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ARTICLE

INFLUENCE OF $NAHCO_3$ POWDER ON COLOR AND ROUGHNESS OF THE COMPOSITE SUBMITTED TO BLEACHING AND EUTERPE OLERACEA.

Influencia del polvo de $NaHCO_3$ en el color y rugosidad del composite sometido a blanqueo y Euterpe oleracea

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ABSTRACT:

Aim: This study aims to evaluate the surface roughness and susceptibility to staining of bleached composite resin with 22% carbamide peroxide, as well as the effect of subsequent prophylaxis with NaHCO3 powder.

Material and Methods: Forty disk-shaped (2 × 6 mm) specimens of composite resin (Z250 XT) were prepared. Half of the specimens were subjected to bleaching with 22% carbamide peroxide, and the other half were stored in artificial saliva. In sequence, all specimens were immersed in acai juice (*Euterpe oleracea*) for 4 h for 14 days, and subdivided into two groups. Group 1 samples were subjected to prophylaxis treatment, while group 2 samples were subjected to treatment with artificial saliva. Surface roughness (Ra) and color (ΔE*) were measured after polishing (T0), bleaching (T1), immersion in acai juice (T2), and application of NaHCO3 powder (T3) using a profilometer and a spectrophotometer.

Results: Statistical analyses (analysis of variance and Tukey's test, $p \leq 0.05$) revealed that regarding color there was statistically significance for the factors in isolation, except for the factor bleaching. For both color and surface roughness there was statistically significant difference for the interaction, except for the interaction between $NaHCO_3$ power and bleaching.

Conclusion: The $NaHCO_3$ air-powder polishing decreases the staining of the composite resin; however, it increases the surface roughness. With respect to the color variable, the whitening factor had no significant effect on the tested material; however, it increases surface roughness.

KEYWORDS:

Composite resins; surface properties; color; dental materials; tooth bleaching; euterpe.

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RESUMEN:

Objetivo: Este estudio tiene como objetivo evaluar la rugosidad de la superficie y la susceptibilidad a la tinción de la resina compuesta blanqueada con peróxido de carbamida al 22%, así como el efecto de la profilaxis posterior con polvo de $NaHCO_3$.

Material y Métodos: Se prepararon cuarenta especímenes en forma de disco (2 × 6 mm) de resina compuesta (Z250 XT). La mitad de los especímenes se sometieron a blanqueo con peróxido de carbamida al 22% y la otra mitad se almacenó en saliva artificial. En secuencia, todos los especímenes se sumergieron en jugo de acai (*Euterpe oleracea*) durante 4 h durante 14 días, y se subdividieron en dos grupos. Las muestras del grupo 1 se sometieron a tratamiento profiláctico, mientras que las muestras del grupo 2 se sometieron a tratamiento con saliva artificial. La rugosidad de la superficie (Ra) y el color (ΔE*) se midieron después del pulido (T0), el blanqueo (T1), la inmersión en jugo de acai (T2) y la aplicación de polvo de NaHCO3 (T3) utilizando un perfilómetro y un espectrofotómetro.

Resultados: Los análisis estadísticos (análisis de varianza y prueba de Tukey, $p \leq 0.05$) revelaron que en relación al color hubo significancia estadística para los factores en forma aislada, excepto para el factor blanqueamiento. Tanto para el color como para la rugosidad de la superficie hubo una diferencia estadísticamente significativa para la interacción, excepto para la interacción entre el poder de $NaHCO_3$ y el blanqueo.

Conclusión: El pulido al aire con polvo de $NaHCO_3$ disminuye el manchado de la resina compuesta; sin embargo, aumenta la rugosidad de la superficie. Con respecto a la variable color, el factor de blanqueamiento no tuvo efecto significativo sobre el material ensayado; sin embargo, aumenta la rugosidad de la superficie.

PALABRAS CLAVE:

Resinas compuestas; propiedades de superficie; color; materiales dentales; blanqueamiento de dientes; euterpe.

INTRODUCTION.

The extensive use of resin composites by dentists has become possible owing to the significant advancements in new restorative materials that enable their applications in both anterior and posterior teeth.[1] However, the failure or success of any esthetic restoration also depends on the color stability and surface roughness, among other characteristics of the material.[2]

Color stability of resin composites is based on extrinsic and intrinsic factors.[2-7] Intrinsic factors are represented by the oxidation of chemical activator, while extrinsic factors alter the color of the composites by the absorption or adsorption of dyes present in food and beverages, oral antiseptics, and smoke.[3-5,7]

Another characteristic that contributes to the success of resin composite restorations is surface roughness. Increase in surface roughness can lead to the adherence of bacterial plaque, and consequently the recurrence of caries and pigmentation of the resin composite, which results in early aging of the restorations.[5,8]

Currently, tooth bleaching is used abundantly in the dental office. This is considered the most conservative treatment for whitening of teeth compared with other treatments. Thus, several bleaching products and techniques are available in the market.[9] The monitored tooth bleaching (home) technique involves the application of carbamide peroxide or hydrogen peroxide at various concentrations on tooth surfaces with the aid of customized trays.[10]

According to Barcessat *et al.*,[9] the home technique has several benefits: the bleaching gel is inexpensive and nondestructive to the tissues, has little recurrence of color, and requires few consultations. Nevertheless, when natural teeth are subjected to bleaching, restorations may undergo a change in color, and this may compromise esthetics.[2] Similarly, the surface roughness may undergo considerable changes.[11] Although it is possible to change the restorations in these situations, this is frequently not necessary, particularly in the posterior teeth.[12-13]

Currently, there is a growing interest for healthy eating, and Euterpe oleracea (acai) has attracted attention owing to its high energy load. Leite *et al.*,[7] demonstrated that after 12 weeks of consuming acai, a superfood, the staining of resin composite Z350 (3M-ESPE) became clinically unacceptable. Prophylactic agents such as sodium bicarbonate jet are more frequently used than the prophylactic paste because it requires a short time for adequate plaque removal and stain removal.[14]

The influence of acai on the color stability and surface roughness of resin composites subjected to bleaching has not been investigated in detail yet. Furthermore, no studies have investigated the effectiveness of sodium bicarbonate jet in removing the possible stains caused. Therefore, this *in vitro* study aims to evaluate the surface roughness and susceptibility to staining of bleached composite resin with 22% carbamide peroxide and the effect of subsequent prophylaxis with $NaHCO_3$ powder.

MATERIALS AND METHODS.

A commercially available microhybrid resin composite product (shade A2) was used in this study (Table 1). The response variables were color (ΔE*) and surface roughness (μm). The other materials used in this study are listed in Table 2. A flowchart of the study design is represented in Figure 1.

Specimen Preparation

Forty samples (n = 10) were prepared (2 × 6 mm) using a Teflon matrix. After inserting the material into the mold, a polyester strip was pressed using 1000 g weight for 20 s onto the surface of the mold with a glass plate (Application mode, Table 1).

After light curing through polyester strips, the specimens were stored in artificial saliva for 24 h at 37±1°C. The specimens were polished successively using the Sof-Lex system (3M ESPE, St. Paul, MN, USA), following the decreasing order of granulation.

Bleaching Treatment

For bleaching treatment, the specimens were randomized into two groups of twenty.

Group 1: The samples were bleached with 22% carbamide peroxide (perfect whiteness, FGM, Produtos Odontológicos, Table 2) for 1 h on daily basis for 14 days using a whitening plate made up of exact dimensions as that of the specimens in 1-mm-thick silicone plates (Bio art - Dental equipments Ltd.).

After each day of bleaching, the samples were rinsed with distilled water to eliminate bleaching material from the sample surface and stored in an artificial saliva at 37±1°C.

Group 2 (control): The samples were stored in distilled water at 37±1°C for two weeks.

Staining procedure

All specimens were subjected to acai juice (Guarani – Amazoo - Agrofruit International from Brasil LTDA, Visconde do Rio Branco, Minas Gerais, Brazil) for 1 h and 4 times a day, for 14 days. The pH of the solutions was measured using a pH meter (PHT; T-1000, TEKNA Ind/Com Ltda, São Bernardo do Campo, São Paulo, Brazil); the pH did not change during the treatment period.

Prophylactic Treatment

Groups 1 and 2 were subdivided into two groups, after 24 h of incubation in acai juice (staining).

Group 1A and Group 2A: The specimens were air-polished with a sodium bicarbonate dental powder (Gnatus, Ribeirão Preto, São Paulo, Brazil) for 10 s. After each day of prophylactic treatment, the samples were rinsed with distilled water to remove any remaining particles and stored in artificial saliva at 37±1°C for 24 h.

Group 1B and Group 2B (control group): the specimens were not treated.

Color Analysis

Color analysis was performed 24 h after the specimen preparation (T0), at the end of bleaching

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treatment (T1), at the end of staining procedure (T2), and 24 h after prophylactic treatment (T3).

For color evaluation, the spectrophotometer model SP62S was used with the software model QA Master I (X-Rite Incorporated - Neu-Isenburg, Germany). Each specimen was carefully manipulated using clinical forceps (Millennium, Golgran, SP, Brazil), dried with absorbent paper, and kept in a device duly prepared with niches for placement of the specimens and standardization of the readouts against an opaque white background.

Color measurements were performed using the CIE L* a* b* color system. The ΔE* value is the total difference between two color stimuli and was calculated using following formula:

$$\Delta E^* = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}.$$

The CIE L * a * b* system uses three parameters to define color: luminosity (lightness), hue, and saturation. Luminosity represents the degree of lightness and darkness of an object, and it is represented by L* value where L* = 100 for white and L* = 0 for black. Parameters a* and b* are used to represent hue. The positive and negative a* values indicate red and green color, respectively, whereas the positive and negative b* values indicate yellow and blue color, respectively. The numerical values of a* and b* represents saturation and intensity of hue. The values of ΔL*, Δa*, and Δb* correspond to the differences in the values of L*, a*, and b*, respectively, compared with the first color readout (initial).

Each specimen was again carefully manipulated using clinical forceps to avoid manual contact with the evaluator, which could deposit residues and/or grease and influence the values found. The specimens were carefully dried with absorbent paper to prevent interference from humidity in the color change values.

Surface Roughness Analysis

The average surface roughness (Ra, µm) was measured using a surface profilometer (SJ-201 P/M; Mitutoyo, Japan). Each specimen was dried using a paper towel and positioned on the device using tweezers (Colgran, São Paulo, Brazil).

The readings were programmed in the control unit and reading register, and the distance of 0.8 × 5 µm covered by the measuring tip was determined and standardized. Surface roughness was measured thrice for each specimen; the measurements were performed using a guide for standardization of readings, and the arithmetic mean of these values was used for statistical analysis.

Analysis was performed 24 h after specimen preparation (T0), at the end of bleaching treatment (T1), at the end of staining procedure (T2), and 24 h after prophylactic treatment (T3).

Statistical Analysis

Data on color and roughness were obtained and analyzed by three-way ANOVA (time dependent factor), after checking for normality and homoscedasticity using a statistical software program (GMC, version 2002). Differences between mean values were compared through the Tukey's test at a significance level of 5% ($p \leq 0.05$).

RESULTS.

After performing the preliminary test of normality of color data (ΔE*), the variance analysis demonstrated statistical significance ($p \leq 0.05$) for the factors in isolation, except for bleaching (p=0.1263).

Thus, the group subjected to the prophylactic agent ($NaHCO_3$ powder) showed lower color change values (3.56±0.09) than the untreated group (3.83±0.09). For the factor time in isolation (p=0.0000), the results are shown in Table 3.

When the interactions were analyzed, statistical differences were also verified ($p \leq 0.05$) between the interactions of prophylactic agent × time (p=0.0001) and bleaching × time (p=0.1319) (Table 3); however, there was no statistically significant difference for the interaction of prophylactic agent × bleaching (p=7.6177).

Relative to the surface roughness, variance analysis demonstrated that there was statistical

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Figure 1. Flow chart of the study protocol.

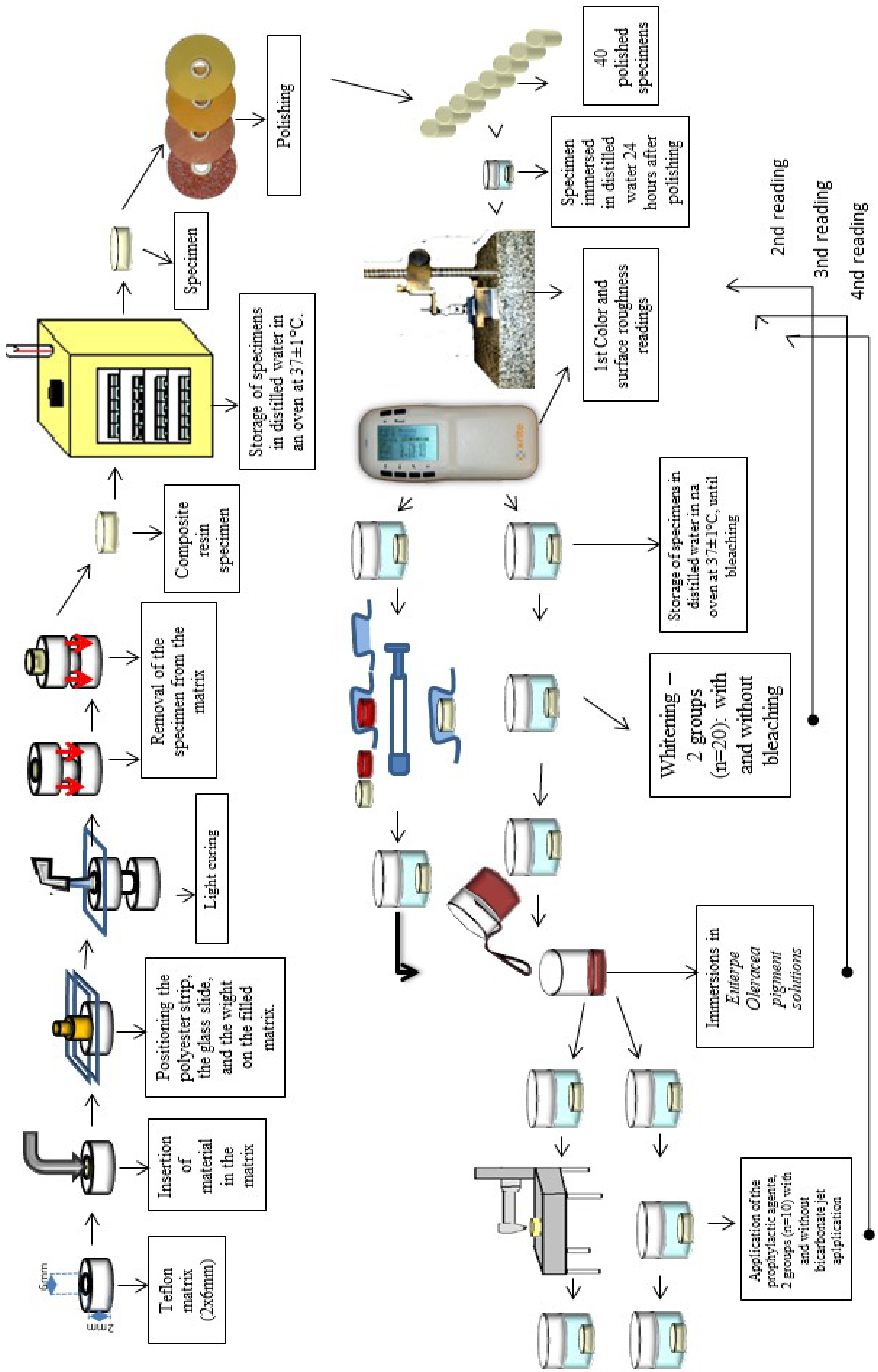

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Table 1. Composite resin used in the study.

Material /Manufacturer	Composition	Application mode
Filtek Z250 XT - 3M ESPE, St. Paul, MN, USA	Organic matrix: Bis-GMA, UDMA, Bis-EMA. Photo initiators, stabilizers Inorganic particle: Zirconium/Silica filler (0.01-3.5 µm) (84.5 wt%, 60 vol%).	Applied in one increment, light cure (40s) with LED (Optilight Max- Gnatus, Ribeirão Preto-SP, Brasil) - 1200 mW/cm².

Bis-GMA: Bisphenol-A glycidyl dimethacrylate. **Bis-EMA:** Ethoxylated bisphenol-A dimethacrylate. **UDMA:** Urethane dimethacrylate.

Table 2. Bleaching product and acai juice used in the study.

Material /Manufacturer	Composition
Whiteness Perfect 22% - FGM - Produtos Odontológicos	22% carbamide peroxide, carbopol neutralized, potassium nitrate, Sodium fluoride, Humectant (glycol), deionized water.
Acai Juice - Agrofruit International, Brasil LTDA. Visconde do Rio Branco, MG	Acai pulp, guarana extract, sugar, flavoring.

Table 3. Color change averages (ΔE *) for the Time factor: for the interactions of Prophylactic Agent x Time and Bleaching x Time with their respective standard deviations. T1: at the end of the bleaching treatment; T2: at the end of the staining procedures and T3: 24 hours after prophylactic treatment.

	T1	T2	T3
	1.8 (±0.07)[a]	4.89 (±0.07)[c]	4.4 (±0.07)[b]
	T1	T2	T3
With Prophylactic Agent	1.77 (±0.09)[a]	4.99 (±0.09)[c]	3.91 (±0.09)[b]
No Prophylactic Agent	1.82 (±0.09)[a]	4.79 (±0.09)[c]	4.90 (±0.09)[c]
	T1	T2	T3
With Bleaching	2.89 (±0.09)[b]	4.57 (±0.09)[d]	3.96 (±0.09)[c]
Without Bleaching	0.7 (±0.09)[a]	5.21 (±0.09)[e]	4.85 (±0.09)[d,e]

Different superscript letters correspond to statistically significant differences.

Table 4. Surface roughness (Ra) averages for the Time factor: for the interaction Prophylactic Agent x Time and Bleaching x Time with their respective standard deviations. T0: 24 hours after the specimen preparation; T1: at the end of the bleaching treatment; T2: at the end of the staining procedures and T3: 24 hours after prophylactic treatment.

	T0	T1	T2	T3
	0.73 (±0.06)[a]	0.93 (±0.06)[a]	0.88 (±0.06)[a]	1.65 (±0.06)[b]
	T0	T1	T2	T3
With Prophylactic Agent	0.65 (±0.08)[a]	0.88(±0.08)[a]	0.88(±0.08)[a]	2.57(±0.08)[b]
No Prophylactic Agent	0.82 (±0.08)[a]	0.97(±0.08)[a]	0.88(±0.08)[a]	0.74(±0.08)[a]
	T0	T1	T2	T3
With Bleaching	0.88(±0.08)[a,b]	1.31(±0.08)[b]	1.18(±0.08)[b]	2.13(±0.08)[c]
Without Bleaching	0.58 (±0.08)[a]	0.55(±0.08)[a]	0.58(±0.08)[a]	1.17(±0.08)[b]

Different superscript letters correspond to statistically significant differences.

significance for all factors in isolation. For the prophylactic agent in isolation, the specimens were subjected to the agent, and higher surface roughness values were obtained (1.24±0.06) than the non-treated specimens (0.85±0.06). For the factor bleaching in isolation, it resulted in higher surface roughness values for this group (1.37±0.06) than the unbleached group (0.72±0.06). The results for the factor time in isolation are grouped in Table 4.

In the analysis of the interactions, the authors verified that there was a statistically significant difference for all the interactions (Table 4), except for the interaction between bleaching and the prophylactic agent.

DISCUSSION.

In dental esthetics, the natural appearance of tooth should be mimicked and the color of restorative materials should be stable over times.[15] However, when exposed to the oral environment, restorative materials tend to undergo pigmentation and staining due to intrinsic or extrinsic factors.[4,6,16,17]

With respect to the factor bleaching in isolation, the authors verified that there was no statistically significant color change between the bleached and unbleached groups; however, the interaction analysis provided greater details of the discoloration pattern of the test specimens.

We analyzed the interaction between time × bleaching and observed that the test specimens subjected to bleaching presented higher color change values than the test specimens that were stored in artificial saliva, which was different from that found in isolation. As verified in the table of values of this reaction, we observed that in T1, the bleached group presented higher color change values than the non-bleached group. However, this situation was reversed in the other groups, which may have generated no significant difference between the bleached and unbleached groups analyzed in isolation.

Anagnostou *et al.*,[18] reported that polished resin composite surfaces were more resistant to bleaching than unpolished surfaces owing to the

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residual monomer present in unpolished surfaces.

Another factor that could have influenced the results of the present study was the use of an inorganic filler content of the resin Z350. According to Wang *et al.*,[12] the shape, quantity, and distribution of fillers determine the clinical performance of resin composites and could offer greater resistance to bleaching. Celik *et al.*,[19] corroborated the findings of Wang *et al.*,[12] and reported that the different results between studies could be related to the surface roughness, composition of the substrate, and rate of water absorption.

With respect to bleaching, Anagnostou *et al.*,[18] reported that the resins that were stored for 24 h in an artificial saliva before bleaching yielded the best results in terms of color stability compared with the resins that received continuous bleaching. Moreover, color changes after bleaching were clinically invisible since color change value greater than 3.3 was considered clinically unacceptable.[20] However, the mechanism of change in the color of restorative materials induced by bleaching has not been elucidated yet.[18]

With respect to surface roughness, in the study by Wang *et al.*,[12] the author verified (as found in this study) that there was an increase in the surface roughness values in resin composites subjected to bleaching. In the analysis of the factor time in isolation, the authors verified in T2 that the test specimens underwent a significant change in color values from 1.8 (±0.07) after bleaching to 4.89 (±0.07), which was considered clinically unacceptable.

The pigmenting challenge in this study was performed with acai juice, an Amazonian fruit frequently used due to its promising antioxidant action.[21] This popularity, and the little knowledge about its effect on dental restorative materials, associated with tooth whitening and the use of sodium bicarbonate jet, was the reason why the authors chose acai juice as the pigmenting challenge.

Many studies[1,3,20] have demonstrated that resin composites are susceptible to staining by beverages commonly found in diet. Food rich in anthocyanins, such as myrtle, red grapes, red wine, and acai juice, have strong colors. As anthocyanin is soluble in water, it releases pigments that may appear red, purple, or blue, depending on the pH.[20]

When the interaction time × bleaching was analyzed at T2, the authors verified that the group that underwent bleaching presented lower color change values than the group that was not subjected to bleaching. The color variation was determined by comparing the respective readouts (T1, T2, and T3) with the initial readout (T0).

Herein, what may have occurred was that in T1, one of the groups underwent bleaching; that is, there was a negative variation in color, and when this group was subjected to the pigmenting agent, the sum of these values resulted in a lower value than that of the group that was not subjected to bleaching.

Furthermore, Colluci *et al.*,[22] reported that the process of degradation and sorption of liquids was dependent on the hydrophilicity of the matrix polymer, localization of the hydrolyzable matrix chains, and inorganic filler content. This could explain why the resin composite used presented a color change after submission to acai juice.

After the application of the pigmenting challenge, prophylaxis was performed with a sodium bicarbonate jet, where an increase in the surface roughness and a reduction in the color values of the test specimens were verified. The color change was still clinically unacceptable., These results were in agreement with the results reported by Hongsathavij *et al.*,[14] who observed the sodium bicarbonate jet presents optimum results in the removal of extrinsic stains. However, the sodium bicarbonate jet significantly increases the surface roughness of the resin composite.

The increase in surface roughness of resin composite may be the result of the bicarbonate particles' action launched under pressure, together with the water jet on the resin composite surface, acting directly on the organic matrix, which removes it and detaches several inorganic particles. Moreover, according to Colluci *et al*.,[22] the application of a bicarbonate jet increases the surface roughness of the specimens, which could increase the retention of coloring agents.

When the authors analyzed the interaction between time and prophylactic agent factors, they verified that both the color change and surface roughness were similar within the same time interval for the group subjected and the group not subjected to the prophylactic agent. The values differed only in T3, in which the group subjected to the sodium bicarbonate jet showed expected reduction in color change values and an increase in surface roughness. The differentiating treatment over time was performed only in T3, the time at which the sodium bicarbonate jet was applied in one group and the other was kept in artificial saliva. Thus, the same results were found for the prophylactic agent in isolation.

Thus, dentists must pay attention to the application of sodium bicarbonate jet because this initially produced the removal of stains, but it promoted an increase in the surface roughness of the studied resin composite. Therefore, a solution to this problem may be to polish the surfaces after prophylaxis with the sodium bicarbonate jet. According to Sedrez-Porto *et al*.,[23] it is essential to polish restorations to ensure color stability of the resin composites.

CONCLUSION.

It was concluded that $NaHCO_3$ air-powder polishing decreased the staining of the composite resin; however, it increased the surface roughness.

With respect to the color variable, the whitening factor had no significant effect on the tested material. However, it increased the surface roughness of the composite resin.

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