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(RESEARCH ARTICLE)

The Effect of Pineapple Juice (*Ananas comosus* (L.) Merr.) on the compressive strength of nanofiller composite resin

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Abstract

Background Nanofiller composite Resin is the result of the latest developments using nanotechnology, has mechanical advantages such as compressive strength, tensile, and fracture and wear resistance, but this resin is hydrophilic so it can absorb water. Absorption of water containing acid has the potential to decrease the compressive strength of composite resins.

Objective: To determine the effect of soaking pineapple juice (Ananas comosus L. Merr) with concentrations of 25%, 50%, 75% and 100% to decrease the compressive strength of the composite resin nanofiller.

Research Method: This study used post test control group design. The sampling method used 4 groups of samples each group, consisting of 6 groups, namely 4 treatment groups and 2 control groups. The treatment group consisted of pineapple fruit juice (Ananas comosus L. Merr) concentration of 25%, 50%, 75% and 100% and the control group consisted of a positive control group (distilled water) and negative control (no treatment). The next step is to test the compressive strength of each group using a universal testing machine, then the test data is analyzed using a one-way ANOVA test with the condition that the data must be normal and homogeneous, one-way ANOVA test requirement sig value < 0.05.

Results: Based on the analysis using One-Way Anova obtained sig value = 0.000, which means there is a significant difference between the group with the group that has the lowest. compressive strength value at immersion with a concentration of 100%.

Conclusion: There is a decrease in the compressive strength of nanofiller composite resin in pineapple juice immersion (Ananas comosus L. Merr) with a group that has the lowest value of compressive strength at immersion with a concentration of 100%.

Keywords: Nanofiller Composite Resin; Pineapple Juice; Compressive Strength

1. Introduction

Data from the 2018 Indonesia Basic Health Research (Riskesdas) indicate that the prevalence of dental caries in Indonesia is approximately 90% of the total population. One of the most commonly used treatments for dental caries is tooth restoration using filling materials. Composite resin has become the primary choice among restorative materials

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(17). The popularity of composite resin is closely associated with patients' demand for tooth colored restorations that exhibit favorable mechanical properties and are capable of maintaining durability within the oral cavity (20).

Nanofiller composite resin was selected in this study because it represents one of the most recent developments in composite resin materials. This type of composite resin utilizes nanotechnology, characterized by filler particles at the nanoscale (1–100 nm), and exhibits superior physical properties similar to microfilled composite resin, particularly in terms of satisfactory esthetic outcomes (5). In addition, nanofiller composite resin demonstrates mechanical advantages comparable to hybrid composite resin, especially with regard to compressive strength, tensile strength, and resistance to fracture and wear (17). Despite these advantages, nanofiller composite resin also has certain limitations, notably its tendency to absorb water, which may lead to deterioration of both physical and mechanical properties. The hydrophilic nature of composite resin contributes to increased water sorption within the resin matrix (5).

Composite resin is inherently hydrophilic, meaning that it is capable of absorbing water. This water absorption may result in a reduction in compressive strength, which is one of the most critical mechanical properties of composite resin (21s). The selection of restorative materials must therefore take into account their ability to withstand substantial masticatory loads and resist fracture. One essential mechanical property required of restorative materials is adequate compressive strength. Compressive strength plays a crucial role in representing a material's resistance to crack propagation or fracture caused by masticatory pressure during the chewing process experienced by the restoration A decrease in composite resin compressive strength may occur due to the absorption of water containing acidic components. Acids present in the absorbed water can disrupt the bond between the resin matrix and the filler particles, thereby reducing the overall strength of the composite and increasing its susceptibility to damage (18). One beverage known to contain acids is pineapple juice (3).

Over the past five years, Indonesia has become the third largest exporter of canned pineapple in the world, following Thailand and the Philippines. In addition to canned pineapple, Indonesia also exports fresh pineapple and pineapple juice. The primary export destinations for Indonesian pineapple products include the United States, the Netherlands, Spain, Germany, and several other countries (13).

East Java is one of the major pineapple producing regions in Indonesia, with a production volume of approximately 171 thousand tons in 2015. The main pineapple plantation centers in East Java are located around Mount Kelud, which is administratively divided into Kediri Regency and Blitar Regency. The pineapple variety predominantly cultivated in this area is the Queen variety (10). Pineapples cultivated in Indonesia are generally classified into two major groups, namely Queen pineapple and Cayenne pineapple. Kelud Queen pineapple is considered a superior variety due to its significantly higher vitamin C content compared to Cayenne pineapple and other varieties (10).

Pineapple fruit provides numerous health benefits, as it consists of approximately 90% water and is rich in potassium, calcium, iodine, sulfur, and chlorine. Pineapple contains bromelain enzymes, fiber, water, tannins, flavonoids, and steroids, all of which are known to inhibit bacterial growth (15). In addition, pineapple contains polar compounds with antioxidant activity, particularly phenolic compounds, aside from flavonoids (8).

Pineapple is rich in citric acid, malic acid, ascorbic acid, oxalic acid, fiber, and water content. Citric acid belongs to the group of organic acids and exhibits an acidic pH (19). The level of acidity increases with increasing pineapple concentration; therefore, pineapple juice is categorized as a fruit juice with a low pH and a sweet taste. The pH of fresh pineapple juice typically ranges from 3.5 to 4.0 (2). An increase in pineapple juice concentration enhances the ionization constant of hydrogen ions (H^+) in the acidic compounds, resulting in a further decrease in pH (9). Low pH solutions may cause erosion on the surface of composite resin materials, leading to the release of filler particles and consequently reducing the compressive strength of the composite resin (1).

To date, to the best of our knowledge, there has been no study investigating the effect of pineapple juice (*Ananas comosus* (L.) Merr.) on the compressive strength of nanofiller composite resin. Therefore, this study aimed to determine the effect of pineapple juice at concentrations of 25%, 50%, 75%, and 100% on the compressive strength of nanofiller composite resin.

1.1. Buah Nanas (Ananas comosus L. Merr)

Pineapples are tropical plants with fresh fruit that have a combination of sweet and slightly sour flavors (14) Pineapple contains the enzyme bromelain, which serves to tenderize meat. Other benefits of pineapple are as a remedy for constipation, urinary tract disorders, hemorrhoids, gout, and anemia (12). The content of pineapple (Ananas comossus L. Merr) contains citric acid, which has antibacterial properties. Pineapple is rich in organic acids, including citric acid, malic acid, and oxalic acid. Citric acid is the most dominant acid in pineapple, accounting for 78% of the total acids present. The content of malic acid in pineapple is about 13% (6). Pineapple is very beneficial for dental health because it contains the enzyme bromelain, which can suppress plaque growth, thereby reducing plaque scores in the oral cavity (16). Pineapple processed into juice has a low pH with a sweet taste and contains compounds that are good for health. These compounds include ascorbic acid, bromelain, carotenoids, phenolic compounds, and flavonoids (2).

Figure 1 Pineapple (*Ananas comossus* L. Merr) (Destriana et al., 2021)

1.2. Compressive Strength

Several factors that can affect the compressive strength of composite resin are the amount of pressure received, material composition, polymerization process, and conditions in the oral cavity such as beverages consumed. The degradation process of the composite resin matrix due to exposure to acidic pH beverages can change the microstructure of the composite by forming pores in the composite resin, causing a number of residual monomers to escape from these pores (4). Therefore, it is necessary to consider the filler content, filler type, filler size, and degree of conversion (7).

2. Material and methods

This study was an experimental laboratory study employing a post test control group design. The study population consisted of 24 nanofiller composite resin specimens. The preparation and dilution of pineapple juice were conducted at the Laboratory of the Faculty of Pharmacy, Bhakti Wiyata Institute of Health Sciences, Kediri, East Java.

The materials used in this study included nanofiller composite resin, pineapple juice at concentrations of 25%, 50%, 75%, and 100%, distilled water (aquadest), and petroleum jelly (Vaseline). The instruments used were a light curing unit, acrylic molds, cement stopper, aluminum foil, gauze, tissue paper, micropipette, beaker glass, universal testing machine, pH meter, incubator, plastic filling instrument, agate spatula, volumetric flask, gloves, immersion containers, wooden sticks, thread, sealed containers, and a juicer

2.1. Making Nanofiller Composite Resin

The specimens used in this study consisted of nanofiller composite resin fabricated in a cylindrical shape, with a diameter of 5 mm and a thickness of 2 mm. Acrylic molds were prepared according to these dimensions. A total of 24 composite resin specimens were fabricated. Nanofiller composite resin was inserted into the acrylic mold until completely filled using a plastic filling instrument. The mold was then compacted by placing the top section onto the acrylic mold, followed by tightening the screws and nuts to ensure uniform compression.

All specimens were polymerized by light curing for 40 seconds using a light curing unit. Light exposure was applied perpendicularly to the specimen surface at a distance of 1 mm. After polymerization, the screws and nuts were removed, followed by removal of the top section of the acrylic mold. The hardened composite resin specimen was then retrieved from the middle section of the mold.

2.2. Preparation of Pineapple Juice

The pineapple fruit used in this study was obtained from a pineapple plantation located on the slopes of Mount Kelud. The pineapple variety used was Queen pineapple, harvested at five months of age, as five month old Queen pineapples are known to contain high levels of secondary metabolites (15). The inclusion criteria for the pineapple fruit were Queen pineapples harvested five months after flowering, with an elongated and conical shape, sweet taste, yellowish reddish coloration, fresh condition, and absence of spoilage. The pineapple fruit was cut, and the flesh was separated from the peel and core using a knife. The pineapple flesh was then chopped into small pieces and processed using a juicer. The resulting juice was filtered using sterilized cloth and gauze, after which it was covered with aluminum foil. The filtered liquid obtained represented 100% pineapple juice derived from five month old pineapple fruit. Each concentration was prepared in a volume of 10 mL. The desired juice concentrations were prepared using the following dilution formula:

$$M1 \times V1 = M2 \times V2$$

M1 = molarity before dilution
M2 = molarity after dilution
V1 = volume before dilution
V2 = volume after dilution

2.3. pH Measurement

The degree of acidity of pineapple juice at concentrations of 25%, 50%, 75%, and 100% was measured using a digital pH meter.

Figure 2 pH Measurement

The pH meter was activated by pressing the "on" button. Prior to measurement, the pH meter was calibrated using standard buffer solutions of known pH values. The pH electrode was immersed in the buffer solution and allowed to equilibrate until a stable reading was obtained. After calibration, the electrode was immersed into the pineapple juice sample, ensuring that the electrode was fully submerged in the liquid. The reading was allowed to stabilize, which was indicated by the absence of significant fluctuations in the displayed value. Measurements were repeated, and the mean pH value was calculated to obtain the final pH for each concentration. Based on measurements obtained using the pH meter, the pH value of pineapple juice was found to be 4.4. To maintain stability of the experimental conditions, pH measurements were monitored and the immersion solutions were replaced every 3 hours throughout the experiment.

2.4. Soaking Nanofiller Composite Resin

Pineapple juice solutions at concentrations of 25%, 50%, 75%, and 100% were prepared by pouring 10 mL of each solution into sealed containers, after which the samples were inserted into the containers using tweezers. The sealed containers were then placed in an incubator set at 37 °C. The samples were divided into five treatment groups: Group 1 was immersed in 25% pineapple juice for 8 hours per day, Group 2 in 50% pineapple juice for 8 hours per day, Group 3 in 75% pineapple juice for 8 hours per day, Group 4 in 100% pineapple juice for 8 hours per day, and Group 5 in distilled water (aquadest) for 8 hours per day. Immersion was conducted for 8 hours daily over a period of 9 days, resulting in a total immersion time of 72 hours. This immersion duration was based on the assumption that an individual requires approximately 6 minutes to consume pineapple juice per intake; thus, immersion over 2 years corresponds to 732 days (6 minutes × 732 = 4,392 minutes), which is equivalent to 73.2 hours (4,392 minutes ÷ 60 minutes). Therefore, a total immersion time of 72 hours was considered equivalent to two years of composite resin use in the oral cavity (Karaman et al., 2012). The pH of the pineapple juice solutions was controlled at a value of 4.43. If any deviation from the predetermined pH value occurred, the altered solution was replaced with a freshly prepared solution every 3 hours to maintain a controlled pH. After completion of the immersion period, the samples were removed from the containers, drained on tissue paper until dry, and then placed into labeled sealed containers.

2.5. Measurement of Compressive Strength of Nanofiller Composite Resin

The instrument used in this study to evaluate compressive strength was a universal testing machine. The testing procedure was carried out as follows:

The cylindrical resin composite specimen was placed on the designated platform of the testing apparatus. The loading head was positioned directly above the specimen until it came into contact with the composite surface. The loading head was then moved downward to apply compressive force to the specimen while continuously observing the specimen until fracture or failure occurred. Once the specimen fractured or failed, the application of load was terminated, and the maximum load displayed on the digital screen was recorded.

$$Cs = P/A$$

Cs = Compressive strength (N/mm2 atau MPa)
P = Maximum load applied to the composite resin (N)
A = Area of a circle = πr2

Figure 3 Universal Testing Machine

3. Results and discussion

3.1. The Effect of Soaking Pineapple juice on the Compressive Strength of Nanofiller Composite Resin

The data were obtained from compressive strength measurements of the composite resin specimens based on pineapple juice (Ananas comosus L. Merr) at concentrations of Concentrations of 25%, 50%, 75%, and 100% as treatment groups, with distilled water serving as the positive control group and untreated composite resin serving as the negative control group.

Based on the One Way ANOVA results presented in Table 4, the significance value obtained was $p = 0.000$. Since the p value was less than 0.05 ($p < 0.05$), it can be concluded that there were statistically significant differences in compressive strength among the study groups.

3.2. Sample Making Proses

This study aims to determine the effect of pineapple juice (Ananas comosus L. Merr) concentrations of 25%, 50%, 75%, and 100% on the compressive strength of nanofiller composite resin. The results of the One-Way ANOVA test showed a significance value of 0.000. This value is less than 0.05, indicating that there is a significant difference in the compressive strength of nanofiller composite resin between each group. These results prove that the research hypothesis is accepted, namely that there is a decrease in the compressive strength of nanofiller composite resin when immersed in pineapple juice.

Table 1 Compressive Strength Measurement Result

Sample	Compressive Strength Test Results (Mpa)					
	Group 1 25%	**Group 2 50%**	**Group 3 75%**	**Group 4 100%**	**Group 5 (+)**	**Group 6 (-)**
1	231.72	153.4	109.06	108.36	248.8	263.4
2	241.46	129.83	98.27	66.32	225.8	255.77
3	244.99	138.82	102.52	60.57	247.9	270.78
4	246.29	124.24	93.88	79.3	255.8	272.76
Average	241.115	136.5725	100.9325	78.6375	244.575	265.6775
Standard deviation	6,58739	12,72488	6,46537	21,30744	13,00522	7,73612

Based on the data obtained from 6 sample groups, namely the treatment group using pineapple juice with concentrations of 25%, 50%, 75%, and 100%, the positive control group using distilled water, and the negative control group using composite resin without treatment. Based on Table D, it was found that the average values of the six sample groups were as follows: the control group without treatment was 265.67 MPa, the positive control group using distilled water was 244.57 MPa, the 25% concentration group was 241.11 MPa, the 50% concentration group was 136.57 MPa, a concentration of 75% with a value of 100.93 MPa, and a concentration of 100% with a value of 78.63 MPa.

Table 2 Shapiro-wilk Normality Test

Sample	*Statistic*	*df*	*Sig.*
25%	0.863	4	0.272
50%	0.955	4	0.746
75%	0.990	4	0.955
100%	0.900	4	0.429
C+	0.850	4	0.226
C-	0.927	4	0.580

Based on the results of the normality test using the Shapiro–Wilk test, the significance values for all treatment groups immersed in pineapple juice at concentrations of 25%, 50%, 75%, and 100%, as well as the positive control group (distilled water) and the negative control. group (untreated composite resin), were greater than 0.05 ($p > 0.05$). Specifically, the significance values were 0.272 for the 25% concentration, 0.746 for 50%, 0.955 for 75%, 0.429 for 100%, 0.226 for the positive control, and 0.580 for the negative control group. Therefore, it can be concluded that all datasets were normally distributed.

Table 3 Levene-Test Homogeneity

	Levene Statistic	df1	df2	*Sig.*
Based on Mean	1.404	5	18	0.270
Based on Median	0.974	5	18	0.460
Based on Median and with adjusted df	0.974	5	9.011	0.483
Based on trimmed mean	1.373	5	18	0.280

The results of the homogeneity test using Levene's test demonstrated a significance value of 0.270, which meets the criterion of $p > 0.05$. This indicates that the variances among all sample groups were homogeneous. As both assumptions, normal distribution and homogeneity of variance, were satisfied, parametric statistical analysis using One Way ANOVA was deemed appropriate.

Table 4 One Way-Anova Statistical

	Sum of Squares	df	*Mean Square*	F	*Sig.*
Between Groups	134526,326	5	26905,265	173,562	0.000
Within Groups	2790,324	18	155,018		
Total	137316,650	23			

Based on the One Way ANOVA results presented in Table 4, the significance value obtained was p = 0.000. Since the p value was less than 0.05 ($p < 0.05$), it can be concluded that there were statistically significant differences in compressive strength among the study groups.

Table 5 Least Significant Difference (LSD) Test

Sample	25%	50%	75%	100%	C+	C-
25%		0.000*	0.000*	0.000*	0.699	0.012*
50%	0.000*		0.001*	0.000*	0.000*	0.000*
75%	0.000*	0.001*		0.021*	0.000*	0.000*
100%	0.000*	0.000*	0.021*		0.000*	0.000*
C+	0.699	0.000*	0.000*	0.000*		0.028*
C-	0.012*	0.000*	0.000*	0.000*	0.028*	

Based on the results of the Least Significant Difference (LSD) post hoc test presented in Table 5, the following findings were observed. At a pineapple juice concentration of 25%, a statistically significant difference in compressive strength was found when compared with all other concentration groups, except for the positive control group. This finding indicates that nanofiller composite resin specimens immersed in 25% pineapple juice exhibited compressive strength values comparable to those of the positive control group immersed in distilled water. At pineapple juice concentrations of 50%, 75%, and 100%, as well as in the negative control group, statistically significant differences were observed when compared with all other groups. The 75% concentration group demonstrated statistically significant differences relative to all remaining groups. Similarly, the 100% concentration group showed statistically significant differences when compared with all other groups. The positive control group immersed in distilled water exhibited statistically significant differences compared with all other groups, with the exception of the 25% pineapple juice group.

4. Conclusion

Based on the findings of this study, it can be concluded that immersion in pineapple juice reduces the compressive strength of nanofiller composite resin. Among the tested concentrations, immersion in 100% pineapple juice resulted in the lowest compressive strength, whereas immersion in 25% pineapple juice produced the highest compressive strength compared to concentrations of 50%, 75%, and 100%.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest.

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