

Effect of alcoholic and non-alcoholic beverages on color stability and surface roughness of resin composites: An *in vitro* study

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Abstract

Background: Consumption of certain beverages may affect the esthetic and physical properties of the resin composite, thereby undermining the quality of restorations.

Aim: To analyze the effect of three beverages (Whiskey, Coca-Cola, and Nimbooz) on color stability and surface roughness of two different types of resin composites at various time intervals *in vitro*.

Materials and Methods: A methacrylate-based nanofilled composite and a silorane-based microhybrid composite were used. Each material was randomly divided into four equal subgroups of 10 samples each according to the beverages used (Whiskey, Coca-Cola, Nimbooz, and Distilled water). The samples were immersed in each beverage for 10 minutes each day for 56 days. Color change and surface roughness measurements were noted at the baseline — the seventh, fourteenth, twenty-eighth, and fifty-sixth day.

Statistical Analysis Used: RANOVA and Bonferroni tests were used to find the difference in color change and surface roughness in the two resin composites when immersed in different beverages. The Pearson Correlation test was carried out to test if any correlation existed between color change and surface roughness.

Results: Silorane-based resin composites were more stable in different beverages over time.

Conclusion: The effect of interaction of different resin composites, various beverages, and time depended on a multitude of factors.

Keywords: Beverages; color change; resin composite; surface roughness; time

INTRODUCTION

Esthetic failure is one of the most common reasons for the replacement of restorations. Color changes in resin composites occur from intrinsic and extrinsic factors. Intrinsic factors involve chemical changes in the material. Extrinsic factors, such as, adsorption or absorption of stains, pose a major problem for esthetic restorations. Surface roughness is one reason for exterior discoloration.^[1]

Consumption of certain beverages may affect the esthetic and physical properties of the resin composite, thereby, undermining the quality of restorations.^[2] The chemicals in beverages can lead to wear and surface degradation of composite restorations, resulting in unesthetic external pigmentation, such as, stains. Due to its low pH, ethanol can produce erosion and alter some properties of

composites, as well.^[3] Alcohol is also thought to act as a plasticizer of the polymer matrix.^[4] It is not known if the alcohol in typical alcoholic beverages has a negative effect on the wear resistance of resin composites.

Different types of composites may behave differently. Currently nanocomposites are being increasingly used. Of late, silorane-based resin composites have been introduced. The effect of different beverages on these two types of materials is relatively unknown.

This knowledge is important to the practitioner for the selection of restorative material for the management of patients, where an exogenous erosive habit is under treatment.

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Aims and objectives

The aim of the present study was to analyze the effect of three common alcoholic and nonalcoholic beverages (Whiskey, Coca-Cola, and Nimbooz) on the surface roughness and color stability of two different types of resin composites (Nanohybrid and Microhybrid) *in vitro*.

1. To evaluate the color change in both the resin composites in different beverages at different time intervals
2. To evaluate the change in surface roughness in both the resin composites in different beverages at different time intervals
3. To see if any co-relation exists between the change in the surface roughness and color stability

MATERIALS AND METHODS

Two visible light-cured resin composites were used in this study.

Group 1: Methacrylate-Based Nanofilled Composite {CERAM X™ Mono nano-ceramic restorative (Dentsply Caulk, DE, USA)}. M2 shade

Group 2: Silorane-Based Microhybrid Composite {FILTEK™ P90 Low-Shrink Posterior Restorative (3 M ESPE St. Paul, MN, USA)}. A2 shade

Forty disk-shaped samples (8 mm×2 mm) were prepared for each material using a Teflon mould.^[5] The samples were cured as per the manufacturer's instructions.

Each disk was polished using the Super-Snap polishing system according to the manufacturer's instructions (Shofu Inc, Kyoto, Japan). The same operator polished all the samples in random sequence.

All the samples were stored at 37°C in distilled water for 24 hours for rehydration and completion of polymerization.^[6]

After 24 hours of storage, each material was randomly divided into four subgroups of 10 samples each, according to the beverages used.

1. Group 1A and 2A: Distilled Water (Control)
2. Group 1B and 2B: Coca-Cola (Coca-Cola Company, India). pH=1.57
3. Group 1C and 2C: Nimbooz (Pepsi Foods Pvt. Ltd., India). pH=2.32
4. Group 1D and 2D: Original Choice Whiskey (John Distilleries Ltd., Bangalore). 42.8% v/v. pH=3.76

The samples were blotted dry using tissue paper and the baseline readings were obtained for Surface Roughness (Ra) and Color Change (ΔE) for each group.

Surface roughness was measured using a Profilometer,

Surtronic 3+ (Taylor Hobson, Precision). The diamond stylus tip of 2 μ m radius was placed at the extremity of the disk-shaped sample and it traversed the surface of the disk to trace a 4.8 mm course, providing the first measurement of Ra in micrometers. Two additional measurements were taken by rotating the disk to 90° and the mean Ra was obtained from the three values.^[7]

Color change was measured using a Spectrophotometer, Spectrolino (Gretag-Macbeth AG, Germany). The color was assessed using the CIEL*a*b* measuring system. The color measurements were performed at the center of the resin composite disks and repeated thrice. The ΔE values were obtained for each sample and the mean of the values was calculated.^[8]

After baseline readings the samples were immersed in the respective beverages. The immersion regimen followed was as follows: The samples in each group were immersed in the respective beverage for 10 minutes every day. For the remaining part of the day, the samples were kept immersed in distilled water. This regimen was followed for 56 days. Surface roughness and color measurements were checked on the seventh, fourteenth, twenty-eighth, and fifty-sixth day.

For statistical analysis, SPSS for windows V. 11.5 was used. Repeated Measures of analysis of variance (RANOVA) and the Bonferroni test were used to find the difference in color change and surface roughness in the two resin composites when immersed in distilled water, Coca-Cola, Nimbooz, and Whiskey. The Pearson Correlation test was performed to test if any correlation existed between color change and surface roughness.

RESULTS

There were three variables in this study: Two resin composites, four immersion solutions, and five time intervals. The interaction between these three variables produced statistically significant results in color change ($P<0.001$; $F=53.581$) and surface roughness ($P<0.001$; $F=12.879$).

When discoloration of the two resin composites was considered, the overall maximum discoloration took place in the methacrylate-based composite when compared with the silorane-based composite, and the results were statistically significant. Figure 1 shows a linear increase in color change with increasing time in both the materials.

When discoloration in different beverages was considered, maximum discoloration took place in Coca-Cola>Whiskey>Nimbooz and minimum in Distilled water. Figure 2 and 3 show a linear increase in color change

in both the materials, at different time intervals, in four different immersion solutions.

When change in surface roughness of the two resin composites was considered, the overall maximum surface roughness change took place in the methacrylate-based composite as compared to the silorane-based composite and the results were statistically significant. Figure 4 shows a linear increase in surface roughness with increasing time in both the materials.

When the surface roughness change in different beverages was considered, the maximum change in surface roughness took place in Coca-Cola>Whiskey>Nimbooz and minimum in Distilled water. Figures 5 and 6 show a linear increase in surface roughness in both the materials, at different time intervals, in four different immersion solutions.

The Pearson Correlation test showed a correlation of 0.936 for Ra values and 1 for Delta E values

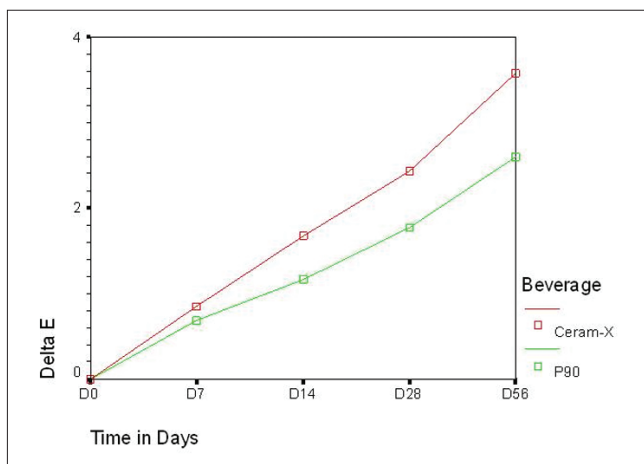


Figure 1: Comparison of Delta E of Ceram-X and P90

DISCUSSION

The present study was conducted on two resin composites; one was a methacrylate-based nanohybrid composite and

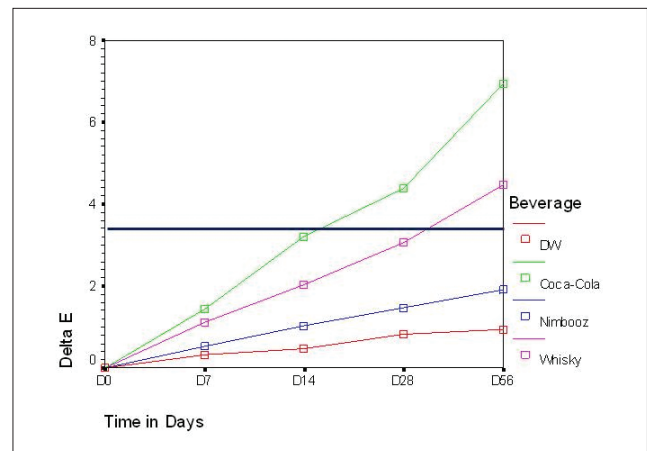


Figure 2: Comparison of Delta E in Ceram-X in different beverages over time

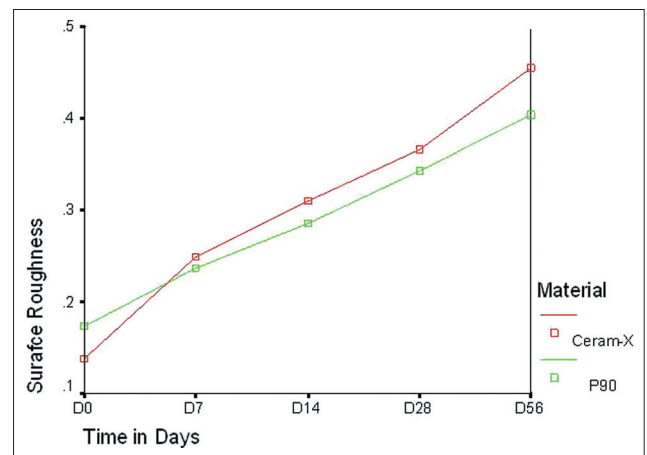


Figure 4: Comparison of Ra of Ceram-X and P90

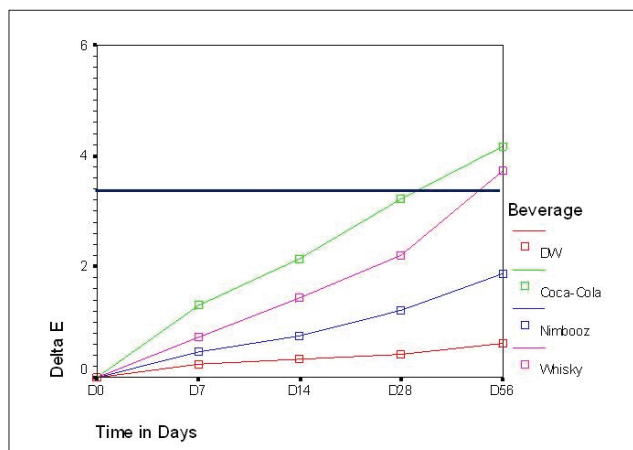


Figure 3: Comparison of Delta E in P90 in different beverages over time

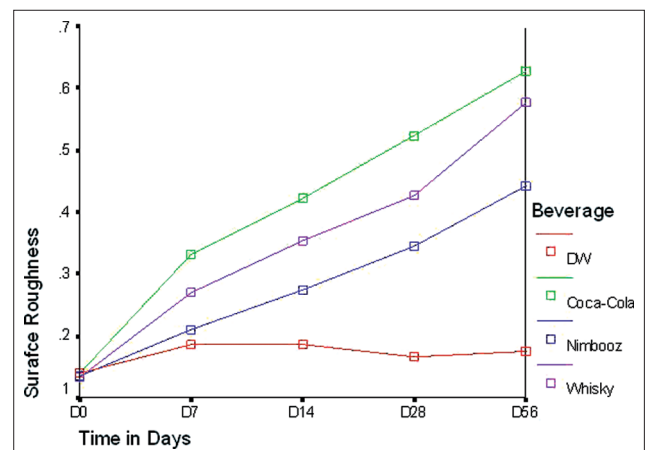


Figure 5: Comparison of Ra in Ceram-X in different beverages, over time

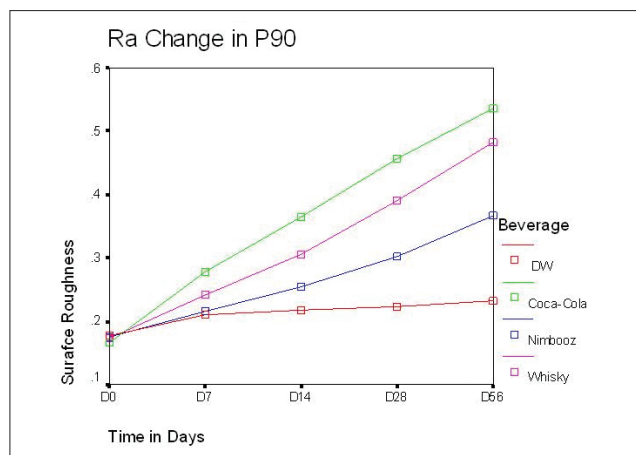


Figure 6: Comparison of Ra in P90 in different beverages over time

the other was a silorane-based microhybrid composite. Long-term clinical performance and color stability of the nanofilled composites are yet to be known and proven. Similarly, the silorane-based resin composite is a relatively recent product and has not been researched on its degradation under acidic conditions and color stability.

In the present study, surface roughness assessment was chosen because surface micromorphology would effect the staining susceptibility. The CIEL*a*b* system for measuring the chromaticity was chosen to record color differences, because it is well-suited for the determination of small color differences.^[9]

Commonly consumed alcoholic (Whiskey) and nonalcoholic beverages (Coca-Cola and Nimbooz) were used as the discoloration media in the present study, to evaluate the discoloration of resin composites in an *in vitro* setting. Among the alcoholic beverages, previous studies have evaluated the effect of red wine on the discoloration of a resin composite. As the consumption of whiskey is presumably higher and more prevalent than red wine, it became even more reasonable to select it as one of the staining solutions.

During consumption, food or drink comes in brief contact with the tooth surfaces before it is washed away by saliva. However, in the previous studies, substrates usually contacted acidic foodstuff for a prolonged period of time. Thus, the immersion regimen selected was to immerse each sample in the respective beverage for ten minutes each day. For the remaining part of the day the samples were kept in distilled water to mimic the neutralizing effect of saliva. The measurement of color change and surface roughness was made at different time intervals (baseline, the seventh, fourteenth, twenty-eighth, and fifty-sixth day) to see the relationship of time on surface degradation.

According to the results of this study, both materials became significantly stained and rougher after they were subjected to the immersion regimen. This can be ascribed to the capability of acid media to soften resin-based restorative materials.^[10]

Overall, the maximum change in both color and surface roughness took place in methacrylate-based composite as compared to silorane-based composite and the results were statistically significant. This result could be explained on the basis of different chemical compositions of both the materials. Ceram-X is a nanohybrid composite containing methacrylate-modified polysiloxane and dimethacrylate resin, while Filtek P90 contains a silorane resin. Both had comparable filler loading: 76% (w/w) and 57% (v/v) for Ceram-X and 76% (w/w) and 55% (v/v) for Filtek P90. Thus, the degradation that took place could not be attributed to its higher/lower resin content. This was in accordance with the observations made in the previous studies, which stated that relatively small differences in the filler-resin ratio could not explain variations in water sorption.^[2,11]

Staining of resins by beverages is caused by the adsorption or absorption of colorants by the resins^[12] and the resin's affinity for extrinsic stains is modulated by its water sorption rate.^[1,13] Methacrylate-modified polysiloxane and dimethacrylate resins may have higher water sorption compared to the silorane resin. Siloranes may be extremely hydrophobic, perhaps making the oxirane groups inaccessible to attack by water or water-soluble species.^[14] The increased synergism between filler particles and resin matrix may be responsible for the reduction in water sorption and solubility.^[15] Also nanohybrid fillers seem to be less color-resistant than the micron-sized fillers due to the former's relatively high water sorption character.^[16]

As the interface between the resin and filler particles is one of the weakest points of the composite material, with a high sensitivity to water sorption, it may be supposed that hydrolytic degradation of this interface can modify the way in which light is scattered by the particles.^[11]

In this study the Pearson Correlation test showed that there was a correlation between both the tested parameters. The smoother the surface, the more resistant the material was to staining.^[1]

When different beverages were compared, Coca-Cola had the most degrading effect on both the parameters followed by Whiskey and Nimbooz. No significant change was seen in distilled water. All the beverages used in the study were acidic with Coca-Cola being the most acidic (pH=1.57)>Nimbooz (pH=2.32)>Whiskey (pH=3.76). Lower pH was seen to negatively affect the wear resistance of composite materials.^[17] Lower pH increased the erosion in polymers.^[18] Thus, the higher degradation that took

place in Coca-Cola could be attributed to its lower pH. However, Nimbooz showed a lower degradation than Whiskey. This result could be due to the alcohol content of Whiskey (42.8% v/v), as solvents such as ethanol penetrate the resin matrix.^[19] Studies have shown sub-superficial degradation, expansion, and inferior physical properties when Bis-GMA-based composites were exposed to the ethanol solvent.^[20]

More surface roughness change in Coca-Cola than Whiskey is supported by an earlier study, in which Coca-Cola caused a significant increase in surface roughness than sugar cane spirit (alcoholic graduation 39.00% v/v).^[7]

When discoloration in Coca-Cola and alcoholic beverages is compared, the result of the present study is conflicting. However, the previous studies compared the staining ability of Coca-Cola with red wine, in which red wine caused more color change.^[9,21,22] Cola gains its color through the addition of caramel color and red wine, mainly from grapes. Probably the caramel in Coca-Cola has more staining ability than the colorants present in Whiskey.

Time was found to be a critical factor for the color stability of tooth colored restorative materials. In the present study, results showed that as the immersion time increased, the color changes became more intense.^[23]

Values of ΔE^* greater than or equal to 3.3 are visually perceptible and clinically unacceptable to 50% of the trained observers.^[24]

In this study, in the methacrylate-based composite, ΔE^* in the Coca-Cola group crossed the 3.3 level around the fourteenth day, while in the Whiskey group it crossed after the twenty-eighth day. In Nimbooz and the distilled water group ΔE^* was below 2 at all time intervals. Although in the silorane-based composite, the ΔE^* in the Coca-Cola group crossed the 3.3 level around the twenty-eighth day while in the Whiskey group it crossed near the fifty-sixth day. In the Nimbooz and distilled water group, the ΔE^* was below 2 at all time intervals.

It is difficult to extrapolate the results of this study to *in vivo* conditions. However, the results of this study can give an insight into how different resin composites may behave when exposed to different beverages, thus affecting the clinician's choice of material and the patient's control of dietary habits.

CONCLUSION

The results of this *in vitro* staining and surface roughness study showed that the effect of interaction of different resin composites, various beverages, and time, depended on a multitude of factors.

- The silorane-based resin composite exhibited better color stability and relatively lower surface roughness when compared to methacrylate-based resin composites in alcoholic and nonalcoholic beverages
- Coca-cola, among the three beverages, caused the highest discoloration and surface roughness change in both the tested resin composites
- Both the resin composites exhibited increased staining and surface roughness change, over time, on selective exposure to alcoholic and nonalcoholic beverages

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