Background: Essential oil–based gutta-percha solvents have been extensively studied due to their nontoxicity and effectiveness compared to conventional solvents. These solvents can also be used to remove different types of endodontic sealers. Bioceramic-based sealers have become increasingly popular; however, they are difficult to dissolve. Objective: The aim is to examine the differences in efficacy between eucalyptus oil (Eucalyptus globulus), sweet orange oil (Citrus sinensis), and grapefruit oil (Citrus paradisi) as bioceramic sealer solvents. Methods: Thirty-two bioceramic sealer samples were placed in cylindrical stainless steel molds 1.5 mm in height and 8 mm in internal diameter and were placed in an incubator to set. After 72 h, the sealer samples were weighed to obtain their initial weights. Then, they were divided into three groups of ten, which were immersed in 1 ml of eucalyptus, sweet orange, or grapefruit oil for 1 min, and one group of two, used as negative controls. The sealer samples were placed in an incubator for 24 h to dry and weighed once more to obtain their final weights. The differences in weight were calculated and analyzed using one-way analysis of variance. Results: The analysis of the initial and final weight differences of the sealer samples immersed in the three essential oils revealed no statistically significant differences between them. Conclusions: The three essential oils have comparable efficacies as bioceramic sealer solvents.

Keywords: Bioceramic sealer, eucalyptus oil, grapefruit oil, solvent efficacy, sweet orange oil.

Background: Endodontic treatment is a procedure performed to restore dental health after a tooth is diagnosed with irreversible pulpitis. The leading causes of endodontic treatment failure are inadequate cleaning of the root canal, multiplication of bacteria inside the dentin tubule due to inadequate hermetic seal, and the presence of accessory or secondary root canals that were not obturated. Microleakage can also occur in cases of insufficient seal between the gutta-percha and the sealer or the dentin and the sealer, or when there are gaps within the sealer.

Endodontic sealer is one of the most critical factor in achieving a hermetic seal in accessory root canals. Bioceramic-based endodontic sealers have attracted attention due to their biocompatibility, antibacterial, and antifungal properties. Such sealers can be classified according to their main components, which are calcium silicate, calcium phosphate, or a combination of both. Calcium silicate sealers promote periapical healing, bone regeneration, and rarely cause peripheral leakage because of mineral and apatite deposits on the root canal walls.

Nonsurgical endodontic retreatment requires the removal of previous obturation materials. This is done with the help of manual, ultrasonic, or rotary instrumentation.

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Eucalyptus oil (Eucalyptus globulus) and sweet orange oil (Citrus sinensis) have been researched as alternative solvents because they are more biocompatible compared to chloroform and xylene. They have been reported to effectively dissolve gutta-percha and endodontic sealers.2,13 Efficient as it may be, sweet orange oil is toxic, although less than other endodontic solvents.14,15 This is important since materials that are placed inside the root canal have access to periapical tissues and the circulation system.16 Due to the toxicity levels of sweet orange oil, grapefruit oil (Citrus paradisi) has been investigated as an alternative solvent and has shown to effectively dissolve gutta-percha.14

As the use of bioceramic sealers increase, a solvent that is effective and safe to use during endodontic retreatment is needed.5,17 The efficacy of a solvent can be evaluated by measuring the difference in the mass of the sealer before and after immersion in the solvent.18 Although the effectiveness of eucalyptus, sweet orange, and grapefruit oils in dissolving gutta-percha has been extensively researched, no studies have assessed their efficacy in dissolving endodontic sealers, especially bioceramic sealers containing calcium silicate. The aim of this study, therefore, was to examine the differences in efficacy between eucalyptus, sweet orange, and grapefruit oils as bioceramic sealer solvents.

**Materials and Methods**

This was an *in vitro* experimental study conducted in the Laboratory of Dental Material and Testing Center of Research of the Faculty of Dentistry of Trisakti University, Jakarta, Indonesia. A total of 32 calcium silicate-based bioceramic sealer samples (Sure-Seal Root, Sure-endo, South Korea) were placed into stainless steel molds with an internal diameter of 8 mm and a height of 1.5 mm. The samples were then divided into three groups of 10, each group immersed in eucalyptus, sweet orange, and grapefruit oils (Organic Supply Co., Indonesia). Two samples were used as negative controls, with distilled water used as a solvent.

The bioceramic sealer samples were placed into molds with the help of a straight probe. The top and bottom surfaces of the molds were covered using glass slides to obtain a smooth surface.18 The samples were placed on a glass plate and then placed on a stainless steel tray filled with distilled water. The tray was covered with plastic wrap to create a humid condition, which is necessary for the reaction of bioceramic sealers, and then placed in an incubator at 37°C for 72 h to set.19 After 72 h, the glass slides were removed, and any excess material surrounding the molds was cleaned using a Lecron carver.

The samples were weighed using a digital analytical balance to obtain their initial masses. Using a syringe, 1 ml of each solvent was placed in a glass beaker. The samples were then immersed in the solvents for 1 min. After immersion, the excess solvent on the samples was absorbed using tissues. Then, the samples were placed in an incubator at 37°C for 24 h and subsequently weighed once again to obtain their final masses.

The differences between the samples’ masses before and after they were immersed in the solvents were calculated, expressed as mean mass loss ± standard deviation, and analyzed to assess the efficacy of each solvent. The data were tested for normality using Shapiro–Wilk test, homogeneity and were further analyzed using one-way analysis of variance (ANOVA). The dependent variable was the amount of bioceramic sealers dissolved, while the independent variable was the kind of essential oil solvent. The level of statistical significance was set to *P* < 0.05. Statistical analysis was performed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA).

**Results**

The negative control showed a mean mass loss of 3.1 mg. The mean mass losses of the bioceramic sealer samples after immersion in the three essential oils are shown in Table 1. Grapefruit oil resulted in the highest mean mass loss, while eucalyptus oil resulted in the lowest. However, one-way ANOVA showed no statistically significant differences between the three solvent groups [Table 2].

**Discussion**

The statistical analysis showed no significant differences in efficacy between eucalyptus oil, sweet orange oil, and grapefruit oil as bioceramic sealer solvents.
solsents. Therefore, the null hypothesis of this study was rejected. This is in line with the findings of Martos et al., who reported that sweet orange and eucalyptus oils were equally effective in dissolving calcium hydroxide, zinc oxide eugenol, silicon, and resin-based sealers.¹³

In this study, distilled water resulted in a certain sealer mass loss. This result is in contrast to the findings of Alzraikat et al., who immersed MTA Fillapex, a kind of bioceramic sealer, in distilled water and observed no mass loss.²⁰ This difference may have been caused by the presence of sealer powder in the mold that was washed away when immersed in the solvent, resulting in a decrease in weight observed in our study. It may also have been caused by the release of calcium ions (Ca²⁺) when the calcium silicate-based bioceramic sealer was soaked in distilled water, which did not happen in MTA Fillapex, a salicylate resin-based bioceramic sealer.²⁰,²¹

Calcium silicate-based bioceramic sealers are hydrophilic and therefore set in humid environments.¹⁹

In this study, the samples were placed on a stainless steel tray filled with distilled water and then sealed with plastic wrap to create a humid condition for the sealer to set.²⁰ This was done to overcome a limitation of the incubator used, which did not have a humidity regulator. The setting process lasted 72 h, significantly longer than the manufacturer’s recommendation of 25 min, despite being in the same prescribed 100% humidity.

Bioceramic sealers that contain calcium silicate have a high pH due to the formation of calcium hydroxide from the reaction of Ca²⁺ ions with water. Calcium hydroxide crystal layers form and grow on the sealer’s surface. Therefore, it can be assumed that when the bioceramic sealer was immersed in the essential oils, the dissolved compound was calcium hydroxide. Martos et al. found that eucalyptus oil is less effective than sweet orange oil in dissolving calcium hydroxide-based endodontic sealers.¹³ This is in line with our results, which showed that sweet orange oil and grapefruit oil was more effective than eucalyptus oil, even though the difference is not statistically significant.

Further statistical analysis was conducted using paired t-test to see if there is any difference between the sample’s mass before and after immersion in the solvent. The result shows that there is a significant difference for the three essential oils. This means that eucalyptus oil, sweet orange oil, and grapefruit oil can dissolve bioceramic sealer significantly within 1 min. However, further research needs to be conducted to compare these solvents with distilled water to know if these essential oil solvents are more effective in dissolving bioceramic sealers than distilled water.

Eucalyptus oil is obtained using steam distillation from dried E. globulus leaves.²² This oil mostly consists of 1,8-cineole compounds, which have been reported to dissolve gutta-percha and have anti-inflammatory and antibacterial properties.²²³ Sweet orange and grapefruit oils are commonly extracted using the cold press method.²⁴ One of the most abundant compound found in their rinds is d-limonene, which Grabliauskienė et al. and Jantarat et al. found to effectively dissolve gutta-percha.¹¹,¹⁴,²⁵ Despite the known compounds responsible in dissolving obturation materials, there is no available information on the mechanism by which eucalyptus and citrus essential oils dissolve endodontic sealers.

**CONCLUSIONS**

This study shows that eucalyptus, sweet orange, and grapefruit oils have comparable efficacies as bioceramic sealer solvents. Future studies could further investigate their efficacies by increasing the immersion duration or varying the solvents’ temperature.

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**Conflicts of interest**

There are no conflicts of interest.

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