.88$), whereas a statistically significant difference was observed in surface hardness ($p=0.00$). Additionally, a significant difference was found in consumer acceptance of the organoleptic properties ($p=0.001$). Coconut shell liquid smoke has potential as a cleaning agent for removable dentures made from acrylic resin.*

Keywords - coconut shell liquid smoke, denture cleaner, surface roughness and hardness, organoleptic properties

I. INTRODUCTION

Acrylic resin materials offer the advantage of translucency and a color that closely resembles gingiva. However, they also present disadvantages, including high porosity, water absorption, shrinkage, and the

presence of residual monomer.[1-2] The use of acrylic resin removable dentures necessitates maintenance through routine cleaning with specialized denture cleaning agents.

Currently, a variety of synthetic products are available for use as denture cleaners; however, their applicability is restricted to certain denture materials. For example, sodium hypochlorite solution, recognized for its antimicrobial properties, is not advised for cleaning dentures made of metal materials.[3] This is because prolonged use of sodium hypochlorite can negatively impact the physical and mechanical properties of acrylic resin dentures, resulting in issues such as discoloration, increased surface roughness, and diminished surface hardness.[4]

Coconut shell liquid smoke, derived from the combustion and purification of coconut shell waste, presents a promising alternative for mitigating the side effects and broadening the application of denture cleaning agents.[5] The presence of phenol, acetic acid, and carbonyl compounds in coconut shell liquid smoke has been demonstrated to exhibit antibacterial, antioxidant, analgesic, and anti-inflammatory properties.[6-7] Hutama et al. indicated that a 6% concentration of liquid smoke effectively inhibits the growth of *Candida albicans* on acrylic resin plates.[8] Furthermore, other studies have shown that liquid smoke at a concentration of 6.25% effectively inhibits the growth of *Streptococcus mutans*, *Streptococcus sanguis*, and *Porphyromonas gingivalis* [9-10]; at 50%, it inhibits *Staphylococcus epidermidis* [12]; and at 25%, it inhibits *Staphylococcus aureus*. [13] However, the phenol and acetic acid content in coconut shell liquid smoke is suspected to adversely affect the physical and mechanical properties of acrylic resin plates, such as increasing surface roughness and decreasing surface hardness. Studies by Noviyanti et al. and Dwimarta et al. have demonstrated an increase in surface roughness with the use of Robusta coffee bean paste and a decrease in surface hardness with the use of 70% small white ginger extract on acrylic resin plates, attributed to the phenolic compounds present in these materials.[14-15]

Liquid smoke derived from coconut shells is characterized by a pungent odor, necessitating the incorporation of fragrance agents such as peppermint oil. Peppermint oil is distinguished by its minty, sweet, cool, and fresh aroma, which effectively masks or diminishes the strong odor of coconut shell liquid smoke.[16]

Therefore, the efficacy of coconut shell liquid smoke and peppermint oil as acrylic denture cleaning agents on the surface roughness, hardness, and organoleptic properties of acrylic resin dentures was assessed in this study.

II. METHOD

This study was approved by the Health Research Ethics Commission (KEPK) of the Faculty of Medicine at Diponegoro University (reference number: 432/EC/KEPK/FK-UNDIP/XII/2022).

A 20% coconut shell liquid smoke solution, a 0.5% peppermint oil solution, and a 0.5% sodium hypochlorite solution were prepared in the Biochemistry Laboratory at the Faculty of Medicine, Diponegoro University. A solution comprising 20% coconut shell liquid smoke and 0.5% peppermint oil is prepared by combining 150 ml of each diluted component in a sterile container, resulting in a total volume of 300 ml.

The fabrication of acrylic cylinder plates commenced with the creation of a model using red wax. The model was then subjected to flasking and subsequent dewaxing. Subsequently, heat-cured acrylic was introduced into the flask, and polymerization was initiated by boiling in water. The resulting acrylic cylinder was meticulously polished to achieve a smooth and glossy surface. A total of 36 cylindrical samples of heat-cured acrylic resin plates were fabricated, each with a diameter of 30 ± 1 mm and a height of 5 ± 1 mm, characterized by a smooth, shiny, and flat surface. The samples were randomly selected using a simple random sampling method and subsequently divided into control and treatment groups. The samples were immersed for 92 h, and the solution was replaced every 24 h. Following immersion, the plates were dried with tissue paper, and their surface roughness was measured using a Mitutoyo SJ-210 Surface Roughness Tester at the Industrial Metrology Laboratory, Faculty of Mechanical Engineering, Diponegoro University.

Surface roughness measurements were performed on one side of each heat-cured acrylic resin plate, with each measurement conducted three times to determine the average value for each plate. Subsequently, the samples underwent surface hardness evaluation using the Vickers Hardness Tester HMV-2000 Shimadzu at the

Materials Laboratory, Faculty of Mechanical Engineering, Diponegoro University. This procedure involved applying a 100-gram force to the center of each plate for 30 s.

The organoleptic properties of 20% coconut shell liquid smoke and 0.5% peppermint oil solution were analyzed through a hedonic (liking) test at the Dentistry Study Program, Faculty of Medicine, Diponegoro University, which involved respondents the pre-clinical dentistry students. Twenty students were in good health and did not experience hearing or smell problems. Students were asked to observe the color and smell of the solutions in the control and treatment groups and then directed to fill out a questionnaire that described their preference for the two solutions.

To compare the mean surface roughness and hardness within the study groups, unpaired t test was applied. To compare colour and smell between the study groups, Mann-Whitney U test was applied.

III. RESULT

3.1 The results of the surface roughness test of heat cured acrylic resin plate

Surface roughness. Table 1 shows minimal, maximal and mean value of the surface roughness after 92 h of immersion. The average surface roughness values of the heat-cured acrylic resin plates in each sample group are presented in Fig. 3.

Based on these measurements, immersion of heat-cured acrylic resin plate in a 20% concentration coconut shell liquid smoke and 0.5% concentration of peppermint oil solution had a higher average surface roughness value (0.80 μ m) than immersion in a 0.5% concentration of sodium hypochlorite solution (0.78 μ m).

The results of the hypothesis test using the independent T test showed $p = 0,880$ ($p > 0.05$), which means there was no significant difference in the average surface roughness of the heat-cured acrylic resin plates between the group immersed in 20% coconut shell liquid smoke and 0,5% peppermint oil and the group immersed in 0.5% sodium hypochlorite.

3.2 The results of the surface hardness test of heat cured acrylic resin plate

Surface hardness. Table 2 shows minimal, maximal and mean value of the surface hardness after 92 h of immersion. The average surface roughness values of the heat-cured acrylic resin plates in each sample group are presented in Fig. 4.

Based on these measurements, immersion of heat-cured acrylic resin plate in a 0.5% concentration of sodium hypochlorite solution had a higher average surface hardness value (42,41 VHN) than immersion in a 20% concentration of coconut shell liquid smoke and 0.5% concentration of peppermint oil solution (34,21 VHN). The results of the hypothesis test using the independent T test showed $p = 0,000$ ($p < 0.05$), which means there as a significant difference in the average surface hardness value of the heat-cured acrylic resin plate in the group immersed in 20% coconut shell liquid smoke and 0,5% peppermint oil solution and the group immersed in 0.5% sodium hypochlorite solution.

3.3 The hedonic test results of the organoleptic properties of 20% coconut shell liquid smoke and 0.5% peppermint oil solution

Based on the results of the validity and reliability tests, the research questionnaire was declared valid and reliable to serve as a research instrument so that it could be used as a hedonic test questionnaire for the organoleptic properties of 20% coconut shell liquid smoke and 0.5% peppermint oil solution. The results of the hedonic test on the respondents are shown in Fig. 5 and the average values of the hedonic test results for each sample group are shown in Table 3.

The hedonic test for color and smell of the two sample solutions was tested on 20 students, and it was found that a 20% concentration of coconut shell liquid smoke and 0.5% concentration of peppermint oil solution had the highest consumer acceptance results, totaling seven students who rated it as rather dislike and 0,5% concentration of sodium hypochlorite solution had the highest consumer acceptance, totaling 16 students who rated it as normal. The hedonic test results for the organoleptic properties of a 0.5% sodium hypochlorite

solution had a higher average hedonic value than a 20% concentration of coconut shell liquid smoke and a 0.5% concentration of peppermint oil solution.

The results of hypothesis testing using the Mann-Whitney U test showed $p=0,001$ ($p < 0.05$), which means that there is a significant difference in consumer acceptance of the organoleptic properties of a 20% concentration of coconut shell liquid smoke and 0.5% concentration of peppermint oil solution as an acrylic resin removable denture cleaner.



Figure 1. Surface roughness measurement of heat cured acrylic resin plate.



Figure 2. Surface hardness measurement of heat cured acrylic resin plate

Table 1 Average, standard deviation, minimum, and maximum surface roughness of heat cured acrylic resin plate

Sample Group	Average \pm SD (μm)	Min-Max
20% of liquid smoke + 0,5% of peppermint oil	0,80 \pm 0,37	0,350-1,848
0,5% of sodium hypochlorite	0,78 \pm 0,40	0,419-1,915

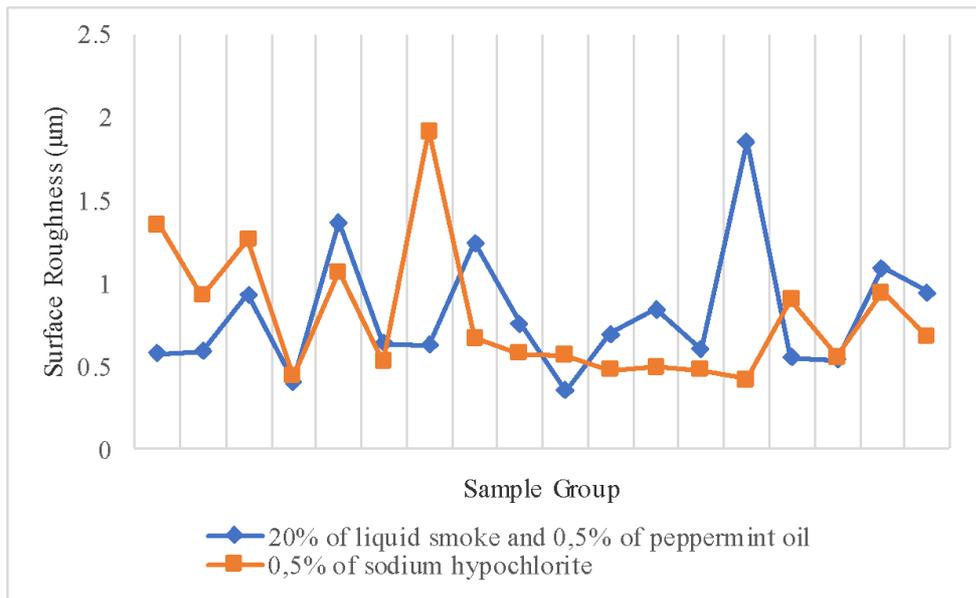


Figure 3. The surface roughness of heat cured acrylic resin plate

Table 2 Average, standard deviation, minimum, and maximum surface hardness of heat cured acrylic resin plate

Sample Group	Average ± SD (VHN)	Min-Max
20% of liquid smoke + 0,5% of peppermint oil	34,21 ± 1,65	30,50-36,40
0,5% of sodium hypochlorite	42,41 ± 1,63	39,30-45,90

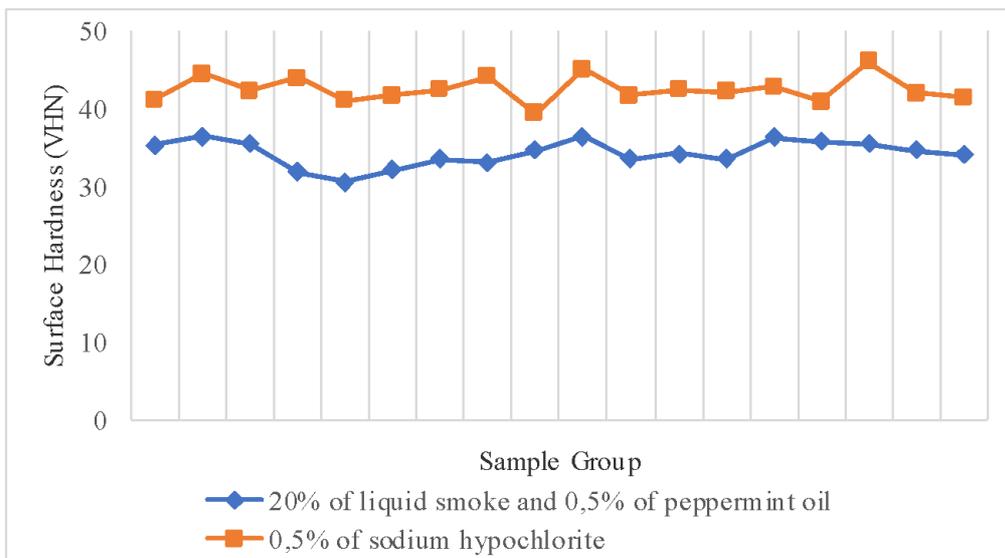


Figure 4. The surface hardness of heat cured acrylic resin plate

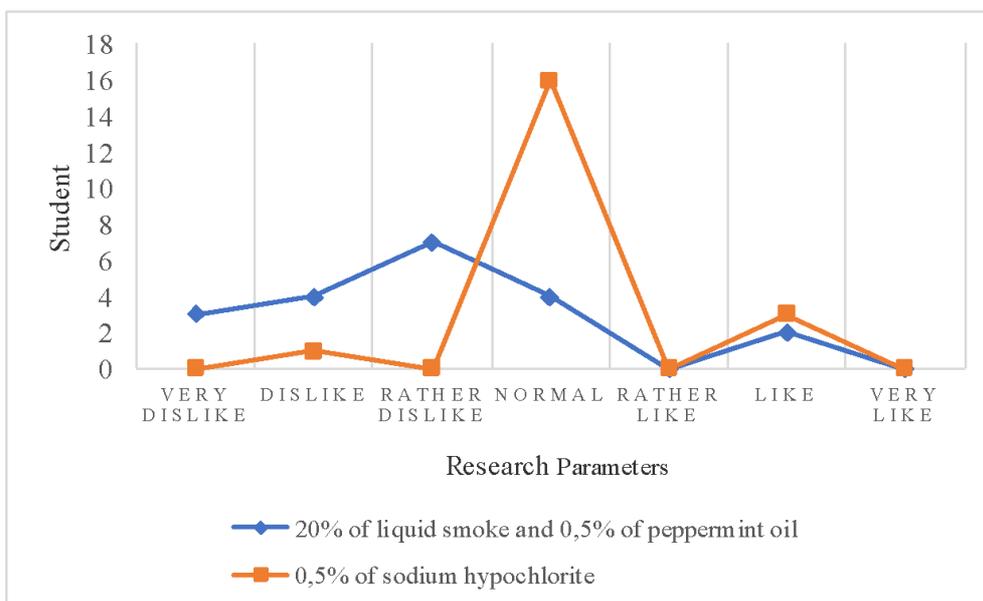


Figure 5. The results of the hedonic test for the color and smell of the two solutions

Table 3 Average, standard deviation, minimum, and maximum consumer acceptance of organoleptic properties

Sample Group	Average ± SD	Min-Max
20% of liquid smoke + 0,5% of peppermint oil	3,00 ± 1,41	1-6
0,5% of sodium hypochlorite	4,20 ± 0,89	2-6

IV. DISCUSSION

The results showed that there was no significant difference ($p = 0,880$) or equal value in the surface roughness of the heat-cured acrylic resin plate immersed in 20% coconut shell liquid smoke and 0.5% peppermint oil solution and immersed in 0.5% sodium hypochlorite solution. The alteration in surface roughness of the heat-cured acrylic resin plate can be attributed to the interaction between the phenol and acetic acid groups present in the coconut shell liquid smoke and the ester groups of the heat-cured acrylic resin, leading to ion release. This study's findings were corroborated by the research conducted by Fadriyanti et al. (2018), which demonstrated that flavonoids, classified under the phenol group in the extract of the endophytic fungus *Aspergillus* sp., can influence the surface roughness of heat-cured acrylic resin plates.[17]

The phenolic and acetic acid constituents present in coconut shell liquid smoke have the potential to influence the surface roughness of heat-cured acrylic resin plates. This is attributed to their acidic nature and high polarity, which can induce chemical degradation of the acrylic resin surface.[18] The degradation process initiates when the polyester chains within the heat-cured acrylic resin plate interact with phenolic and acetic acid groups under acidic conditions, leading to the hydrolysis of ester groups into carboxylic acids and alcohols. The resultant disruption of polyester chains manifests as randomly distributed microcracks within the heat-cured acrylic resin plate. Over time, these microcracks contribute to surface irregularities, thereby increasing the surface roughness of the heat-cured acrylic resin plate.[19-20] The surface roughness of heat-cured acrylic resin plates immersed in sodium hypochlorite solution may be altered due to interactions between the chemical constituents of sodium hypochlorite and the ester groups of the acrylic resin. This interaction ultimately results in a reduction of polymer bond strength, thereby affecting the surface roughness of the acrylic resin plate. This assertion is corroborated by research from Fadriyanti et al. (2018) which showed that immersion of heat cured acrylic resin plates in sodium hypochlorite solution had an effect on surface roughness.[17]

The results also showed that there was significant difference ($p = 0,000$) or unequal value in surface hardness of the heat cured acrylic resin plate immersed in 20% of coconut shell liquid smoke and 0.5% of peppermint oil solution and immersed in 0.5% of sodium hypochlorite solution. The changes in the surface hardness of the heat-cured acrylic resin plate immersed in coconut shell liquid smoke with 20% of coconut shell liquid smoke and 0.5% of peppermint oil solution can be caused by a similar interaction between the phenol groups and acetic acid from coconut shell liquid smoke and the ester groups from heat-cured acrylic resin. This caused the surface of the acrylic resin plate to expand and soften, resulting in a decrease in the surface hardness of the acrylic resin plate owing to a continuous decrease in the strength of the polymer bond. This opinion is supported by research from Dwimatha et al. (2018), who showed that the phenol compounds present in 70% small white ginger extract could cause a change in the hardness value of the heat-cured acrylic resin plate.[14] A higher concentration of coconut shell liquid smoke can also cause greater hydrolysis processes, thereby reducing the surface hardness of the heat-cured acrylic resin plate. This can occur because the high concentration increases the phenol and acetic acid content, resulting in a lower pH value of the solution.[14-17]

The results of the hedonic test for organoleptic properties revealed a significant difference ($p = 0.001$) between the 0.5% sodium hypochlorite solution, 20% coconut shell liquid smoke, and 0.5% peppermint oil solution. The combination of 20% coconut shell liquid smoke and 0.5% peppermint oil exhibited a lower average hedonic value, attributed to the strong fragrance of peppermint oil, which was not favored by

consumers. Coconut shell liquid smoke, characterized by its clear yellowish color and distinctive odor, is commonly utilized as a smoke fragrance and food preservative. A study by Talib et al. (2018) demonstrated that coconut shell liquid smoke effectively preserved skipjack tuna, achieving high hedonic ratings from research subjects in terms of appearance, taste, smell, color, and texture.[21] This suggested that coconut shell liquid smoke had the potential for consumer acceptance when combined with a fragrance ingredient that could mask its distinctive odor. Peppermint oil, known for its fresh, sweet, and cool mint aroma, is widely employed as a fragrance agent in cosmetics, food, pharmaceutical, and industrial products.[16-22] Djafar et al. (2021) found that incorporating 0.15% peppermint oil in the water hyacinth mouthwash formulation imparts a minty aroma and taste, thereby enhancing the quality of the mouthwash preparation.[23]

This research indicated that the combination of coconut shell liquid smoke and peppermint oil held potential for consumer acceptance as a cleaning agent for acrylic resin removable dentures. The observed variation in consumer acceptance might be attributed to the suboptimal concentration of these two components, resulting in an undesirable odor. Consequently, future research should focus on optimizing the concentrations of coconut shell liquid smoke and peppermint oil to develop a solution with organoleptic properties that align with consumer preferences.

V. CONCLUSION

Based on the results of the research, it showed that the heat cured acrylic resin plate were immersed in 20% coconut shell liquid smoke and 0.5% peppermint oil solution had equal surface roughness value with immersed in 0.5% sodium hypochlorite solution. This study also showed that the heat-cured acrylic resin plate immersed in 20% coconut shell liquid smoke and 0.5% peppermint oil solution had a lower surface hardness value than that immersed in 0.5% sodium hypochlorite solution. Consumer acceptance of the organoleptic properties of 0.5% sodium hypochlorite solution as an acrylic resin denture cleaner was better than that of 20% coconut shell liquid smoke and 0.5% peppermint oil solution. Based on the results of this study, it can be concluded that coconut shell liquid smoke has potential as an acrylic resin removable denture cleaner.

References

- [1] Margo A, Setiabudi I, Gunadi HA, Burhan L, Suryatenggara F. Buku Ajar Prostodonsia Sebagian Lepasan. 2nd ed. Gunadi HA, editor. Jakarta: Penerbit Buku Kedokteran EGC; 2018. 333 p.
- [2] Nandal S, Ghalaut P, Shekhawat H, Gulati M. New Era in Denture Base Resins: A Review. Dental Journal Advance Studies. 2013;01(03):136–43.
- [3] Zarb, Hobkirk, Eckert, Jacob. Prosthodontic Treatment for Edentulous Patients [Internet]. 13th ed. 2013. 189–90 p. Available from: <http://pageburststore.elsevier.com>
- [4] Ozyilmaz OY, Akin C. Effect of Cleansers on Denture Base Resins Structural Properties. Journal Applied Biomaterials and Functional Materials. 2019;17(1).
- [5] Oktaviani A. Proses Pembuatan Asap Cair Grade A dari Limbah Tempurung Kelapa dengan Teknologi Redistilasi-Filtrasi. Universitas Brawijaya; 2019.
- [6] Sarwedah M, Feriadi, Wahyuni T, Arisanti TN. Pemanfaatan Limbah Komoditas Perkebunan untuk Pembuatan Asap Cair. 2019;25(1).
- [7] Keryanti, Permanasari AR, Yulistiani F, Sihombing RP, Wibisono W. Applications of Liquid Smoke from Biomass on Food Products: A Review. 2020;198(Issat):518–24.
- [8] Utama MHT, Windriyatna W, Ngestiningsih D, Ariani RMD, Prihatiningsih T. Liquid Smoke Submersive Effectiveness of Acrylic Plate To the Growth of *Candida Albicans*. Diponegoro Medical Journal (Jurnal Kedokteran Diponegoro). 2021;10(5):320–3.
- [9] Hutaeruk Christiurnida A M. Pengaruh Pemberian Asap Cair pada Berbagai Konsentrasi terhadap Pertumbuhan *Streptococcus mutans* Penyebab Karies Gigi. Jurnal Kedokteran Diponegoro. 2016;5(1):34–42.
- [10] Meiliza Ariesti Christiurnida Hutaeruk, Gunawan Wibisono VRC. Pengaruh Pemberian Asap Cair pada Berbagai Konsentrasi terhadap Pertumbuhan *Streptococcus sanguis* Penyebab Gingivitis. Jurnal Kedokteran

- Diponegoro [Internet]. 2016;5(1):34–42. Available from: <http://ejournal-s1.undip.ac.id/index.php/medico>
- [11] Wibowo A, Vidyahayati IL, Wibisono G, Ciptaningtyas VR. Pengaruh Pemberian Asap Cair pada Berbagai Konsentrasi terhadap Pertumbuhan *Porphyromonas gingivalis* Penyebab Nekrosis Pulpa. 2016;5(4):451–9.
- [12] Darojah P, Santoso O, Ciptaningtyas VR. Pengaruh Asap Cair Berbagai Konsentrasi terhadap Viabilitas *Staphylococcus epidermidis*. Diponegoro Medical Journal (Jurnal Kedokteran Diponegoro). 2019;8(1):390–400.
- [13] Darojah P, Santoso O, Ciptaningtyas VR. Pengaruh Asap Cair Berbagai Konsentrasi terhadap Viabilitas *Staphylococcus aureus*. Diponegoro Medical Journal (Jurnal Kedokteran Diponegoro). 2019;8(1):390–400.
- [14] Dwimarta AJ, Saputera D, Wijayanti TF. Efek Ekstrak Jahe Putih Kecil 70% terhadap Nilai Kekerasan Basis Resin Akrilik. Dentin Jurnal Kedokteran Gigi. 2018;II(1):40–4.
- [15] Noviyanti AM, Parnadji R, Soesetijo FA. Efektifitas Penggunaan Pasta Biji Kopi Robusta sebagai Pembersih Gigi Tiruan terhadap Kekasaran Permukaan Resin Akrilik Heat Cured. Pustaka Kesehatan. 2018;6(2):339.
- [16] Sharmeen JB, Mahomoodally FM, Zengin G, Maggi F. Essential Oils as Natural Sources of Fragrance Compounds for Cosmetics and Cosmeceuticals. Molecules. 2021;26(3).
- [17] Fadriyanti O, Putri FI, Surya LS. Perbedaan Kekasaran Permukaan Resin Akrilik yang Direndam dalam Larutan Sodium Hipoklorit dan Ekstrak Jamur Endofit *Aspergillus sp.* (Akar *Rhizophora mucronata*). 2018;5(2):153–61.
- [18] Kalasworjati RT, Soesetijo A, Parnadji RR. Pengaruh Rebusan Minyak Atsiri Daun Sirih Merah (*Piper crocatum*) sebagai Bahan Pembersih Gigi Tiruan Resin Akrilik terhadap Kekasaran Permukaan dan Perubahan Warna. Stomatognatic - Jurnal Kedokteran Gigi. 2020;17(2):50.
- [19] Nugraha PW, Arifin R, Wardhana AS. Pengaruh Pasta Kelakai (*Stenochlaena palustris*) Konsentrasi 30% terhadap Kekasaran Permukaan Heat Cured Acrylic. 2022;VI(2):65–70.
- [20] Rifdayanti GU. Pengaruh Perendaman Ekstrak Batang Pisang Mauli 25% dan Daun Kemangi 12,5% terhadap Nilai Kekasaran Permukaan. 2019;III(3).
- [21] Talib DA, Gunawan S, Husen A. Karakteristik Uji Organoleptik Ikan Cakalang Asap dengan Menggunakan Asap Cair Tempurung Kelapa, Sabut Kelapa dan Kayu Mangrove. Agrikan: Jurnal Agribisnis Perikanan. 2020;13(1):83–90.
- [22] Malekmohammad K, Rafieian-Kopaei M, Sardari S, Sewell RDE. Toxicological Effects of *Mentha x piperita* (Peppermint): A Review. Toxin Rev [Internet]. 2021;40(4):445–59. Available from: <https://doi.org/10.1080/15569543.2019.1647545>.
- [23] Djafar F, Yamlean PVY, Siampa JP. Formulasi Mouthwash Ekstrak Eceng Gondok (*Eichhornia crassipes* (Mart.) Solms) sebagai Antibakteri Karies Gigi (*Streptococcus mutans*). Journal Pharmacon. 2021;10(4):1169–77.