

Literature Review

Discoloration of Nanohybrid and Nanofiller Resin Composites after Exposure to Turmeric

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ABSTRACT

Background: Recently, the demand of aesthetic restorative has greatly increased and encourages the development of composite resin material. The latest technology of composite is nanohybrid and nanofiller composites. However, color stability of nanohybrid and nanofiller resin composites can be influence by intrinsic and (or) extrinsic factor. Intrinsic factor depends on the composition on the resin composite and extrinsic factor such as colored food and beverages. Turmeric as a food ingredient, that is often consumed by Indonesians can cause discoloration in composites, because it contains the active pigment curcuminoid. The discoloration of nanohybrid and nanofiller composites can caused by the process of water sorbston and curcumin particles. **Purpose:** Explain the discoloration of nanohybrid and nanofiller resin composites after exposure to turmeric and the factor that influence. **Reviews:** The reaction between the curcumin contained in turmeric and nanohybrid as well as nanofiller composites can cause discoloration in both composites. One of the reasons behind the discoloration on composite resin is that the composite resin can absorb water and its substances are carried by the water. Discoloration of composites was influence by the concentration of turmeric solution, pH of the solution, finishing and polishing process, temperature, time of exposure, composition of filler and matrix. **Conclusion:** Turmeric as an extrinsic factor can cause color changes in nanohybrid and nanofiller composites ($\Delta E > 3.3$), where the level of color change can be obtained by intrinsic factors, such as composition of filler and matrix, and other extrinsic factors.

Keywords: turmeric; curcumin; nanofiller; nanohybrid; discoloration; color stability

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INTRODUCTION

Based on Basic Health Research 2018; cavity or caries is the most common dental and oral health problem in Indonesia. Caries, especially on anterior teeth, is a signal for a treatment of tooth-colored restorations¹. The increasing demand for tooth-colored restorative materials, especially for anterior teeth, has driven the development of composite resins in the field of nanotechnology. This development is known as nanocomposites, consisting of nanohybrid and nanofiller composites²⁻⁴. The main focus in caries treatment, especially on anterior teeth, is not only on prevention and treatment - but also on the color stability⁵.

Both nanofiller and nanohybrid composites as aesthetic restorations with filler particles in nanometer scale are expected to have good level of color stability⁶. At present, both nanohybrid and nanofiller composites can still change color due to intrinsic and extrinsic factors. The intrinsic factor is influenced by the composition of the composite^{7,8}, while the extrinsic factors are influenced by exposure to

food and beverages containing dyes, temperature, finishing and polishing processes, as well as the changes in oral conditions^{9,10}.

As a food ingredient, turmeric contains dyes which cause dye deposits on composites. It is a plant which commonly found in Southeast Asia and often consumed by Indonesians as food, beverage, or medicine^{11, 12}. It contains the active coloring pigment, curcuminoid, which produces a yellow color. Curcuminoids are from phenolic compounds consisting of curcumin, monodesmetocurcumin, and bidesmotocurcumin. The main component which can give yellow color is curcumin¹³. Turmeric can cause color changes in nanohybrid and nanofiller composites through chemical reactions between curcumin and composite resin components, as well as through a water absorption process accompanied by curcumin particles. Foods which contain coloring agents are able to change the color of the composite resin through absorption over a period of exposure^{6,7,14}. The purpose of this study is to explain the discoloration which occurs in nanohybrid and nanofiller composites

after having exposure to turmeric, as well as the factors which affect it.

REVIEWS

Nanocomposites (Nanohybrid and Nanofiller Composites)

Nanocomposites are materials which are popular in dentistry as aesthetic restorations - since they have a high degree of translucency and polish^{15,16}. In general, composite has three main compositions which determine the properties to be produced; namely fillers, resin matrix and coupling agents¹⁷. Nanofiller composite was created with the aim of combining the advantages of both hybrid and microfiller composites in one restoration material. It is composed of particles with a nanometer size (1-100 nm). The size of the nanoparticles produces composites which have high translucency properties. The shrinkage polymerization of nanofiller composite has minimal value and good resistance with low attrition¹⁸. Meanwhile, nanohybrid composite is a combination of nanoparticles and microfillers. It has a lower level of surface smoothness and weariness than nanofiller composite¹⁵.

Jain and Wadkar (2015) reported that nanofiller composite has better surface smoothness and abrasion resistance than nanohybrid composite. Surface smoothness can reduce the risk of plaque build-up; so that color stability can be maintained¹⁹. Demrici et al., (2018) evaluated the discoloration in the fill between nanohybrid and nanofiller fillings. The evaluation result (in the fifth year) showed that nanofiller composite had a better level of color stability¹⁵.

Turmeric

In Indonesia, Turmeric - which in Latin is called *Curcuma domestica* or *Curcuma longa* is used as a fragrance for traditional food coloring and medicines. It is often used in everyday life. It contains fructose, glucose, protein, vitamin C, essential oils and curcumin; which is a substance that gives turmeric its distinctive color. Curcumin gives a yellow-orange effect²⁰. The chemical formula of curcumin [1,7-bis (4-hydroxy-3-methoxyphenyl) -1,6-heptadiene-3,6-dione] is C₂₁H₂₀O₆. It is included in polyphenols with a chemical structure similar to ferulic acid^{12,20,21}.

The Effects of Turmeric Exposure on Nanohybrid and Nanofiller Composites

The reaction between the curcumin contained in turmeric and nanohybrid as well as nanofiller composites can cause discoloration in both composites. Curcumin is a polyphenol compound known as a hydrogen donor; therefore, it can release hydrogen ions (H⁺). The hydrogen ions released by curcumin can cause ionic reaction in the composite which a patient has. The hydrogen ions will react with the oxygen molecules present in the siloxane (Si-O-Si) bonds; so that the siloxane bonds later break down into silanol (-Si-OH). The function of siloxane bond is to increase the attachment

between the resin matrix and filler particles. This process will cause disruption on the matrix and filler bonds^{7,22}.

One of the reasons behind the discoloration on composite resin is that the composite resin can absorb water and its substances are carried by the water. The changes in oral cavity as well as the daily habits of humans in consuming food or drinks containing dyes are able to reduce the restoration's color stability^{8,23-25}. The water, which is absorbed by the composite resin, can cause the hydrolysis process to become H⁺ and OH⁻. The OH⁻ ion produced by water binds to the oxygen molecules present in the siloxane (Si-O-Si) bonds; therefore, the siloxane bonds later break down into Si-OH and OH⁻. OH⁻ ions formed will continue to disrupt other siloxane bonds; as long as the composite resin continues to be exposed to water. The silanol (Si-OH) bonds formed by water and curcumin will disrupt the bond between the resin matrix and filler particles^{14,17,26}.

The rate of the bond disposal between the matrix and filler particles in the chemical reaction process between curcumin and composite, as well as in the water absorption process, is determined based on the composition of the composite. Nanofiller composite resin has a filler size on the nanoparticle scale which is in unison and smaller than that of nanohybrid composite; so that less filler particle mass measurement is released. Nanohybrid composite is composed of filler nanoparticles and microhybrid particles. It has various particle sizes and tends to be larger than nanofiller composite. The release of the filler particles can form microcracks. Their formation depends on the mass of the released filler meaning the greater the mass of the released filler, the bigger the microcracks formed. Microcracks can cause discoloration in composite resin^{17, 23}.

The discoloration which occurs is proportional to the mass of the released filler particles and the microcracks formed, which is affected by the composition of the constituent filler^{3,27}. The particle size of the nanohybrid composite filler which is bigger than the nanofiller composite is able to cause a higher discoloration which occurs in nanohybrid composite compared to nanofiller composite.

DISCUSSION

Color is a perception which resulted from a light reflection. At present, patients not only attach great importance to tooth-colored restorations at the start of the treatment, but for a long period of time. As previously explained, composite resins can experience discoloration which is affected by internal and external factors²⁸. The magnitude of the discoloration is generally symbolized by ΔE , where ΔE value <1.0 is not visible to humans' eyes, while $\Delta E > 3.3$ is considered clinically unacceptable²³.

The internal factor which influences the process of discoloration of composite resin includes the composition of the filler and matrix. The effect of filler on composites is determined by the type, shape, size and number of fillers³. Composites with large filler particles are more

prone to discoloration. The increasing number of fillers in a composite composition affects the physical, chemical and mechanical properties of a restoration such as water absorption, color stability, as well as wear resistance^{8,28}. The filler particles tend to be hydrophobic; therefore, the more the number, the less the composite will absorb water. The small filler particles in the finishing and polishing process will produce a smoother surface, since fewer filler particles are released. Surface smoothness is one of the main factors for the color stability of the composite surface, since it is related to the absorption process. In addition to the size of the filler, the operator's ability to carry out the finishing and polishing processes will also affect the restoration's surface smoothness. A smooth surface on the restoration will reduce the potential for plaque retention.

Research conducted by Usha et al., (2018) and Bhat et al., (2019) shows different results in evaluating discoloration after exposure to turmeric on nanohybrid and microhybrid composites. The research by Usha et al., (2018) shows that the discoloration which occurs in the two composites has similar values, since the matrix composition and filler size in the two composites used are similar. Meanwhile, the result from the research by Bhat et al., (2019) shows that microhybrid composite indicates greater discoloration, since its matrix composition absorbs more water^{3,27}.

The composition commonly used as a matrix in composite resin is a group of monomers which are mostly dimethacrylate. Monomers which often used are Bisphenol-A-Glycidyl Methacrylate (Bis-GMA), urethane dimethacrylate (UDMA), and triethylene glycol dimethacrylate (TEGDMA)²⁹. The Bis-GMA matrix produces stiffer restorations; therefore less water absorption occurs compared to TEGDMA. TEGDMA is the matrix with the highest water absorption rate among the other two matrices¹⁶. This has been proven in a research conducted by Ceci et al., (2017); which stated that nanofiller composite resin has a greater discoloration value than microfiller and nanohybrid composite resins. The nanofiller composite resin used was Filtek Supreme XTE, which contains TEGDMA³⁰. Both TEGDMA and Bis-EMA have low viscosities; hence they are usually added to reduce the viscosity of Bis-GMA and UDMA. UDMA and Bis-EMA have a lower water absorption rate compared to Bis-GMA and TEGDMA^{9,17}. Moreover, UDMA has a lower level of viscosity and water absorption compared to the other two matrices^{8,31}. This has been proven by a research conducted by Thaliyadeth et al., (2019); which stated that the discoloration due to exposure to turmeric on nanohybrid composite is higher than microfiller - since the nanohybrid composite used have a Bis-GMA matrix composition, while the microfiller composite used have a UDMA matrix composition⁷.

Other studies conducted by Chittem et al., (2017), Malhotra et al., (2011), Usha et al., (2018) and Bhat et al., (2019) compared discoloration due to exposure to turmeric on nanohybrid and microhybrid composites. The results of the four studies are different due to differences in the composition of the resin matrix used. The addition of TEGDMA to composites which contain

Bis-GMA matrix will cause an extreme water absorption process^{3,9,23,27}.

External factors which cause discoloration in composites are exposure to food or drinks containing dyes; one of which is turmeric. It contains curcumin, which is included in polyphenols with a chemical structure similar to ferulic acid^{12,20,21}. Through the chemical reactions and water absorption processes previously described, turmeric can cause discoloration on both nanohybrid and nanofiller composites.

A research conducted by Amin et al., (2012), Kumari et al., (2015), Das et al., (2017) and Rajasree et al., (2019) shows that turmeric caused the highest discoloration compared to other media on both nanohybrid and nanofiller composites; with a value $\Delta E > 3.3$. The reason is because turmeric has small molecular particles^{24,32-34}. Different results are found in the research of Meena et al., (2019) and Bindal et al., (2015); which stated that the discoloration which occurs in red wine and tobacco is higher than in turmeric. Red wine is a drink with an acidic pH, while the pH of turmeric is relatively normal or alkaline. Foods or drinks with a low pH have a greater erosive effect; therefore, the resulting discoloration would be greater^{5,9,16,35,36}.

Other factors which affect the rate of discoloration of nanohybrid and nanofiller composites due to exposure to turmeric are the concentration of turmeric solution and the time of exposure. Monika et al., (2018) evaluated discoloration on nanohybrid composite with exposure to different concentrations of turmeric. The results show that the amount of discoloration which occurs is proportional to the concentration of the turmeric solution used¹¹. The opposite result is found in a study conducted by Bhat et al., (2019); which stated that the concentration of the turmeric solution used was very high, however, the result of the discoloration was not too large. This happened because in his research, the turmeric solution was filtered²⁷.

Based on all the researches which have been done regarding the discoloration of nanohybrid and nanofiller composite resins, especially due to exposure to turmeric, all of them indicate that the two composites can experience discoloration. The discoloration occurs is related to the water absorption process. The value of the discoloration which occurs due to exposure to turmeric is $\Delta E > 3.3$ with different results; where the value is not clinically acceptable, so that it is necessary to make restorations. The amount of discoloration on nanohybrid and nanofiller composites in all studies varied widely. This is due to differences in treatment. Factors which affect it include differences in the concentration of turmeric solution, pH of the solution, finishing and polishing processes, temperature, duration of exposure, as well as the composition of the matrix and filler - where these two components are the determinants of the physical and mechanical properties of the composite.

Based on the particle size of the filler, it can be said that nanofiller composite has a smaller discoloration value compared to nanohybrid composite. Filler particles are hydrophobic; therefore the smaller the size and volume, the more stable the color of the composite will be.

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