ORIGINAL ARTICLE

The effect of *Pangium edule* (kluwek) extract on the discoloration of resin composite microhybrids: an experimental laboratory

Irsan Ibrahim[1,2*]
Tuti Alawiyah[1]
Herlin Amelia[1]

[1]Department of Dental Material, Science, and Technology, Faculty of Dentistry, Prof. Moestopo University, Indonesia

* Correspondence:
irsan_henshin@yahoo.com

Received: 22 April 2024
Revised: 02 July 2024
Accepted: 22 July 2024
Published: 31 July 2024
DOI: 10.24198/pjd.vol36no2.54437

p-ISSN 1979-0201
e-ISSN 2549-6212

Citation:
Ibrahim, I. Alawiyah, T. Amelia, H. The effect of Pangium edule (kluwek) extract on the discoloration of resin composite microhybrids: an experimental laboratory. Padj J Dent, July. 2024; 35(2): 181-189.

ABSTRACT

Introduction: Composite resin is a restoration material that is often used because it has high aesthetic value. Hybrid composite resins are currently one of the most popular materials for aesthetic restoration. This is due to several advantages, including low shrinkage, low abrasion, and better surface smoothness than small-particle composite resins. *Pangium edule* is a spice used in a variety of dishes, including rawon, brongkos vegetables, and konro soup. Apart from its function as a flavouring, *Pangium edule* also makes food browner in color. This Kluwekstudy aims to analyze the effect of *Pangium edule* extract on the discoloration of resin composite microhybrids. **Methods:** Type of research is experimental laboratory use of 24 microfiller hybrid resin composite specimens with a diameter of 6 mm and a thickness of 2 mm were used. The 24 specimens were divided into three groups based on their soaking time: 1 day, 3 days and 5 days, to see any color changes. Each treatment time group consisted of 8 specimens soaked in the *Pangium edule* solution. The Vita Easy Shade tool was used to verify color change measurements. Analyzed data using the one-way Anova test **Results:** The one-way Anova test findings revealed a significant difference (p=0.000) in the color change of composite resin that was soaked in *Pangium edule* solution for one, three, and five days. **Conclusion:** The change in the color of microhybrid composite resin soaked in *Pangium edule* solution for 1 day, 3 days and 5 days can cause color changes, especially in the hue value.

KEYWORDS

discoloration, resin composite microhybrid, *Pangium edule*

INTRODUCTION

Composite resin is a commonly used restoration material due to its superior aesthetic value. Composite resins have developed over time to improve their physical and mechanical properties. In a survey conducted by Tyas (2005) on 100 users of filling materials, it was found that the use of composite resin filling materials was 55%, amalgam 28%, GIC 15%, and polyacid-modified composite resin 2%. Based on this percentage, it is clear that many patients use composite resin as a dental filling material.[1,2,3] Hybrid composite resin is an aesthetic restoration material that is currently becoming more popular. Hybrid composite resin materials are currently often used due to their numerous advantages, including better surface smoothness compared to small particle composite resins, low shrinkage and abrasion, a high compressive strength that is nearly as durable as amalgam, making them a popular choice for dental restoration. Class IV restorations, such as anterior restorations on the incisal tip, are examples of posterior and anterior restorations.

More than 80% of patients are having concern regarding the possible discoloration of the hybrid composite resin'filling material they used.[4,5,6]

Heyne noted that *Pangium edule*, also known as *Pangium edule*, kluwak, picung, or kepayang, is part of the biodiversity of Indonesia that can be utilized as a natural dye. *Pangium edule* is a spice used in a variety of dishes, including rawon, brongkos vegetables and konro soup. Apart from its function as a flavouring, *Pangium edule* also provides a blackish brown color to food. The brown coloring substance from *Pangium edule* can be used as an alternative to synthetic coloring substances such as Chocolate Brown FH and Chocolate Brown HT.[7,8] Hilditch, Williams, and Mangunwardoyo said that *Pangium edule* contains various substances, including beta-carotene, cyanic acid, hydrocarpic acid, khaulmogric acid, gloric acid and tannin. According to Heruwati, tannin is also an antioxidant that acts as an antibacterial agent. This makes *Pangium edule* dye very good when applied to food because it can function as a preservative. Tannin can be extracted from a compound through extraction. According to Artati and Fadilah's study, tannins are a class of polar polyphenolic chemicals that dissolve in acetone, glycerol, alcohol, and hydroalcoholics as well as water. Tannins are insoluble in chloroform, petroleum ether and benzene.[7,8] Tannin is a substance that is widely distributed in plants, including leaves, unripe fruit, stems and bark. The organic substances in tannin have very complex components, such as phenolic compounds. According to Desmiaty, phenolic chemicals can precipitate proteins out of a solution but are difficult to separate and crystallize. Tannins in immature fruit can be used as energy in metabolic processes in the form of tannin oxide and are a source of acid in the fruit. They are one of the secondary compounds in plants which are not directly involved in metabolic processes but influence hormonal activities in the body. In general, tannins are found in many dicotyledonous plants. In addition, Hagerman asserted that tannin functions as an antioxidant. The distribution, nature and number of tannins vary depending on the type and age of the plant. Tannins in cell tissue are found in vacuoles, so they do not interfere with cell metabolism. When viewed through a microscope, cells containing tannin are brown.[9]

After being immersed in a luwak coffee solution for five days (one year), the nanohybrid composite resin will change color, losing some of its brilliance. This is due to the presence of gallic acid. Gallic acid is a tannin group compound that has a chromophore group (color absorber) in the form of a conjugated double bond or benzene ring, which can cause a substance or molecule to appear colored, as well as the presence of an OH group as an autosochrome (color binder).[10] The adsorption of polar dyes on the composite surface is the primary reason of the composite resin's color shift in tea. Coffee has been found by Mark Seferstein to be more chromogenic than tea. The color change in coffee is caused by the dye adsorption on the composite surface. Fine coffee particles settle into holes that may be formed due to the polymerization shrinkage of the resin during the polymerization process. Fewer polar dyes and coffee-soluble polyphenols, such as tannins, caffeine, and caffeic acid, may have entered the resin, possibly because they are more compatible with the polymer matrix.[11]

After soaking for seven days, coffee and black tea beverages can generate the greatest color changes on microhybrid and flowable composite resin when compared to Red Bull, Pepsi Cola, orange juice, and water. This change can be seen in the translucency of the two composite resins. The degree of color change in composite resin varies depending on the type of drink consumed.[12] Nanohybrid, microhybrid, and microfill composite resins can change color after being soaked in tea for more than 12 hours, compared to 6 hours and 1 hour of soaking. These results suggest that patients should avoid beverages containing dyes for at least 12 hours after filling with composite resin.[13]If micro- and nanohybrid composite resins are immersed in liquid for longer than three days, they will undergo color changes. The drinks that cause the most color changes are black coffee, black tea, green tea and water, respectively.[14]

Compared to microhybrid composites, nanohybrid composites have greater color stability. In composite resins, smaller filler particles can increase resistance to discoloration; therefore, microhybrid composites are more susceptible to discoloration than nanohybrid composites. Qat (Arabic tea) can cause greater color changes in both composites than other coloring solutions (coffee drink, Qishr, red tea, Dilsi Cola, and distilled water) and produces the largest color changes. Cola dilation causes abrasion of the composite specimen, which can lead to discoloration. Soaking time plays a role in color change because increasing soaking time can increase the ability of the dye to cause color change (an indirect role of pH).[15]

Therefore, researchers are interested in examining whether people's habit of continuously consuming *Pangium edule* can affect their fillings, especially fillings with microhybrid composites. This study aims to analyze the effect of *Pangium edule* extract on the discoloration of resin composite microhybrids.

METHODS

This experimental study used a total of 24 microfiller hybrid resin composite (Quadrant Universal LC, Cavex, Netherland) specimens with a diameter of 6 mm and a thickness of 2 mm based on ISO 4049. The 24 specimens were divided into three groups based on their soaking time: 1 day, 3 days and 5 days, with the purpose of detecting any color changes.[10] Each treatment time group consisted of 8 specimens soaked in *Pangium edule* solution. *Pangium edule* powder is made by extracting the *Pangium edule* with water and then drying it. Before soaking, the specimen is dried with silica gel for 24 hours so that when examining the color of the specimen, it is not biased by the color of the water reflection in the specimen. Color change measurements were checked using the Vita Easy Shade tool which is based on the Munsell color system, namely color categories divided into three groups: value/lightness, hue, and chrome.[16] According to the Munsell system, hue designates a particular kind of color, such as red, yellow, green, blue, and so forth. Munsell's color pie chart organizes hues into logical groups based on the primary colors. Value quantifies a color's brightness or darkness. Pure white is represented by a number of 10, while gray and deeper hues are covered by values in between, which range from 0 to 10. Chroma measures a color's saturation or intensity. The color is stronger or purer when the chroma value is higher. In a Munsell color diagram, the chroma is arranged so that circles or ellipses represent the color's saturation or intensity from the center (value) outward. The study used a parametric statistical test, especially one-way ANOVA, to ascertain the variation in color changes among the time variables, specifically 1 day, 3 days, and 5 days.

RESULTS

All specimens underwent a first stage of color measurement before soaking, and a second stage was conducted after soaking for one, three, and five days. Both the first-stage measurement findings and the second-stage measurement results were not consistent. Even though this study's results are not all the same, it is still necessary to assess the color changes (chromo, hue, and lightness) brought on by the *Pangium edule* effect. As a result, this study used the color change difference (delta, Δ) between before and after immersion. The immersion time group showed a slight decrease after 1 day of immersion for chrome and hue color values, then stabilized until 5 days of immersion. Figure 1 illustrates a significant decline in the lightness value following a 3-day immersion period.

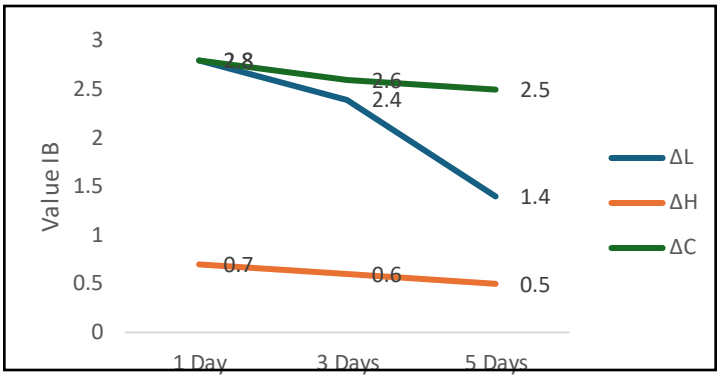

Figure 1. Graph of color changes in microhybrid composite resin soaked in *Pangium edule* solution.

To determine whether or not there is an effect of color change on the composite resin soaked in *Pangium edule* solution with the three soaking times, a statistical test was carried out. The first statistical test was to determine whether the examination data using the VITA Easy Shade tool was normally distributed or not. Since there were less than 50 data specimens, the Shapiro-Wilk method was used to test the research data for normality. The data normalcy test is a hypothesis test used to determine whether or not the acquired data follows a normal distribution.The data that will be checked for normal distribution is the difference in data after and before immersion, because in this study, the specimens were soaked starting from zero minutes, so immersion of the specimens was not continued after soaking for 1 day.[16]

Based on the statistical normality test results, it has been confirmed that the data distribution is normal ($p>0.05$) across the groups of lightness difference, chrome difference, and hue difference. Therefore, a parametric test, specifically a One-Way ANOVA test, can be carried out as one of the requirements for carrying out an ANOVA test is having normal data distribution. According to the results of the One-Way ANOVA test[16], $p<0.05$ is significant (Table 1), which means there is a significant difference in the color change of composite resin soaked in *Pangium edule* solution for 1, 3 and 5 days.

Table 1. Results of the one way ANOVA test on groups of immersion time in the *Pangium edule* solution.

Variable	Immersion Time	Immersion Time	Sig.
Lightness difference	1 day	3 days	.000*
		5 days	.000*
	3 days	1 day	.000*
		5 days	.203
	5 days	1 day	.000*
		3 days	.203
Chrome difference	1 day	3 days	.006*
		5 days	.007*
	3 days	1 day	.006*
		5 days	.910
	5 days	1 day	.007*
		3 days	.910
Hue difference	1 day	3 days	.000*
		5 days	.000*
	3 days	1 day	.000*
		5 days	.023*
	5 days	1 day	.000*
		3 days	.023*

*Sign p <0,05

DISCUSSION

Energy in the form of electromagnetic waves is what Ragain described as light traveling through space. Only a specific range of color waves may be seen by the human eye. This range of wavelengths is referred to as visible light; wavelengths outside of it, such as infrared, ultraviolet, or x-ray, cannot be referred to as visible light. There is no perfect monochromatic radiation in nature; in fact, all colors consist of a combination of light. Different wavelengths, taken together, are considered a blended color. White light consists of all wavelengths of the visible spectrum. For example, if sunlight passes through a glass prism, the light will be refracted by the prism and divided into a color spectrum. Our perception of color depends on the wavelength of light reflected or emitted by the body. Although color measurements are carried out objectively, color perception remains a subjective sensation that depends on the observer's sensitivity of the and the external factors in which the color stimulation appears (Figure 1).[17,18] Meanwhile, a sensor that measures the light spectrum reflected by the specimen's surface is used in this study to measure the color of the specimen using a color scheme from Vita Easy Shade.

In dentistry, color plays an important role and is typically assessed in reflected light with a color measurement device or through visual observation. We employed the Munsell color system, which serves as a basis for color measurement in dentistry. This system used hue, value, and chroma within a three-dimensional framework. Colors like yellow, red, and blue are examples of hues. The wavelengths of the light being examined are also related to hue. In this dimensional system, a color's value corresponds to its lightness or darkness. A low-value tooth seems non-vital and gray. When it comes to matching tooth colors, value is the most crucial color component. Color intensity, or the degree of hue saturation of a color, is measured by chroma.[18]

Water functions as a plasticizer in a polymer matrix, stimulating the resin volume and decreasing the polymer matrix's glass transition temperature (Tg) by gradually weakening the resin-dentin connection in the oral cavity, according to De Munck, Toledano, Lassila, and Thonemann. Furthermore, water absorption at the resin-dentin interfacial bond has a negative effect on the hydrolytic degradation of collagen fibers in the hybrid layer. However, many studies report that water absorption can also reduce resin gaps by means of hygroscopic expansion over time.[19]

The color changes that occur in composite resin are related to its water absorption properties of the composite resin. Composite resin has the ability to absorb water, so other solutions in the oral cavity can cause discoloration. Water will seep into the composite resin material, subsequently degrading the siloxane bonds through a hydrolysis reaction and weakening the filler bonds in the resin matrix interphase. This will make it easier for water to enter the composite resin, which can cause color changes.[20,21]

Color differences in composite resins are caused by intrinsic and extrinsic factors. The intrinsic factors that influence the color change of composite resin include the resin matrix and its interphase with the filler material. Meanwhile, the extrinsic factor that influences color change is the absorption of dyes such as tea, soft drinks and mouthwash. Of these various factors, the resin matrix is the most important in the occurrence of color changes.[27]

According to Da Silva, composite resin with a UDMA matrix exhibits superior color stability compared to composite resin with bis-GMA.[22] The low viscosity of bis-GMA causes many particles to decompose in the water. The more bis-GMA particles that decompose, the more liquid enters the matrix.[22]

In this research, changes in the color of the microhybrid composite resin due to immersion in the *Pangium edule* Reinw extract solution can occur because *Pangium edule* contains dyes and acids (Figure 1 and Table 1). Warnasih claims that *Pangium edule* imparts a dark brown hue to food. *Pangium edule* 's brown dye can be used in place of artificial dyes like chocolate brown. Tannin is a dye

(brownish color) contained in *Pangium edule* , which can increase microcracks on the surface of the composite resin and cause color changes due to the absorption of tannin. The acid content can also cause color changes in composite resin. This can happen because the acid content can lead to roughness and microleakage, which in turn absorbs the dye from the food onto the surface of the composite resin, resulting in color changes. In this research, the pH of the solution was 4.70, and the microhybrid composite resin underwent a change in lightness, chrome and hue in after soaking for 5 days.[7]

In this research, there was a change in the color of the microhybrid composite resin that was soaked in *Pangium edule* extract solution for 1 day, 3 days, and 5 days. Because *Pangium edule* contains tannin (Figure 2), the color darkens and becomes brownish.

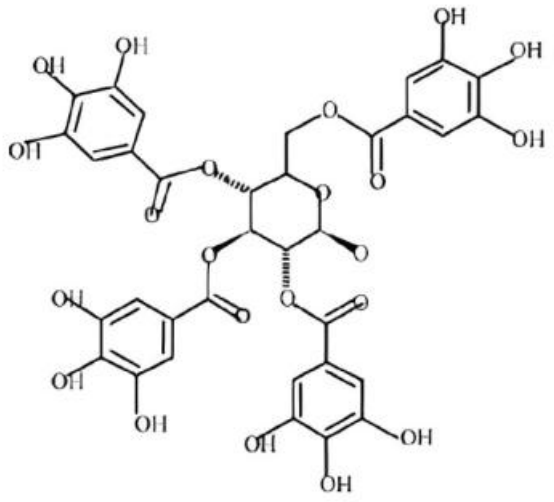

Figure 2. HydrolysableTannin.[20]

According to Widyastuti's research, the tensions between the particles become tighter, and smaller color changes result from a higher filler content and a smaller filler size. These results are in accordance with the assumption that the soaking time of 1, 3, and 5 days affects the color change of the composite resin. This color change is attributed to the tannin content in *Pangium edule* , which leads to the absorption of microhybrid composite resin and the subsequent color change. The weaknesses of micro hybrids are that they are sensitive to humidity, polymerization shrinkage, and are unstable in water or liquids, causing their physical strength to decrease over time. Exposure to water can soften the resin matrix, hydrolysis occurs, and microcracks followed by material degradation. Tannin is a coloring substance found in *Pangium edule* , which can increase micro-cracks on the surface of the composite resin and cause color changes due to the absorption of tannin.[7,23]

Changes in the color of the microhybrid composite resin due to immersion in the *Pangium edule* Reinw extract solution can occur because *Pangium edule* contains dyes and acids. Based on the findings of Widyastuti's research, the more filler there is and the smaller the filler particles are, the stronger the forces between the particles, resulting in fewer color changes.[23] Tannin is a coloring substance contained in *Pangium edule* , which can increase micro-cracks on the surface of the composite resin and cause color changes due to the absorption of tannin. The content of cyanide, khaulmogratic, hydrocarpic and gorlic acids in *Pangium edule* seeds can also be the cause of color changes in the composite resin. This can happen because the acid content can cause roughness and microleakage, so that the dye in the food is absorbed by the surface of the composite resin and causes color changes.[19,21] Immersion Causes these tannins to seep into the composite resin material,leading to the degradation of the siloxane bonds in the composite occurs.

At the resin matrix interface, the hydrolysis reaction occurs and affects the filler material's binding . In other words, the color changes in composite resin (Figure 3).

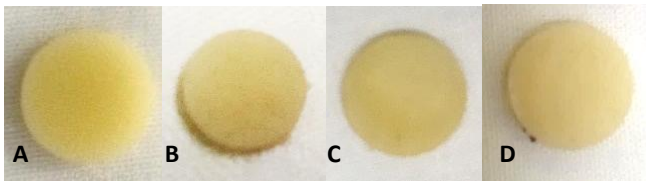

Figure 3. Composite Specimen: A. Before immersion; B. Soaking 1 day; C. Soaking 3 days; D. Soaking 5 days.

In this investigation, the composite resin composition included a bis-GMA matrix, which, according to Da Silva, has a low viscosity and allows numerous particles to break down in water. Since bis-GMA matrix composite resin is also used in this study, it is consistent with Da Silva's research. As bis-GMA particles break down, liquid will seep into the matrix at a higher rate. After five days of immersion, the composite resin exhibits a marginal decline in hue and chrome color values whereas there is a noticeable drop in lightness values throughout the same period. In this research, the composite resin will be yellower and darker in color after soaking, as shown in Figure 3. The addition of triethylene glycol dimethacrylate can improve the polymerization process of the composite resin because it contains double bonds of carbon atoms, which can help form polymers when exposed to radiation.[24,25] Therefore, the absorption and solubility processes are anticipated to produce better polymerization results.

Apart from that, the pH of the *Pangium edule* solution, which shows an acidic pH (pH = 4.70), affects the structure of the composite resin in this research. This study aligns with the research conducted by Tanthanuch and Erdemir, who found that soaking composite resin in various low-pH liquids led to a higher reduction in the resin's surface hardness. Acids or low-pH solutions can release H+ ions, which can then permeate into the composite resin.[28] The pH of this acid also influences the solubility of the composite structure. The composite resin system's pH may fluctuate as a result of tannin hydrolysis. These modifications may have an impact on the resin's rate of polymerization or hardening, as well as the mechanical qualities and color stability of the final composite. The pigments or color of the resin may be affected by the newly created components, changing the color of the composite resin substance.

Changes in the color of microhybrid composite resin soaked in *Pangium edule* solution for 1, 3, and 5 days can cause color changes, especially color changes in hue. These findings support the studies conducted by Supiyana, Diansari, Reddy, Raeisosadat, Widyastuti, Karadas, Garoushi, and Esmaeili who found external variables might cause composite resin to alter color. This can happen because the presence of flavonoid (tannin) content in *Pangium edule* (*Pangium edule reinw*) influences the solubility of the chemical bonds of the microhybrid composite resin, leading to an increase in microcracks on the surface of the composite resin. These microcracks, filled with color pigments from tannin, can cause changes in color. According to these facts, the more often we consume foods containing *Pangium edule*, the greater the discoloration of the tooth fillings.[13]

There are several limitations to this research. Although the color change of the composite resin can be known, the influence of surface roughness on the color change of the composite resin has not been evaluated. On the other hand, the specimens were not brushed after soaking, which may have affected the composite resin's staining susceptibility. In future research, the influence of surface roughness and brushing on the color stability of restoration materials needs to be investigated further. *Pangium edule* is frequently used as a spice in recipes, such as Indonesia's Padang rendang. When cooked, *Pangium edule* is added to food in comparatively small amounts to give it a particular flavor and scent. Due to the moderate amount utilized, this ingestion is usually safe. But it's crucial to understand that *Pangium*

edule contains harmful ingredients, including cyanide and hydrocyanic acid. Consequently, *Pangium edule* consumption in large amounts or over an extended period of time may be harmful to one's health.

CONCLUSION

The color alterations in microhybrid composite resin restorations are significantly influenced by *Pangium edule* extract. The color of the composite restoration material may change as a result of exposure to *Pangium edule* extract. The Implication of this research for dentists is that when using composite resin materials in dental treatment, it is crucial to consider this color shift in order to maintain the aesthetics of the final results.

Author Contributions: Conceptualization, I.I., T.A., and H.A.; methodology, I.I., T.A., and H.A.; software, I.I., T.A., and H.A.; formal analysis; I.I., T.A., and H.A.; investigation, A.U.Y.P.; resources, I.I., T.A., and H.A.; data curation, I.I., T.A., and H.A.; writing original draft preparation, A.U.Y.P.; writing review and editing, A.U.Y.P., A.G., and P.A.
Funding: Faculty of Dentistry, Prof. Moestopo University, Indonesia
Institutional Review Board Statement: Not applicable
Informed Consent Statement: Not applicable
Data Availability Statement: Not applicable
Conflicts of Interest: The authors declare no conflict of interest

REFERENCES

1. Mulla SA, Kondkari SA, Patil A, Jain A, Mali S, Jaiswal HC, et al. A Look Into the Cytotoxicity of Composite Fillings: Friend or Foe? Cureus. 2023;15(10).https://doi.org/10.7759/cureus.46327
2. Shen C, Rawls HR, Esquivel-Upshaw JF. Phillips' Science of Dental Materials E-Book. 2021;54-7.
3. von Bülow A, Gente R, Gente M. Extension of the working time of dental composites due to a new type of white operating lamp. Biomed Eng Tech. 2023;68(6):593-8.https://doi.org/10.1515/bmt-2022-0453
4. Ceci M, Viola M, Rattalino D, Beltrami R, Colombo M, Poggio C. Discoloration of different esthetic restorative materials: A spectrophotometric evaluation. Eur J Dent. 2017;11(02):149-56.https://doi.org/10.4103/ejd.ejd_313_16
5. Anusavice KJ. Phillips' Science of Dental Materials (Anusavice Phillip's Science of Dental Materials) [Internet]. 11th ed. Vol. 12, Elsevier Saunders. USA: Elsevier; 2021. p 588 :https://www.elsevier.com/books/phillips-science-of-dental-materials/shen/978-0-323-69755-2
6. Sakaguchi RL, Ferracane JL, Powers JM. Craig's restorative dental materials. Craig's Restor Dent Mater. 2018;1-340.
7. Warnasih S, Hasanah U. Ekstraksi Zat Warna Dari Pangium edule (Pangium Edule Reinw) Menggunakan Berbagai Pelarut. Ekologia. 2018;18(1):40-8.https://doi.org/10.33751/jsi.v1i02.1000
8. Mamuaja CF, Lumoindong F. Antimicrobial Activity of Kluwek (Pangium edule) Seed Extract as Natural Preservatives of Tuna Fish Ball . J Pengolah Has Perikan Indones. 2017;20(3):592601.
9. Sukaryo S. Tannin is extracted from Pangium edule (Pangium edule Reinw) using 70% ethanol solvent; the effect of extraction time is examined. Neo Tek. 2016;2(2).https://doi.org/10.37760/neoteknika.v2i2.768
10. Diansari V, Ningsih DS, Arbie TA. The impact of coffee beverages with civet on the color change of nanohybrid composite resin. Cakradonya Dent J. 2015;7(1):790-5.
11. Madhyastha PS, Naik DG, Kotian R, Srikant N, Bhat KMR. Effect of staining solutions on color stability of silorane & methacrylate restorative material. Int J Biomed Sci IJBS. 2015;11(1):29.https://doi.org/10.59566/IJBS.2015.11029
12. Karadas M. The effect of different beverages on the color and translucency of flowable composites. Scanning [Internet]. 1 November 2016;38(6):701-9. https://doi.org/10.1002/sca.21318
13. Esmaeili B, Afkhami S, Abolghasemzadeh F. The effect of time between curing and tea immersion on composite resin discoloration. Gen Dent. 2018;66(2):64-8.
14. Mahajan RP, Shenoy VU, Sumanthini M V, Mahajan HP, Walzade PS, Mangrolia R. Comparative Evaluation of the Discoloration of Microhybrid and Nanohybrid Composite Resins by Different Beverages: A Spectrophotometric Analysis. J Contemp Dent Pract. 2019;20(2):226-30.https://doi.org/10.5005/jp-journals-10024-2502
15. Al-Shami AM, Alshami MA, Al-Kholani AI, Al-Sayaghi AAM. Color stability of nanohybrid and microhybrid composites after immersion in common coloring beverages at different times: a laboratory study. BDJ open. 2023;9(1):39.https://doi.org/10.1038/s41405-023-00161-9
16. Ibrahim I, Luthfia P, Akbar MR, Karina C.Impact of Intensity of LED Light on Color Alterations in Flowable Composite Resin. J Ilm dan Teknol Kedokt Gigi. 2021;17(1):9-15.https://doi.org/10.32509/jitekgi.v17i1.1254
17. Dahlan MS. Statistics for Health and Medicine, Series 1, Edition 6. Jakarta Epidemiol Indones. 2020;1-311.
18. Ragain JC. A review of color science in dentistry: Colorimetry and color space. J Dent Oral Disord Ther [Internet]. 2016;4:1-5. https://pdfs.semanticscholar.org/dc20/2381d931b40ad0a1efde54cd3c029d28249b.pdf
19. Aprilianti E. The effect of citrus limon and whitening toothpaste to teeth color changes (study on the right maxillary central incisor of 18 year old female). In: International Dental Conference of Sumatera Utara 2017 (IDCSU 2017). Atlantis Press; 2018. P 211-4.
20. Sunani S, Hendriani R. Review Article: Classification and Pharmacological Activities of Bioactive Tannins. Farmaka. 2023;3(2):130-6.https://doi.org/10.24198/ijbp.v3i2.44297
21. Van Noort R, Barbour M. Introduction to Dental Materials-E-Book. 2023;73-94.
22. Manappallil JJ. Basic dental materials. 4th ed. 2015;84-5.https://doi.org/10.5005/jp/books/12669_9

23. Hermanegara NA. Disparities in Color Changes After Immersion in 0.2% Chlorhexidine Gluconate Mouthwash for Conventional, Hybrid, and Nanofil Composite Resin. Universitas Muhammadiyah Surakarta; 2014.
24. Kristanti Y. The color of the nanohybrid composite resin changes as a result of soaking in coffee solutions with various sugar contents. J PDGI. 2016;65(1):26-30.
25. Darvell BW. Materials science for dentistry. 10th ed. 2018; p 250-1.
26. Wu J, Weir MD, Zhang Q, Zhou C, Melo MAS, Xu HHK. Novel self-healing dental resin with microcapsules of polymerizable triethylene glycol dimethacrylate and N, N-dihydroxyethyl-p-toluidine. Dent Mater. 2016;32(2):294-304.https://doi.org/10.1016/j.dental.2015.11.014
27. Supiyana S, Sidiqa AN, Sukma N. Variations in the Discoloration of Hybrid Composite Resins Dipped in White and Black Coffee Solutions. J Mater Kedokt Gigi. 2013;2(2):161-8.
28. Azzahra A, Hudiyati M, Yulianti R. Comparison Of The Effect Of Acid Type Of Cuko Pempek On The Surface Hardness Of Microhybrid And Nanohybrid Composite Resin. Sriwij J Dent. 2020;1(2):59-68.https://doi.org/10.32539/sjd.v1i2.254