The Comparison of Color Space Systems Analysis on Enamel Whitening with Infusion Extracts of Strawberry Leaves

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Abstract

Tooth discoloration involves intracoronal or extracoronal color changes on the teeth. Chemical bleaching agents have side effects, and strawberry leaves have ellagic acid, which acts as a natural bleaching agent. Several color space systems are used to measure colors. To determine the bleaching effect of an infusion extract of strawberry leaves and to determine the most suitable color space system on enamel-bleached surfaces. Methods:

This is an in vitro study. Infusion extracts of strawberry leaves were applied to three teeth discolored with tea. Infusion extracts of strawberry with a concentration of 15% were applied to the first specimen and a concentration of 30% applied to the second specimen 28 times; multilevel concentrations of 15% to 30% were applied to the third specimen 14 times for each concentration. The analysis was performed using a color space system using image processing software by Adobe Photoshop.

The infusion extracts of strawberry leaves made the enamel surface darker. Infusion extracts of strawberry leaves cannot bleach teeth that have discoloration, and the most suitable color space to measure enamel-bleached surfaces is the RGB color space system.

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Introduction

Tooth discoloration can involve changes in the hue, color, and translucency of a tooth with many causes. The cause of discoloration is categorized as discoloration from the inside, or intrinsic, and discoloration from the outside, or extrinsic.[1] Intrinsic discoloration can be seen during the pregnancy period or before and after the eruption of the tooth. Intrinsic discoloration before the eruption may be caused by changes in the structural composition or thickness of the hard tissue of the tooth. Aside from the local factors, metabolic disorders or systemic factors can influence the process of tooth formation that may cause tooth discoloration. Alcaptonuria, congenital erythropoietic porphyria, congenital hyperbilirubinanemia, amelogenesis imperfect, dentinogenesis imperfect, the use of tetracyclin, fluorosis, enamel hypoplasia, bone resorption and aging are the causes of intrinsic discoloration.[2] Extrinsic discoloration happens after the eruption of the tooth. It can be caused by a chemical interaction on the tooth surface and the merging of the pellicle and colored stain. Extrinsic discoloration is also associated with cationic antiseptic and metal salts, which has a substance that can react with other substances that may produce other colors on the tooth surface.[2] Amalgam and other restoration materials, diet, and endodontic fillers may cause extrinsic discoloration.[3]

The discolored tooth should be treated to restore its aesthetic function. There are many ways to treat tooth discoloration; one such treatment is bleaching, or tooth whitening. Bleaching is a treatment that uses chemical oxidative that changes the reflecting effect and/or absorbs light from the material structure to increase the white-colored perception.[1] However, tooth-whitening treatment uses chemical materials that have complications and side effects. Free radicals react with proteins, fats, and nucleic acid, which cause cell destruction.[1] One of the chemical materials to whiten teeth is carbamide

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peroxide 2%, which may cause irritation in the mucosa.[4] Therefore, it is necessary to have a tooth-whitening agent that has the same effect with the fewer side effects. Strawberry, or *Fragaria x ananassa* has many benefits from its fruit and leaves. One of the components from strawberry leaves is ellagic acid.[5] This acid is proven to have a tooth-whitening effect.[6]

There are many ways to get a pure extract of a natural material; one is infused extraction. Infused extraction is a solution containing soluble simplicia. This is made by diluting a concentrated infusion in 10 parts water.[7] A color space is a mathematical representation from a set of colors. It is a method in which we can determine, make, and visualize colors. As humans, we can determine colors by their brightness and colors. A color itself is determined by three coordinates or parameters. A parameter describes the position of the color inside the color space used.[8] A color space system is used for specific applications, for example, tools that have flaws in a particular type of a specific color space.[8] There are some systematic methods to determine colors and differences among colors. Unfortunately, there is no perfect system for every purpose. Therefore, there is a need to conduct more research on the infused extractions of strawberry leaves as an agent for tooth whitening and the appropriate color space system to determine the enamel surface color.

Materials and methods

The specimen was accurately identified. Teeth with these criteria were prepared: (1) caries free on a buccal surface, (2) no microstructural defect on the buccal surface, (3) no hypocalcification and hypoplasia, (4) no discoloration on its surface, and (5) smoothing of the buccal surface with a smooth broad. Four out of five teeth were discolored using 1.5 grams of tea diluted in a 50 ml aquadest for two weeks and separated from the treated group. Each tooth was labeled with a transparent nail coat 5 mm x 5 mm on the buccal surface; the nail coat was also applied on the apex of the 3rd, 4th, and 5th teeth.

Infused extract from the leaves was made using aquadest. The extract was diluted to 15% (1) and 30% (2) concentrations in aquadest and placed in a labeled plastic pot at room temperature. Positive control tooth: no treatment. Negative control tooth: aquadest application for seven hours, repeated 28 times. First tooth (1) and second tooth (2) treatment: rinsed with aquadest for five seconds, dried with a chipblower, soaked in the extracts with 15% and 30% concentrations for seven hours, and repeated 28 times. Third tooth (3) treatment: rinsed with aquadest for 5 seconds, dried with a chipblower, soaked in an extract with a 15% concentration for seven hours, and repeated 14 times. The 15th-28th applications used a 30% concentration. When the application was interrupted or stopped for any reason, seven hours post-application, the tooth was rinsed with aquadest for five seconds, dried with a chipblower, and stored at room-temperature. If the application was ready to be continued, the specimen was rinsed with aquadest for five seconds and dried with a chipblower. In the application procedure, it was assumed that there was no additional static charge and a shaker was not used.

A DSLR camera Canon EOS 650D was prepared on a tripod with the following settings: ISO = 200, shutter speed = 1/25, and *f* = 5.6. The LED light position must not reflect light on the label of the tooth. The tooth that would undergo color measurement was positioned with the help of double-tape to ensure that the tooth was stable during the photoshoot and the buccal surface was facing the camera. The photoshoot was done with the following criteria: no shadow appeared on the buccal surface; the camera setting, the distance from the camera to the tooth, and lighting did not change during the shoot. The results were saved to a computer via Adobe Photoshop. The color was determined using Adobe Photoshop using Color Picker and scores were recorded with L, a, b, R, G, B C, M, and Y.

Results

This study was conducted via an in vitro laboratory experiment to determine the effects of tooth whitening using infused extracts of strawberry leaves that can be seen using various color space measurement methods Photos of the tooth surface parameters were recorded using an average value L*, a*, b*, R, G, B, H, S, L, C, M, and Y for every treatment. The normality test using the Kolmogorov-Smirnov test showed that most of the data group has a normal distribution (p>0.05, and therefor tested using a parametric

one-way ANOVA and post-hoc test LSD and to test the correlation between the increase in the concentration as the value of the component color space increased. In this study, there was a control group consisting of a tooth with no treatment and others that experienced tea discoloration. The treatment group consisted of teeth receiving an application of infused strawberry leaf extract at a 15% concentration (first tooth/1), which was applied to teeth infused with strawberry leaf extract at a 30% concentration (second tooth/2). Each infused group was soaked in the strawberry leaf extract for seven hours and repeated 28 times. The other treatment groups of teeth received applications of infused strawberry leaf extract at a 15% concentration for seven hours, repeated 14 times, followed by a 30% concentration for seven hours, repeated 14 times (third tooth/3).

The L* value of the specimen tooth 1 decreased by 15.4; the specimen tooth 2 decreased by 13.8. Based on statistical analysis, the decrease was significant ($p<0.05$) in the luminance value of the CIELAB color space system in both specimens. The L* value of the specimen teeth 3 decreased by 14.8 after administration of the infused strawberry leaf extract with a 15% concentration. After continued application of the infused strawberry leaf extract with a 30% concentration of the abstract, the value of L* on specimen tooth 3 rose as much as 2.2, and was significantly different ($p<0.05$). The a* value of the specimen tooth 1 increased by 5.0; specimen tooth 2 increased by 3.8. Based on statistical analysis, the increase was significant ($p<0.05$) for the value of a* in the CIELAB color space system in both specimens. The a* value of specimen 3 in the specimen tooth occurs after an increase of 1.0 infused strawberry leaves extract 15%. After continued application of infused strawberry leaf extract at a 30% concentration, the grades A* at the specimen tooth 3 rose as much as 0.2; such change was significantly different ($p<0.05$). The B* value of the specimen tooth 1 decreased by 3.4; specimen tooth 2 increased by 1.6. The decrease and increase did not differ significantly ($p>0.05$) for the value of b* color space CIELAB system in both specimens. The B* value of the specimen teeth 3 decreased by 3.2 after the administration of the infused strawberry leaf extract at a 15% concentration. After the continued application of the 30% concentration, the value of b* in the specimen teeth 3 decreased by 4.2; these changes were not statistically significant ($p>0.05$).

Correlation test of CIELAB color method space shows a component correlation of a strongly negative value of L*, moderately positive a*, and strongly negative b*. The R value of the specimen tooth 1 decreased by 34.2; specimen tooth 2 decreased by 31.0. Based on the statistics, the decrease was significant ($p<0.05$) for the value of R (red) RGB color space systems in both specimens. The R value of specimen 3 in the specimen tooth was decreased by 39.6 following the administration of the infused strawberry leaf extract at a 15% concentration. After the continued application of the infused strawberry leaf extract at a 30% concentration, the value of R of the tooth specimens 3 rose as much as 3.0; this change was significantly different ($p<0.05$). The G value of specimen tooth 1 decreased by 42.8; specimen tooth 2 decreased by 39.0. Based on the statistics, the decrease was significant ($p<0.05$) in the value of G (green) RGB color space systems in both specimens. The G value of specimen 3 in the specimen tooth was decreased by 41.2 after administering the infused strawberry leaf extract at a 15% concentration. After the continued application of the infused strawberry leaf extract at a 30% concentration, the G value of specimen tooth 3 rose as much as 5.4, which was a statistically significant difference ($p<0.05$). The B value of specimen tooth 1 decreased by 33.2; specimen tooth 2 decreased by 38.2. Based on the statistics, the decrease was significant ($p<0.05$) in the value of B (blue) RGB color space systems in both specimens. The B value of specimen 3 in the specimen tooth was decreased by 34.6 following the administration of the infused strawberry leaf extract at a 15% concentration. This change was significant ($p<0.05$). After the continued application of the infused strawberry leaf extract at a 30% concentration, the B of specimen 3 rose by 12.6. Based on statistical testing, this change was not significantly different ($p>0.05$). Correlation test of RGB color space method, showed a strongly negative correlation value for component R, a strongly negative G value, and a negative B value.

The C value of the specimen tooth 1 increased by 10.4; the specimen tooth 2 decreased by 12.2. The increase in the value of C (cyan) on the CMY color space system was significantly different ($p<0.05$). The B value of

specimen 3 in the specimen tooth increased by 15.4 for the infused strawberry leaf extract at a 15% concentration. Following continued application of the infused strawberry leaf extract at a 30% concentration, the value of C in specimen tooth 3 rose as much as 0.2; this change was significantly different (p<0.05). The M value of specimen tooth 1 increase by 17.2; specimen tooth 2 increased by 16. According to statistics, the increase in the value of the M for the CMY color space system was significant (p<0.05). The M value of specimen 3 in the specimen tooth increased by 15.6 following the administration of the infused strawberry leaf extract at a 15% concentration. After continued application of the infused strawberry leaf extract at a 30% concentration, the M in specimen tooth 3 decreased as much as 1.0; these changes were significantly different (p<0.05). The Y value of specimen tooth 1 increased by 8.4; specimen tooth 2 increased by 14.2. Based on statistics, the increase in the value of Y (yellow) in the CMY color space systems was not significant (p>0.05). The Y value of specimen 3 in the specimen tooth increased by 10.2 for the infused strawberry leaf extract at a 15% concentration. After the continued application of the infused strawberry leaf extract at a 30% concentration, the value of Y in specimen tooth 3 decreased as much as 6.8; this change was not significant (p>0.05).

The result showed a positive correlation strong value component for C, a strongly positive M, and a positive Y. The H value of specimen tooth 1 decreased by 12.8; specimen tooth 2 increased by 88.8. The H value of specimen 3 in the specimen tooth increased by 35.4 for the infused strawberry leaf extract at a 15% concentration. After the continued application of the infused strawberry leaf extract at a 30% concentration, the H value of specimen 3 rose as much as 34.4. The S value of specimen tooth 1 decreased by 0.07. The S value of specimen 3 in the specimen tooth decreased by 0.15 after the administration of the infused strawberry leaf extract at a 15% concentration. Following the continued application of the infused strawberry leaf extract at a 30% concentration, the value of S in the specimen tooth 3 decreased as much as 0.04. The L value of specimen tooth 1 decreased by 35; specimen tooth 2 decreased by 26.3. The value of lightness in the HSL color space system did not significantly differ (p>0.05). The L value of specimen tooth 3 decreased by 26.3 following the administration of the infused strawberry leaf extract at a 15% concentration. After the continued application of the infused strawberry leaf extract at a 30% concentration, the value of L in specimen tooth 3 rose as much as 8.8; however, this change was not significantly different (p>0.05). The correlation test method showed a correlation for the HSL color space component values, including a moderately positive H, a very strongly negative S negative, and a strongly negative L.

Discussion

In this study, artificial coloring using tea solution was applied on the tooth surface, following the application of infused strawberry leaf extract at concentrations of 15% and 30%. The selection of concentrations of 15% and 30% were based on the concentrations of the tooth whitening ingredient $CH_6N_2O_3$ or carbamide peroxide done at home, ranging from 10–20% concentrations.[10] The application was performed for seven hours and repeated 28 times. It was based on the use of carbamide peroxide as a whitening agent at home, which has demonstrated acceptable results for 10 hours of use for 2–4 weeks.[10] There were several challenges with this study, such as the difficulty of finding strawberry leaves in large quantities. Another obstacle is the making of a spectrophotometer to measure light. This is due to the need to use the camera at a distance, and the lighting and shutter speed are always the same at every shooting.

The analysis of the results of this study was based on the CIELAB, RGB, CMY, and HSL color space systems. These systems help us in knowing where colors are based on color space system components. The CIELAB color space system has value components for L * (luminance), a * (- a * green, + a * red), and b * (- b * blue, + b * yellow). The RGB color space system has value components of R (red), G (green), and B (blue). The CMY color space system includes C (cyan), M (magenta), and Y (yellow). The HSL color space system is comprised of H (hue), S (saturation), and L (lightness). Based on the CIELAB color space, a 15% concentration of infused strawberry leaf extract experienced a decline in the values of L * and b * and an increase in a *. This shows that after application, the tooth surface color shifts toward refined red, blended yellow, and darker.

In the HSL color space system, after the application of infused strawberry leaf extract at a concentration of 15%, there was impairment in the components of hue, saturation, and lightness. This shows that the surface of the tooth became darker. This is in accordance with the lightness value component, whereby if toward 0 becomes darker (black) and the color saturation component whereby if toward 0 will lose the purity of a color.[8] Thus, infused strawberry leaf extract at a concentration of 15% cannot restore the color of a discolored tooth surface. This may be caused by the transport of active substances during the extraction process of strawberry leaves.

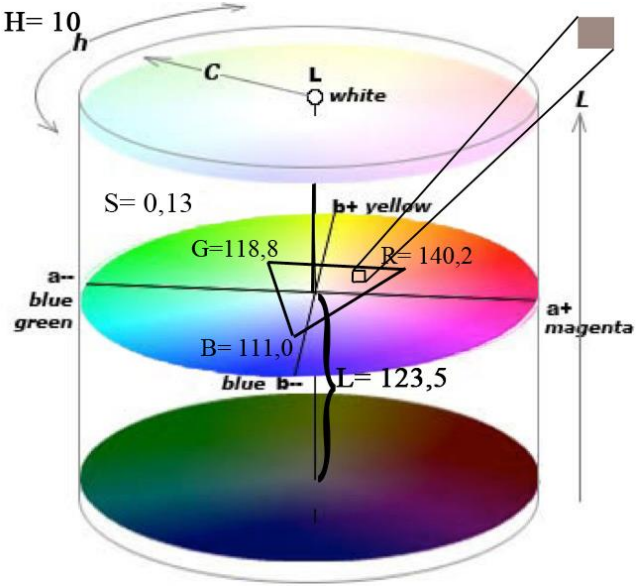

Figure 1. Assessment color using the RGB color space and HSL on specimen tooth 1 (after the application of infused strawberry leaf extract at a 15% concentration).

At a concentration of 30% of infused strawberry leaf extract, the CIELAB color space system showed an increase in a * and b * and a decline in the luminance. This shows that the surface of the teeth after the application of the extract became darker because of the decline in values greater than Keinan luminance value of a * and b *. The RGB color space showed a decrease in the amounts of red, green, and blue, showing that the tooth surface post-color application became darker. Using the CMY color space method, a 30% concentration of infused strawberry leaf extract showed an increase in the values of cyan, magenta, and yellow. This indicates the darkening of the tooth surface color. In addition, the HSL color space system results indicated a reduction in the value saturation and lightness and an increase in the color hue.

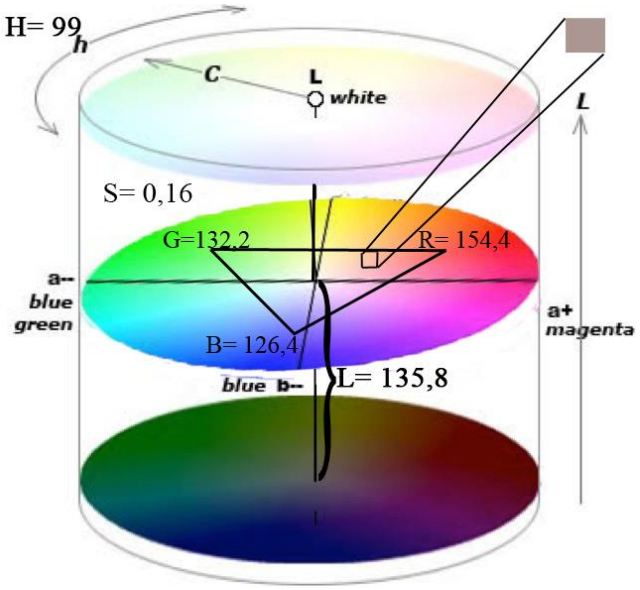

Figure 2. Color scoring system using the RGB and HSL color spaces on specimen tooth 2 (after the application of the infused strawberry leaf extract at a 30% concentration).

Thus, the strawberry leaf extract infused with a concentration of 30% cannot restore the tooth color for extrinsic discoloration. This may be due to the active substance that does not carry over when the extraction process occurs. At a stratified concentration, with the method of the CIELAB color space, tooth surface changed color. In the luminance component, the surface of specimen tooth 3 became darker because the luminance value initially decreased at a given concentration of 15%, but after the application of a 30% concentration, it increased. The a* value component increased when given a 15%-concentration extract, and even more so at 30%, so that the surface of specimen 3 became redder in hue. For b*, the surface of specimen tooth 3 decreased after applying a concentration of 15% as well as the concentration was increased to 30%. This indicates that the third specimen tooth surface discoloration tended toward a yellow hue. Thus, it can be said that the tooth surface of specimen 3 shifted toward a pure red, yellow, and increasingly dark color. In the RGB color space system, red, green, and blue all decreased at a given concentration of 15%. However, after the application was continued, at a 30% concentration, all components of RGB values increased. However, the increase was not as

high as the decrease, so it can be said that specimen 3 became darker. Correlation of increased concentration based on RGB is strongly negative to R and G components and negative to B components. This shows that there is a correlation between the increased concentration and the increased color changes toward darker colors, where the darker color made from the blue color is not as strong as that made from red or green.

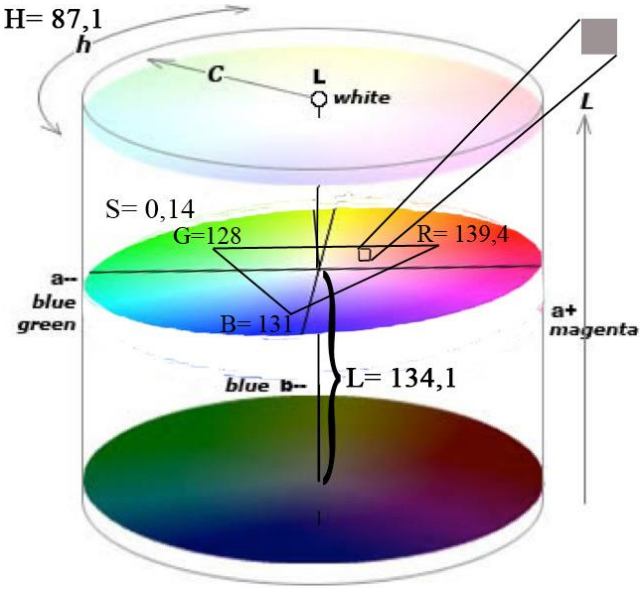

Figure 3. Assessment based on RGB and HSL color space specimen tooth 3 (after the application of infused strawberry leaf extracts at 15% and 30% concentrations).

In the CMY color space system, cyan, magenta, and yellow all rose at a concentration of 15%. However, after the application was continued with a concentration of 30%, there was a decline in the values for magenta and yellow and an increase in cyan. The reduction that occurred was smaller than the rise, indicating that the tooth surface of specimen 3 became darker. Correlation of increased concentration based on CMY is strongly negative to C and M components and negative to Y components. This shows that there is a correlation between the increase in the concentration and more pronounced darkening, where the darker color made from yellow was not as strong as that made from cyan or magenta.

In the HSL color space system, the hue value increased at a concentration of 15% and increased more after the application was continued at a concentration of 30%. This shows that there is a color change toward a red color. In the saturation value, the tooth surface had a tendency to become blurrier in color because of the decrease in the saturation value at a concentration of 15% and became even blurrier after the application was continued at a concentration of 30%. Initially, the lightness value decreased after the concentration of 15% was administered, but after the application was continued at a concentration of 30%, it increased. However, the decrease was greater than the increase; thus, the third specimen became blurrier and darker red. Correlation of increased concentration based on HSL is infirmly negative to hue, strongly negative to saturation, and strongly positive to lightness. This shows that there is a correlation between the increase in the concentration and the increase in the color changes toward blurrier, darker colors, losing their pure color.

This study shows the changes in the tooth surface color after administering strawberry leaf extract; the changes did not correct the tooth discoloration, but instead made the tooth darker. One of the causes of the color change is the presence of the dye in the leaves (green substance/chlorophyll) that makes the surface of the teeth darker. This might be due to the infusion process involving heating, which prevents elagat acid from working effectively. The color change that occurred at a concentration of 30% was less significant than the changes at a concentration of 15%, which may be related to changes in the color of the enamel rods interrupted experiencing saturation point faster at a concentration of 30% than 15%. The RGB and CMY color space models are widely used in the world of coloring. However, the models have differences. CMY is commonly used in the printing process, while RGB is commonly used in the laboratory process. In the present study, RGB was a more sensitive color space system for analyzing the color because it had a considerable range of values before and after the application of infused strawberry leaf extract.

Conclusions

From this research, can be concluded that the use of infused strawberry leaf extract is unable to return the color of a discolored tooth and that the RGB color space system has the highest color space sensitivity of the tooth

surface. The author recommends that further research be done on the materials contained in strawberry leaves and the use of other extraction processes to determine the whitening tooth effect in strawberry leaves. In addition, the destilation process should be repeated twice to acquire an uncontaminated extract. There is a need for further information and publications to conduct further similar research.

Declaration of Interest

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