SANIYA INSTITUTE
E-ISSN 3025-8685
CIGARSKRUIE
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Effect of Soaking Time of Starfruit Extract (Averrhoa Bilimbi L) on Compressive Strength of Nano Hybrid Composite Resin

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Article History
Received: 07-08-2023
Accepted: 20-08-2023
Published: 20-09-2023

Abstract

Starfruit is a popular fruit because of its sour nature. The acidic nature of starfruit with an acidic pH of 1-2 has an effect on restoration materials. Compressive strength is a mechanical property of Nano hybrid composite resin as a requirement for successful long-term restoration. Composite resins have their own limitations, such as the physical properties of liquid absorption, resulting in degradation of the matrix polymer network due to exposure to drinks with acidic pH. This research aims to determine the effect of soaking time on the compressive strength of Nano hybrid composite resin soaked in starfruit extract. This type of research is laboratory experimental with a True Experimental design and a Posttest-only control group design. The sample is cylindrical with a diameter of 5 mm and a thickness of 4 mm. The treatment groups in this study consisted of the Nano hybrid composite resin group soaked in starfruit extract for 9, 27, 54 hours and the control group treated without soaking. Testing using the Universal Testing Machine tool. Data were analyzed using One Way Anova. The One Way Anova test obtained a significance value of 0.003 ($p<0.05$), so the research hypothesis was accepted. There was a decrease in the compressive strength of the Nano hybrid composite resin soaked in starfruit extract.

Keywords: Nano Hybrid Composite Resin, Starfruit, Compressive Strength

How to Cite: Rachmawati, F., & Sri, B. (2023). Effect of Soaking Time for Starfruit Extract (Averrhoa Bilimbing L) on the compressive strength of Nano hybrid Composite Resin. Cigarskruie: Journal of Educational & Islamic Research. Pages, 9-18. Vol. 1, No. 1, 2023.

Introduction

At the moment, dentistry is working on producing the most advanced composite fillings, such as hybrid composite composite varieties (Păstrav et al., 2024). The combination of macrophyll composite resin with microphyll composite resin is what goes into the creation of hybrid composites. In hybrid composites, the combination of two different sizes and types of filler results in a substantial volume of filler that is distributed evenly throughout the material (Ghosh et al., 2023). This hybrid composite resin comes in a few different varieties, the most notable of which are micro hybrid and nano hybrid (Hasanuddin et al., 2023). In the field of dentistry, nano hybrid composite resin is one of the composite resins that is utilized the most frequently (Çağırır Dindaroğlu & Yılmaz, 2024). In contemporary nano hybrid composite resins, the fillers consist of micro filler with a size range of 0.4-5 µm and nano-filler with a size range of 1-100 nm.

Nano hybrid composite resins have their own set of benefits, one of which is a particularly low

shrinkage rate during the polymerization stage (Gürses & Şahin, 2023), excellent mechanical and aesthetic features, excellent color retention, and excellent durability after polishing to a high degree (Schabbach et al., 2023). On the other hand, much like any other dental material, composites have their own set of restrictions, such as the physical properties of solubility and fluid absorption (Elfaleh et al., 2023). As a result of the fluid absorption capabilities of nano hybrid composite resin, which range from 0.5 to 0.6 mg/cm3, exposure to foods and beverages with an acidic pH can lead to the destruction of the composite resin matrix polymer network and the release of components of the composite resin that have not yet reacted (Delikan et al., 2023).

In terms of natural product production, Indonesia is among the most significant countries in the world (Putra et al., 2023). The overall amount of natural materials that Indonesia exports to the global market amounts to 21.06%, which is a reflection of this position (Kang & Park, 2023). In addition, natural components can be used as substitutes for traditional medicinal plants in the formulation of alternative compounds. The usage of these substances in daily use is in addition to this. One natural thing that can be utilized is the star fruit, which is an example of such that. Starfruit is frequently regarded as one of the most popular fruits among Indonesians. This is mostly due to the fact that it possesses a flavor that is distinctively sour (Salihat et al., 2023).

Citric acid and an acidic pH of 1-2 are both found in starfruit extract, and both of these acids are able to penetrate the composite resin complex. Starfruit extract does not include any phenolic compounds. This leads to an excess of H+ ions, which in turn has an influence on the degradation of polymer chain bonds and the breaking of those bonds. In addition to this, it causes the production of micro fractures, also known as cracks, and micro voids, also known as empty spaces, between the filler and the resin matrix. This, in turn, has an impact on the compressive strength of the composite resin. In accordance with the results of the research that was carried out by Tista et al. (2020), Consuming beverages that have a low pH acid content and doing so on a regular basis for a lengthy period of time can result in the erosion of the composite resin filler material, which in turn leads to a reduction in compressive strength. "12" The term "compressive strength" refers to the degree to which a material is able to withstand the application of the maximum load that can be applied to it without crumbling or breaking. To be regarded acceptable, the compressive strength of the restorative material must be equal to or greater than the compressive strength of the natural tooth11. This is a strict requirement. Following immersion in starfruit extract at a concentration of eighty percent, the objective of this study is to determine the compressive strength of Nano hybrid composite

resin. This will be accomplished by following the procedure described above.

Research Method

The research being conducted is of the True Experiment variety, and it is designed with a Post Test and Control Group. The population that was utilized in this study was a nano hybrid composite resin that was cylindrical in shape and had a diameter of 5 millimeters and a thickness of 4 millimeters. The research sample consisted of twenty-four nano hybrid composite resins that were chosen through the use of a purposive sampling method. The following are the criteria for inclusion in this study: a. samples that are solid; b. samples that have a flat surface; c. samples that are the same form and size; and d. samples that are not porous. In the meantime, the criteria for excluding samples are as follows: a. the sample is not solid; b. the surface of the sample is uneven; c. the sample is of different shapes and sizes; and d. the sample is porous. All of the samples were separated into groups, each of which contained six distinct composite resins. After that, each group was submerged in starfruit extract for a varied amount of time. Every participant was assigned to one of four different soaking groups: group 1 had a soaking time of nine hours, group 2 had a soaking time of twenty-seven hours, group 3 had a soaking period of fifty-four hours, and a control group did not receive any soaking at all.

Tools and Materials

Instruments and materials that were utilized in this study included a master mold with dimensions of 5 millimeters in diameter and 4 millimeters in thickness, a celluloid matrix strip, a plastic filling instrument, a glass plate, a cement stopper, a mask, tweezers, a small bottle with a lid for soaking and storing the resin, a measuring cup, tissue, a light cure, a Universal Testing Machine Shimadzu Autograph, a digital pH meter, 3M Filtek Z250XT Nano hybrid composite resin, Vaseline, and starfruit extract.

Work procedures

Establishing permits and obtaining research ethics letters from the dentistry faculty and RSGM IIK Bhakti Wiyata Kediri is the first step in the study method. The following step is to print the Nano hybrid composite resin in the shape of a cylinder, with a diameter of 5 millimeters and a thickness of 4 millimeters. The sample population consisted of twenty-four nano hybrid composite resins, and the selection of samples was carried out according to conditions that included and excluded certain substances. For the purpose of submerging the composite resin, you need then produce a preparation of starfruit extract with a concentration

of eighty percent. Three groups were submerged in the extract for a total of nine hours, twenty-seven hours, and fifty-four hours. A Shimadzu Autograph Universal Testing Machine was utilized in order to evaluate the compressive strength of the findings obtained from the immersion exercise.

Results and Discussion

The purpose of this study was to determine the level of compressive strength of composite resin materials after they were treated with starfruit extract at a concentration of 80% for nine hours, twenty-seven hours, and fifty-four hours, as well as after treatment without soaking. Due to the great water absorption capacity of composite resin from the very first day, this soaking duration was selected as the foundation for the decision. Additionally, the composite resin will continue to absorb water for up to six weeks after seven days have passed; hence, immersion will continue to be effective within nine hours, twenty-seven hours, and fifty-four hours. (10). The findings of the level (average) of compressive strength for each treatment are shown in table V. 1. in the following paragraphs where they are presented.

Table 1. Average Compressive Strength of Nano hybrid Composite Resin

Treatment		Average Compressive Strength (MPa)
Soaking	9 hours	331.5
Soaking	27 hours	289.8
Soaking	54 hours	257.8
No Soaking		343.5

The compressive strength values of the four treatment groups are described in Table 1, which contains the information regarding these values. In the 9-hour soaking treatment, the average compressive strength was measured to be 331.5 MPa. In the 27-hour soaking treatment, the average compressive strength was measured to be 289.8 MPa. In the 54-hour soaking treatment, the mean compressive strength was measured to be 257.8 MPa. In the non-soaking treatment group, the average compressive strength was measured to be 343.5 MPa. Based on the findings of this study, the composite resin material exhibited the lowest compressive strength when it was treated with starfruit extract (Averrhoa Bilimbi L) at a concentration of 80% for a period of 54 hours. On the other hand, the material exhibited the maximum compressive strength when it was treated without starfruit extract. The findings of this investigation were then examined to see whether or not the data were normal. Shapiro-Wilk is the test on normalcy that is utilized.

Table 2. Shapiro-Wilk Normality Test

Shapiro-wilk sample	treatment	(*sig*)
Soaking	9 hours	.065
Soaking Strength	27 hours	.119
Immersion Pressure	54 hours	.880
No Immersion		.111

The results of the Shapiro-Wilk test, which indicate the significance level, are presented in Table V.2, which contains information regarding the normality test. One can draw the conclusion that the data follows a normal distribution if the p-value for each group is greater than 0.05. To determine the extent of the difference in variance between two or more sets of data, the next test to be performed is the Levene test.

Table 3. Levene's test for Homogeneity of Data

Levene's statistic	p value
	2,039 141

This information is presented in Table V.3, which details the homogeneity test that was performed using the Levene's test, which revealed a result of 0.141. The fact that the data is more than 0.05 indicates that it is possible to draw the conclusion that the variation in the data between the groups is homogeneous. A parametric test, known as the One Way ANOVA test, was then carried on the next step.

Table 4. One-way Anova test

	Sig
Between Groups	.003

The results of the One Way Anova test are displayed in Table V.4, where the sig value is 0.003. There is a significant effect if the One Way Anova test's sig value is less than 0.05 (p ‹ 0.05). According to the interpretation of this value, there is a difference in the average compressive strength after soaking in starfruit extract concentration for nine hours, twenty-seven hours, and fifty-four hours, and without soaking in starfruit extract concentration. H0 is rejected and H1 is approved. Eighty percent. The Tukey HSD test was used to determine which groups' differences, and the following outcomes were obtained.

Table 5. Tukey Honestly Significant Difference (HSD) Test

Group K0	K1	K2	K3
K0 `	.994	.090	.004*
K1 `	.994	.241	.013*
K2 `	.090	.241	.457
K3 `	.004*	.013*	.457

Table V.5 provides information regarding the test results of the Tukey Honestly Significant Difference (HSD) test, it shows that:

1. The control group only had a significant difference with the 54-hour immersion treatment group.
2. The 9-hour treatment group only had a significant difference with the 54-hour immersion treatment group.
3. The 27-hour treatment group did not have a significant difference from all treatment and non-treatment groups.

One of the benefits of nano hybrid composite resin is that it has a low shrinkage rate during the polymerization process. Additionally, it possesses high mechanical and aesthetic features. 1. Additionally, Nano hybrid composite resin possesses a high compressive strength, specifically between 350 and 400 MPa, which is one of its mechanical features. The deterioration process that is caused, among other things, by exposure to fluids in the oral cavity is responsible for this change in the compressive strength of composite resin. This change happens because the degradation process is regulated by the composite resin. Resin matrix possesses the ability to absorb water, which leads to hydrolysis, which can lead to degradation between the fillers (Mohammed et al., 2023). As a consequence, water can enter the bond between the two fillers, which can lead to a reduction in the strength of the mechanical characteristics of the composite resin (Islam et al., 2023). Compressive strength is one of the mechanical attributes that must be present in all varieties of composite resin (Mechin & Keryvin, 2023). An important prerequisite for successful clinical filling, apart from compressive strength, is the resistance of the filling material to various fluids in the oral cavity, especially acidic fluids (Singer et al., 2023).

The significance value that was obtained from the One Way Anova test in this investigation was 0.003, which indicated that there was a difference in the compressive strength of the Nano hybrid composite resin when it was subjected to soaking for 9 hours, 27 hours, and 54 hours, as well as when it was not soaked at all as the control group. Based on the findings of the compressive strength test, it was determined that the treatment group that did not undergo immersion had the highest compressive strength when compared to the treatment groups that had immersion for 9 hours, 27 hours, and 54 hours. This is consistent

with the findings of research conducted by (Alhotan et al., 2023), which states that the consumption of food and drink can be a factor that influences the mechanical properties of composite resin in the oral cavity. In particular, exposure to acidic liquids (low pH) can result in a decrease in the compressive strength of Nano hybrid composite resin (Ille et al., 2023). The Averrhoa Bilimbi L. starfruit is a fruit that is widely consumed and not difficult to acquire (Widiastuti et al., 2023). (Duarah et al., 2023) state that because starfruit possesses acidic qualities, it is frequently utilized in the production of processed foods, beverages, and traditional medicines. Demineralization of teeth and restorations is made possible by the acidic environment that is present in starfruit, as well as the high frequency with which it is consumed. It is possible for starfruit to produce expansion due to its high citric acid content and low pH. This can result in the separation of the polymer chains and the breakage of the link between the resin matrix and the filler. According to (Reza et al., 2023), greater acidity in the solution will result in a higher concentration of H+ ions, which will cause the composite resin material to dissolve. This will result in a decrease in the compressive strength of the composite resin.

The results of the Tukey Honestly Significant Difference (HSD) test revealed that the compressive strength of Nano hybrid composite resin treated without immersion was greater than that of the treatment group that was soaked in starfruit extract for 9 hours, 27 hours, and 54 hours. This was the case when compared to the treatment group that included immersion. (Mańka-Malara et al., 2023) conducted research in which it was discovered that immersion in an isotonic beverage resulted in a decrease in the compressive strength of Nano hybrid composite resin. According to (Zhao et al., 2024), the loss in compressive strength can be attributed to the fact that the starfruit extract has an acidic pH that is lower than the normal range. This means that the presence of H+ ions has an effect on the degradation and breaking of polymer chain links, which in turn causes the formation of micro-cracks between the filler and the resin matrix (Jagadeesh et al., 2023).

Pressing composite resin while it is immersed in a solution with a pH that is lower than normal and an abundance of H+ ions causes the chemical bonds of the polymer matrix to become unstable due to cross-linking with H+ ions (Afrinaldi et al., 2023), which ultimately results in the chemical bonds of the polymer matrix being broken. When compared to soaking the Nano hybrid composite resin for 9 hours and 27 hours, soaking it for 54 hours resulted in a lesser strength. This was due to the extremely high water absorption, which caused the filler material to get damaged and caused the composite resin material to undergo chemical deterioration. 4. Low pH solution levels contain high numbers of H+ ions (Ibrahim et al.,

2024). These H+ ions have the potential to influence the mechanical properties of the composite resin surface through the matrix degradation process. Previous studies have discovered that the amount of monomer that is released when the star fruit extract comes into contact with the acid solution is also affected by the amount of time that the extract is soaked in. According to (Han et al., 2023), the compressive strength of the composite resin will decrease as the length of time that the composite resin is in contact with the acid solution increases. This is because more polymer bonds will break and release the monomer (Sheka, 2023). It is also possible for a number of elements, such as composition, restorative materials, polymerization method, and oral cavity circumstances, to have an effect on the decrease in compressive strength of nano hybrid composite resin. According to Prasetyo et al. (2022), the physical properties of the composite resin can be influenced by the quantity and kind of filler used in the composite resin (Chen et al., 2023). These features include the capacity of the composite resin to absorb water and its solubility.

Compressive strength is one of the mechanical attributes that are necessary for all forms of composite resin (Yadav et al., 2023). This is due to the fact that composite resin with a high compressive strength can be utilized as a filling material for posterior teeth that require a significant amount of daily compressive strength or chewing loads. Increasing the compressive strength of a composite resin material results in an improvement in the material's strength and wear resistance (Selvamurugan & Balasubramanian, 2023), as well as the strength and durability of the composite resin once it has been dried (Wang et al., 2023).

Conclusion

After immersion in starfruit extract at a concentration of 80% for nine hours, twenty-seven hours, and fifty-four hours, as well as without soaking, there were variations in the compressive strength of the Nano hybrid composite resin. In addition to that, the group that has been immersed for 54 hours experienced the greatest reduction in compressive strength.

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