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Research Article

Effect of Strawberry Juice (*Fragaria Ananassa*) on Mechanical Properties of Nanofilled Composite Resins

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KEYWORDS

nanofilled composite resins;
mass measurement;
hardness;
surface roughness;
acidic ph;
strawberry juice

ABSTRACT

Introduction: Nanofilled composite resins have small filler particles size (1-100 nm). Its mechanical properties consist of hardness, surface roughness, and water absorption. Composite resins easily degraded by acid pH because it contains polymer with unstable bonds. Degradation can cause water absorption. It can be scratched more easily if they have low hardness. Rough surfaces can cause the risk of plaque formation, secondary caries, discoloration, damage to the surface of the patch, reduces resistance, accelerates abrasion, and can cause irritation to the surrounding soft tissue. **Objective:** To analyze the effect of mechanical properties (water absorption, hardness, and surface roughness) on nanofilled composite resins after strawberry juice (Fragaria ananassa) immersion. **Methods:** This research was a laboratory experimental with post-test and control group design. Forty cylindrical samples of nanofilled composite resins Filtek Z350XT (3M ESPE) (10mm x 2 mm) were divided into four groups: water absorption group, hardness tested group, surface roughness tested group, and control group. Surface roughness tested group and hardness tested group were immersed in strawberry juice each 10 mL for 2 hours a day and repeated for 12 days. After 10 and 12 days of immersion, hardness tested group, surface roughness tested group, and control group will be measured using surface roughness test and hardness test. Water absorption test will be carried out before immersion and after 10 and 12 days of immersion. **Results:** *One Way* ANOVA statistical test on surface roughness test showed a p-value of 0.001 ($p<0.05$) and the water absorption test show a p-value of 0.983 ($p>0.05$). Post Hoc Tukey test had significant difference of roughness tested on day 12 and control group with a p-value of 0.01 ($p<0.05$). **Conclusions:** Strawberry juice increases surface roughness of nanofilled composite resins after 2 hours immersion for 12 days in comparison with control group.

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INTRODUCTION

Consumption of fruit and vegetables is very important in a balanced diet.[1] The content of vitamins, minerals and antioxidants in vegetables and fruit has an important role in reducing the risk of health problems related to diet such as kidney failure, obesity and diabetes.[2] Strawberry (*Fragaria ananassa*) is a fruit that is often found and consumed by Indonesian people to meet their nutritional needs. Strawberries can also be processed into jams and juices.[2,3] Strawberries have many health benefits because they contain various nutrients, such as tannins, flavonoids, and phenolic acids. Currently, people are also starting to be interested in using strawberries as a tooth whitening ingredient because it contains malic acid and are easy to obtain also more economical.[4] The main organic acid content found in strawberries is citric acid. A Study by Ni Made Defy Janurianti (2021) shows that strawberries have a pH in the range of 3.01 - 3.36.[5]

Composite resin is a popular dental repair material and was introduced to dentistry more than 50 years ago.[6] Composite resin has properties that are influenced by factors such as matrix composition, bonding technique, coupling agent, filler, etc.[7] Composite resin has mechanical and physical properties. Its mechanical properties consist of hardness, surface roughness, flexural strength, and modulus elasticity. Its physical properties are solubility, water absorption, and polymerization shrinkage.[8] The size of the filler from nanofilled composite resin is very small (1 to 100 nm). The advantages of having smaller filler particles are smooth and shiny surface, less polymerization shrinkage, better resistance, and low attrition.[6]

Composite resin polymer bonds are unstable so they are easily degraded by acidic pH.[9] Composite resin degradation can occur due to changes in the microstructure of the composite, namely the formation of pores in the composite resin, which causes the remaining monomer to be released from the pores. The empty space will result in diffusion of liquid from outside into the composite resin. This known as water absorption. As a result of this degradation can affect the hardness and surface roughness of the composite resin.[10,11] A study by Nurul Ikhsan (2016), the average surface hardness in the nanofilled composite resin group immersed in the distilled water group was 70.20 VHN.[8] A study by Hasriandy Candra Basri (2017), the average surface roughness in the nanofilled composite resin group immersed in the sterile distilled water control group was 0.55 µm.[9] Composite resin degradation can cause surface roughness. This could lead to the risk of plaque formation, secondary caries, discoloration, damage to the surface of the filling, lowering resistance, accelerating abrasion, and irritation of the surrounding soft tissue.[12,13] This study aimed to analyze the effect of mechanical properties (water absorption, hardness, and surface roughness) on nanofilled composite resins after strawberry juice (*Fragaria ananassa*) immersion.

MATERIALS AND METHODS

In this study, laboratory experiments were conducted with post-test with control group design. The research was carried out at the Dental Material Testing Center & Center of Research (DMTcore), Faculty of Dentistry, Trisakti University. Filtek Z350 XT A3 shade LOT NE75930 (3M ESPE) nanofilled composite resin was used as the sample. Each group consist of 10 samples, the number of which was calculated by Lemeshow formula.[14]

Sample Preparation

Nanofilled composite resin (Filtek Z350XT 3M ESPE) was placed in stainless steel mode in cylindrical shape with 10 mm in diameter and 2mm in height (Fig.1). The samples were condensed using a cement stopper and light cured for 20 second. They were then removed from the mold (Fig.2).

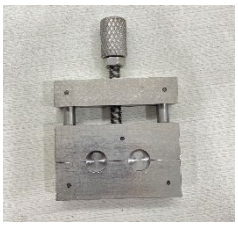

Figure 1. Stainless steel mold with 10 mm in diameter and 2 mm in height

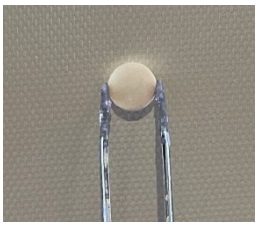

Figure 2. Nanofilled composite resin sample

Mass Measurement

Water Absorption was measured using mass calculation. Mass calculation of the sample was measured using the Analytical Balance, Fujitsu FS-AR210. The method of measurement is put each sample inside the analytical balance after pressing the 'tare' button. Wait a couple seconds until it shows a stable number (Fig.3).

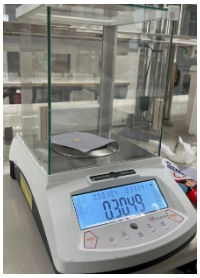

Figure 3. Analytical Balance

Hardness Measurement

Composite resin hardness can be tested using the Vickers Microhardness Tester HMV-G31DT, Shimadzu, Tokyo, Japan (Fig. 4). The Vickers hardness test uses a diamond indenter which produces a square indentation. The results obtained are in the form of values, namely VHN (Vickers Hardness Number).

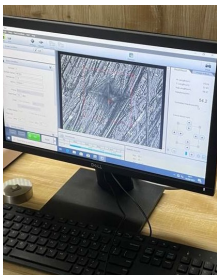

Figure 4. Micro Vickers Hardness Tester

Surface Roughness Measurement

Surface roughness was measured using the Surface Roughness Tester S-100 series, Taylor Hobson, Leicester, United Kingdom (Fig. 5). The method of measurement is by placing the tip of the needle on the surface of each specimen at an angle of 90° 3 times and then taking the average. If the number from the Surface Roughness Tester increases, it means the surface becomes rougher.

Figure 5. Surface Roughness Tester

Water absorption group was measured using analytical balance before immersing sample in distilled water and strawberry juice. Then, all samples were immersed in distilled water for 24 hours to reduce the amount of residual monomer from the polymerization process. The water absorption tested, hardness tested, and surface roughness tested group was immersed into 10 mL of the strawberry juice with pH range 3.3-3,7 in for 2 hours per day for 12 days. While the control group was immersed in distilled water for 24 hours. They were immersed in separated containers to differentiate each group. Immersion for 2 hours per day indicated a consumption of 4 minutes every day for a month (4 minutes x 30 days = 120 minutes = 2 hours). The next 22 hours, the water absorption tested, hardness tested, and the surface roughness tested group was immersed into distilled water. This study used the cycling method, means the strawberry juice and distilled water are replaced every day.

The water absorption tested, hardness tested, surface roughness tested, and the control group were measured after ten and twelve days of strawberry juice immersion simulated as 10 months and 12 months (a year) of consumption using the surface roughness tester.14 Water absorption test was carried out using analytical balance to calculate the mass. Hardness measurement was carried out at the point marked with a marker with a load of 100 gf for 10 seconds. Surface roughness test was carried out by placing the tip of the needle on the surface of each specimen at an angle of 90° 3 times and then taking the average. Roughness average (Ra) is the value used in surface roughness tester. The water absorption group was measured on the first day before immersion of strawberry juice also after ten and twelve days of strawberry juice immersion. Gram (g) is the value used in analytical balance.

Statistical Analysis

The data in this study were analysed using the Shapiro-Wilk normality test (N<50) and Levene homogeneity test. Later, it was continued with parametric tests with the One Way ANOVA test to see the overall significant difference between the sample groups and continued with the Post Hoc Tukey test to find out the differences of each group. This statistical analysis was carried out using IBM SPSS Statistics for Macbook Version 25 (IBM, New York, USA).

RESULTS

Water absorption tested was observed and averaged to found the differences before and after immersion of strawberry juice for 10 and 12 days (Fig. 6). Results revealed the differences in the hardness and surface roughness on day 10 and day 12 day of strawberry juice immersion with the control group are observed and averaged (Fig. 7 and 8). Nanofilled composite mass shows no significance difference from before immersion, day 10 immersion, and day 12 immersion. There was a difference after the hardness test was carried out

comparing the control group and 12-day immersion group but there were no significance differences (Table 1 and 2). There was a significance difference in roughness test from the control group, immersion day 10, and immersion day 12 (Table 1). From Post Hoc Tukey test, there was only 1 pair of surface roughness groups that had significant differences. It is the surface roughness data on the 12-day immersion with the control (Table 2).

Figure 6. Mean water absorption of the nanofilled composite resin (g)

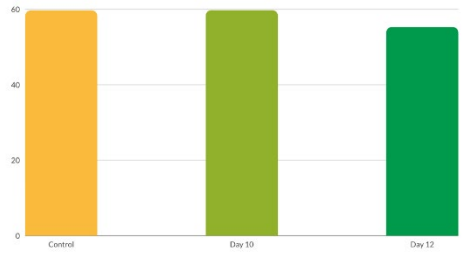

Figure 7. Mean Hardness of nanofilled composite resin (VHN)

Figure 8. Mean Surface Roughness of nanofilled composite resin (Ra, µm)

Table 1. ANOVA test for water absorption, hardness, and surface roughness tested group

	p
Water absorption	0.983
Hardness	0.617
Surface Roughness	0.001*

*p>0.05 (statistically significant difference)

Table 2. Post Hoc Tukey test for surface roughness of nanofilled composite resin

		p
Surface Roughness	Day 10 - Day 12	0.143
	Day 10 - Control	0.061
	Day 12 - Control	0.001*

*p>0.05 (statistically significant difference)

DISCUSSION

Composite resin is a popular dental material and was introduced to the world of dentistry more than 50 years ago.[6] Most classifications of composite resins focus on filler size distribution and filler composition.[15] Nanofilled composite resin is the newest type of composite resin with a size of 1-100 nm and is one of the most commonly used restorative materials due to its superior aesthetic properties.[16] Composite resin polymer bonds are unstable so they are easily degraded at acidic pH. Composite resin degradation can occur due to changes in the microstructure of the composite.[9] There was hydrolysis of the ester contained in the dimethacrylate group in bis-EMA, TEDGMA, and UDMA. Residual monomer will come out of the composite resin resulting pores in the composite. The empty space will change the microstructure of the composite. Liquid will diffuse from the outside into the composite resin due to the resulting pores. The diffusion would cause water absorption.[17,18]

The hardness and roughness of the composite resin are affected by the degradation of the composite resin.[9] The masticatory pressure can be measured using a composite resin surface hardness tester. Composite resin that is not optimal can cause cracking and detached composite from the teeth during mastication.19 Low surface hardness can also cause the material to be scratched more easily.[10,11] Rough surfaces of composite restorations can cause the risk of plaque formation, secondary caries, discoloration, composite breakage, lower resistance, accelerate abrasion, and irritation to the surrounding soft tissue.[12,13]

Based on the descriptive data in this study, water absorption and surface roughness increased at every movement, while hardness only lower on 12th day test. Statistical analysis did not reveal a significant difference for water absorption and hardness. Nevertheless, statistical analysis revealed a significant change in surface roughness day 12th and control group. The results of this study are directly proportional with a study previously reported by Jason Kamadi (2022): There was a significant increase in surface roughness of nanohybrid

composite resin group after immersion in pineapple juice with an acidic pH for 2 hours by cycling method for a period of 12 days.[14] Another study by Vanya Violetta (2022) reported that there was a significant change in the surface roughness of the nanohybrid composite resin samples after 15 days of immersion in a soft drink (coke) which has acidic pH.[13]

Water absorption can occur because water has a molecular diameter of 0.16 nm which is smaller than the distance between the two small polymer chains, making it easier for water to diffuse into the resin matrix. The factor that exacerbates the high absorption of water is the high erosion effect on the surface of the material due to acids. Materials exposed to acids have a low resistance to penetration of water molecules in the polymer chain.[20] Acid pH will damage the matrix and filler bond of the composite resin. Matrix becomes detached and decomposes which causes the formation of microcracks and microvoids resulting in a decrease in the strength and increase in surface roughness of the resins.[8,21,22] Patar Sitanggang (2015) researched the hardness of composite resins immersed in lime juice with a pH of 1.7. Composites continued to experience a decrease in hardness but the composite had not reached its saturation point at 30 minutes of immersion. The hardness of the composite will decrease when the composite reaches its saturation point. This shows that the duration of immersion of the composite resins also affects the level of hardness of the composite resins.[10]

CONCLUSION

Strawberry juice increases surface roughness of nanofilled composite resins after 2 hours immersion for 12 days in comparison with control group. Nevertheless, water absoption and hardness of nanofilled composite resins does not show significant increase after 2 hours immersion for 12 days in comparison with control group.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

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