

Research Report

Compressive strength of fiber reinforced composite after immersion in citric acid of energy drink

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ABSTRACT

Background: Energy drink consumption has been popular in people age 18-35 years old. A few literature showed that this drink can cause damage to teeth and composite due to its acidity. The use of fiber reinforced composite has been increasing due to its good mechanical properties and aesthetic. Fiber reinforced composite has fiber shaped fillers that can withstand mastication forces. A restoration material has to face the complex oral environment to succeed clinically. Compressive strength test is needed to predict the durability of restoration materials against mastication forces. **Purpose:** To determine the effect of energy drink citric acid immersion to fiber reinforced composite compressive strength. **Methods:** 32 cylinder shaped fiber reinforced composite samples with 8mm tall and 4mm diameter were divided into two groups. The first group was immerse in distilled water (K1) as control, and the second group (K2) was immerse in energy drink citric acid. The samples were immersed in an incubator at $\pm 37^{\circ}\text{C}$ for 7 days. After 7 days, samples were washed in water, dried with tissue, and then undergo compressive strength test with Autograph machine at crosshead speed of 10mm/minute. The data were then analyzed using Independent t-test. **Results:** The mean compressive strength of K1 group was 1469.63 MPa and K2 group 1439.57 MPa. The mean value of K2 group was slightly lower than K1 group, but statistically, there was no significant difference between the 2 groups. **Conclusion:** Energy drink citric acid immersion has no effect on fiber reinforced composite compressive strength.

Keywords: Fiber reinforced composite, compressive strength, energy drink citric acid.

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INTRODUCTION

In the oral cavity, restoration materials are exposed with chemicals in saliva, food, drinks and physical force of mastication and oral habits¹. Change of pH inside the mouth is believed to cause the degradation of restoration materials. A few studies have revealed that low pH exposure can damage resin composite mechanical properties². Consumption of packed beverage is a source potentially causing erosion and degradation of resin composite³.

On the present day, one the most consumed beverage among young adults is energy drink. Energy drink has an acidic taste due to citric acid. Citric acid in energy drinks are reported to be higher among other packed beverage such as soft drinks and fruit juice. Several studies reveal that citric acid in high concentration can cause erosion, damage, enamel softening, and surface degradation of restoration materials⁴. Therefore, restoration materials need to withstand the dynamic oral environment¹.

Over the years resin composite has improved to meet the demands of better mechanical and esthetic properties.

Despite its improvement, resin composite is still susceptible to degradation leading to decrease of mechanical and esthetic properties. Physical or chemical structure change due to oral environment exposure can change the mechanical properties of resin composite⁵. Low pH in the oral cavity can lead to increased hydrolytic degradation through the dissolution of inorganic filler and ester bond hydrolysis in the resin matrix causing the material to decrease its viability and strength over time⁶.

Hydrolytic degradation due to water accumulation between filler and matrix can alter the inorganic particle arrangement. This process, along with continuous force on the resin surface are responsible for creating interfacial de-bonding, matrix cracking, surface degradation, filler dissolution, and loss of filler particles. Dissolution of unreacted substance, such as inorganic ions or filler particles, can interfered the materials polymeric bond and alter the mechanical properties (martos)⁵.

In the last decade, the demand of esthetic restoration leads to the innovation of resin composite that has good esthetic but still capable of withstanding mastication forces⁷.

One of the latest innovation of resin composite with filler modification is the fiber reinforced composite (FRC) that has good capability for posterior restoration. Fiber reinforced composite is a composite with fiber or whiskers shaped like fillers embedded in the matrix. The fibers reinforced the restoration by acting as a stress breaker to withstand occlusion force, stopping and deflecting micro-cracks from spreading⁸.

Degradation can decrease mechanical properties of composite and eventually decreased clinical performance of restoration materials. Mechanical properties such as compressive strength can be a crucial indicator for restoration material clinical performance because it can predict the capability of a material to withstand mastication and parafunctional forces. The higher the materials can withstand deformation, fracture, and distribute stress equally, reduce the chances of tensile and compressive failure, higher stability, and higher clinical successful rate. Mastication forces on the posterior region are mostly in the form of compressive force, therefore restoration in this region need to have the ability to withstand compressive forces. Resin composite has to have compressive strength equal to normal teeth to be able to withstand mastication forces and prevent restoration failure such as fracture in the occlusal isthmus of class II restoration. Restoration materials that have lower compressive strength often fracture and may cause periodontal problems or even teeth extraction^{9,10}.

Studies show that there is a decreased in mechanical properties of resin composite after low pH exposure. However, there is still little information regarding the effect of citric acid in energy drink to fiber reinforced composite compressive strength.

MATERIALS AND METHODS

This study is a laboratory experimental study with pre-post test group design. Samples are 32 cylindrical shaped fiber reinforced composite with (8.0 ± 0.1) mm tall and (4 ± 0.1) mm in diameter based on ISO 9917 standardization. Samples are then divided into two groups with 16 samples for each group. The first group (K1) is immersed in deionized water, while the second group (K2) is immersed in energy drink citric acid. The independent variable is the citric acid from energy drink with the concentration of 3364.81 ppm and pH of 2.02. The dependent variable is the compressive strength of fiber reinforced composite.

The materials used in this study is the citric acid from energy drink, fiber reinforced composite (EverX Posterior, GC), distilled water, and Cocoa Butter (GC Tokyo). Tools for creating the samples are acrylic mold, plastic filling instruments, explorer, cement stopper, light curing unit, glass slab, and universal testing machine Autograph Ag-10TE (Shimadzu, Japan) for testing the fiber reinforced composite compressive strength.

Samples are made by placing celluloid strip on the bottom of the acrylic mold and then the mold is placed

on top of a glass slab. The inside of the mold is covered by cocoa butter as a separator. Fiber reinforced composite is filled into the mold and flattened with a plastic filling instrument. Samples are then light cured for 20 seconds as manufacture indication, brought out of the mold, and immerse in distilled water for 24 hour in an incubator at 37 °C to let the composite polymerized completely. The samples are then divided into two groups and immerse in their respectable solution, K1 in distilled water and K2 in energy drink citric acid. Samples are immersed in an air tight container for 7 days at 37 °C, the immersion solution are replaced every 24 hour.

After 7 days, samples are washed in running water and the dried with tissue paper. The samples are then undergo a compressive strength test by placing them in the bottom plate of the testing machine and then the indenter of the machine pressed the samples at the speed of 10 mm/minute. The machine is stopped when the cylinder sample is fractured. The force given by the machine is noted and calculated with this equation:

$$C = \frac{4p}{\pi d^2}$$

p = maximum force given (Newton); *d* = sample diameter (mm)

The data are then analyzed by running through Kolmogorov-Smirnov Z normality test, Levene’s homogeneity test, and Independent t-test to see whether the difference between the two groups is significant or not.

RESULTS

The compressive strength test of fiber reinforced composite on this study is done after the immersion in distilled water and energy drink citric acid for 7 days. The test is done with Autograph AG-10 TE Shimadzu, Japan with KgF (*kilogram force*) unit and converted into international unit of Newton (N).

Table 1. Mean and standard deviation of compressive strength value of each group (N/mm²).

Group	N	Mean	SD
K1	16	1469.63	149.97
K2	16	1439.57	209.44

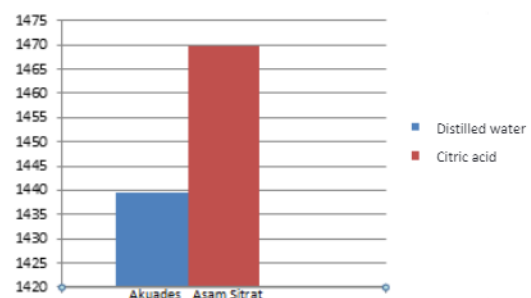


Figure 1. Graphic of the compressive strength mean value between group 1 and group 2.

After the test is done, the result of each group can be seen. K1 shown that the mean is 1469.63 with the standart deviation 149.97 and K2 shown that the mean is 1439.57 with the standart deviation 209.44. The mean and standard deviation of this test is shown on Table 1. There is also the graphic of the compressive strength mean value between group 1 and group 2. As shown in figure 1, there is significance difference between each groups.

The data are then run through a statistic Kolmogorov-Smirnov normality test and the results are the probability value for K1 is 0.994 and K2 is 0.295. Both of the probability value are higher than alpha ($\alpha=0.05$), therefore it can be concluded that the value of the compressive strength has a normal distribution.

The data are then run through Levene's homogeneity test. The probability value is 0.046 which is lower than alpha ($\alpha=0.05$), therefore the value are not homogeneous. The data are then run through Kruskal-Wallis test for another homogeneity test. The result is the probability value is 0.836, which is higher than alpha ($\alpha=0.05$), therefore the data is homogeneous. To see if there is a significant difference, the data are then run through Independent t-test. The result is that the probability value is 0.644 which is higher than alpha ($\alpha=0.05$), therefore it can be concluded that there is no significant difference between the two groups.

DISCUSSION

Based on this study, the data is analyzed and the mean value of K1 group immerse in distilled water is 1469.63 MPa, while K2 group immerse in citric acid is 1439.57 MPa. From this result it is shown that the mean value of group K2 is slightly lower than the mean value of K1. However statistically, there is no significant difference between the 2 groups. This result overruled the hypothesis that citric acid exposure can decreased compressive strength of fiber reinforced composite.

This result is similar to a study by Cilli et al¹², where there is no significant degradation difference between composite immerse in water and citric acid after 7 days. This shows that there are other factors contributing to the compressive strength of fiber reinforced composite. Theoretically, acid exposure makes composite degrade faster and decreased its mechanical properties. However, low pH is not the only factor to cause degradation. Other factors such as the type of acid, buffering effect, chelating properties of the acid can contribute to the rate of erosion¹¹. Based on a study by Munchow et al¹⁴, pH value is not the only factor affecting composite degradation. Combination between the materials that's being immerse, solubility of the materials and the solution, cross link properties of matrix resin, and the amount of solution being absorb can alter the durability of restoration materials. Citric acid in energy drink has a low pH and has chelating properties to attract Calcium ions, but there is a probability that the solubility between citric acid and bisGMA in the resin

matrix has a higher difference so the degradation rate is much slower.

The immersion time or the time of exposure may have contributed to the rate of degradation. Based on a study by Somayaji et al², 7 days of immersion is not enough to alter mechanical properties of composite. There is no significant difference after the immersion on 7 and 14 days, significant difference is seen on the 21st day of immersion. This is due to the time needed for the solution to dissolve the substance in the composite.

Other factors include the composition of the composite itself. Type, size, filler silanization may contribute to the amount of degradation¹². The higher the filler content and the more heterogeneous the fillers, makes the composite stronger against acid exposure¹³. The fiber reinforced composite contains up to 77% filler and contain 2 types of filler which is short E-glass fiber with the length of 1-2 mm and diameter of 17 μ with random orientation and barium borosilicate glass filler with the size of 0.1-2.2 micron. These filler characteristic makes the fiber reinforced composite better at handling acid exposure. In conclusion, it is shown that energy drink citric acid doesn't affect the compressive strength of fiber reinforced composite.

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