UNIVERSIDADE DE UBERABA
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AVALIAÇÃO DA EFICÁCIA DO DENTIFRÍCIO CLAREADOR À BASE DE CARVÃO ATIVADO DURANTE O CLAREAMENTO DENTAL

UBERABA-MG
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Dissertação apresentada ao Programa de Pós-graduação em Odontologia – Mestrado Acadêmico da Universidade de Uberaba, como requisito para obtenção do título de Mestre em Odontologia.

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RESUMO

A alteração de cor dos dentes é um fator que compromete a estética e é uma das principais queixas que levam os pacientes a procurarem o Cirurgião-Dentista. Os procedimentos de clareamento dental são amplamente empregados no consultório odontológico e permitem diminuir a descoloração e melhorar a tonalidade dos dentes. Existem no mercado dentifrícios clareadores que prometem os mesmos efeitos das técnicas caseira e profissional. O objetivo da pesquisa foi comparar o potencial de remoção de manchamento de diferentes técnicas de clareamento dental, associadas ao uso de dentifrício clareador. Foram obtidos 120 fragmentos de esmalte de dentes bovinos sendo estes 6,0mm de largura, 6,0mm de altura e 2,0mm de profundidade. Os dentes foram manchados com café durante 15 dias e, em seguida, clareados por três técnicas: caseira (peróxido de hidrogênio a 10%) por 2 horas diárias a 37°C durante 21 dias, consultório (peróxido de hidrogênio a 35%) em três períodos de 15 minutos, com as amostras armazenadas em água destilada a 37°C, no qual novas seções de clareamento foram realizadas após 7 e 14 dias, e a combinada (peróxido de hidrogênio a 10% e 35%), com uma sessão de clareamento de consultório seguida por 14 dias de clareamento caseiro. Durante o clareamento, os dentes foram escovados com escova elétrica de cerdas macias e dentifrício clareador à base de carvão ativado 15 segundos por dia 3 vezes ao dia. Foram realizadas análises de cor, antes e após os tratamentos, utilizando o sistema CIELab com iluminação padrão D65, através do espectrofotômetro VITA Easyshade. A diferença de cor (ΔE) e os eixos L*, a* e b*, entre os três momentos de avaliação, foram analisados pelo teste ANOVA de duas vias, seguidos pelo teste de Tukey (α=5%). Os resultados mostraram que a combinação do peróxido de hidrogênio a 10% e 35% foi mais efetiva, pois obteve uma maior redução na tonalidade amarelada e um aumento significativo na luminosidade dos dentes. Por outro lado, o carvão ativado não apresentou efeitos relevantes no clareamento dental. A combinação dos dois tipos de peróxido de hidrogênio demonstrou ser estatisticamente superior às outras técnicas, sendo a opção mais vantajosa. Em conclusão, o clareamento combinado apresentou melhores resultados, sendo o método mais eficaz, enquanto o carvão ativado não apresentou resultados relevantes para o clareamento dental.

Palavras-chave: Dentifrícios; Clareamento Dental; Escovação Dentária.

ABSTRACT

Tooth discoloration compromises aesthetics and is one of the primary concerns that prompt patients to seek dental treatment. Teeth whitening procedures are routinely employed in clinical practice to reduce discoloration and enhance the natural tooth shade. Additionally, numerous whitening toothpastes are marketed with claims of delivering effects comparable to those achieved by at-home and professional techniques. The objective of this study was to compare the stain removal efficacy of various tooth whitening protocols when used in conjunction with a whitening toothpaste. A total of 120 bovine enamel specimens (6.0 mm × 6.0 mm × 2.0 mm) were prepared. The teeth were stained with coffee for 15 days and then whitened using three techniques: at-home (10% hydrogen peroxide) for 2 hours daily at 37°C for 21 days, in-office (35% hydrogen peroxide) in three 15-minute sessions, with the samples stored in distilled water at 37°C, with new whitening sessions performed after 7 and 14 days, and the combined technique (10% and 35% hydrogen peroxide), with one in-office whitening session followed by 14 days of at-home whitening. During the whitening process, each specimen was brushed with a soft-bristled electric toothbrush using an activated charcoal-based whitening toothpaste for 15 seconds, three times per day. Color measurements were recorded before and after the treatments using the CIELab system under standard D65 illumination with a VITA Easyshade spectrophotometer. The color difference (ΔE) along with the L*, a*, and b* values at three evaluation points were statistically analyzed using two-way ANOVA followed by Tukey's post hoc test ($\alpha = 0.05$). The results indicated that the combined application of 10% and 35% hydrogen peroxide was the most effective protocol, producing a more pronounced reduction in yellow chroma and a significant increase in tooth brightness. In contrast, the use of activated charcoal did not result in any significant improvement in tooth whitening. Thus, the combined hydrogen peroxide approach was statistically superior to the other techniques evaluated, making it the most advantageous option. In conclusion, the combined whitening protocol yielded the best results, demonstrating superior efficacy in stain removal, while the incorporation of activated charcoal did not provide any meaningful benefits in the tooth whitening process.

Keywords: Dentifrices; Tooth Bleaching; Toothbrushing.

SUMÁRIO

1 INTRODUÇÃO

A área das ciências da saúde que mais vem se desenvolvendo está relacionada à estética pessoal, onde as influências sócio-culturais levam o indivíduo a buscar tratamentos médicos e odontológicos para satisfazer seus anseios de bem-estar e beleza. A alteração de cor dos dentes é um fator que compromete a estética e é uma das principais queixas que levam os pacientes a procurarem o Cirurgião-Dentista (Joiner; Luo, 2017).

O dente é um órgão policromático, sendo a dentina responsável pela coloração amarelada. O esmalte, que é translúcido, irá atenuar a cor da dentina, e, na medida em que maior for a mineralização do esmalte, maior será sua translucidez. As áreas cervicais e incisais dos dentes refletem esse comportamento do esmalte e da dentina. Na região incisal, que não possui camada de dentina interposta, a tonalidade se situa numa gradação entre o branco e o azul, enquanto que na cervical, cuja camada de esmalte é mais fina, a coloração da dentina se sobressai e se torna mais evidente. O tempo também exerce influência nas estruturas dentais, de modo que, ao longo dos anos, o esmalte sofre desgaste e por sua vez a dentina se torna mais espessa, dada a formação de camadas reparadoras ou de dentina secundária, o que promove o escurecimento dos dentes (Tabatabaian *et al*., 2021).

O processo de escurecimento da estrutura dental ocorre devido à formação de estruturas quimicamente estáveis, responsáveis pela instalação progressiva de manchas na coroa dental (Hatirli *et al*., 2021). Alterações na coloração da estrutura dentária podem ter origem tanto em fatores extrínsecos como intrínsecos. As manchas extrínsecas geralmente são decorrentes da alimentação ou consumo de bebidas, e estão associadas a substâncias corantes como café e tabaco, ao acúmulo de biofilme e ao uso de determinados tipos de medicamentos, sendo essas manchas superficiais e de fácil remoção. Já as alterações intrínsecas podem ser congênitas e, portanto, relacionadas à formação dos dentes - ou adquiridas através de um trauma dental, danos pulpares severos e fluorose (Joiner; Luo, 2017).

Desse modo os pigmentos que provocam essas manchas formam uma molécula capaz de refletir luz em comprimento de onda visível pelo olho humano, em uma intensidade superior à luz refletida pela estrutura do dente, obtêm-se o dente escurecido (Alkahtani *et al*., 2020). Os pigmentos incorporados na estrutura dental só podem ser removidos pelo clareamento ou por procedimentos ainda mais invasivos,

implicando tanto no desgaste como na restauração dos dentes (Epple *et al*., 2019).

Atualmente, os procedimentos de clareamento dental são amplamente empregados no consultório odontológico e permitem diminuir a descoloração e melhorar a tonalidade dos dentes. Desse modo, para obtenção de sucesso no tratamento clareador, é preciso conhecer e dominar os diferentes materiais, métodos de ativação e técnicas. O clareamento dental pode ser executado em dentes vitais e não vitais. O tratamento pode ser realizado no consultório ou em casa pelo próprio paciente (técnica caseira). A técnica caseira foi descrita por Haywood e Heymann, em 1991, e destaca-se por seu baixo custo e segurança, devido ao uso de agentes clareadores em baixa concentração em uma moldeira individual confeccionada a partir de modelos de gesso e pela obtenção de resultados efetivos após 2 a 6 semanas (Alkahtani *et al*., 2020).

No entanto com o decorrer dos anos, foi questionado se o tempo necessário para a realização do clareamento caseiro não era demasiadamente longo. Assim, pensou-se na possibilidade da utilização de agentes clareadores em altas concentrações aplicados nos dentes pelo Cirurgião-Dentista no consultório odontológico. Isso possibilitou diminuir o tempo necessário para o clareamento dental, já que o paciente apresentava seus dentes mais claros em uma ou duas sessões clínicas. Contudo, essa abordagem pode causar efeitos adversos, como sensibilidade dental temporária, irritação gengival e desequilíbrio no tom dos dentes (principalmente em pacientes com restaurações). O uso excessivo de agentes clareadores também pode levar ao enfraquecimento do esmalte, tornando os dentes mais suscetíveis ao desgaste e cáries. Esses efeitos, embora temporários, exigem cuidados pós-tratamento. (Rocha *et al*., 2023).

Embora a química do processo clareador seja complexa, a grande maioria dos produtos funciona pela oxidação, que remove a mancha por liberação de oxigênio e ação mecânica de limpeza, convertendo os materiais orgânicos em dióxido de carbono e água (Zhong *et al*., 2023). O elemento ativo dos agentes clareadores é basicamente um peróxido, tendo como formas de apresentação o peróxido de hidrogênio, o peróxido de carbamida e o perborato de sódio (este utilizado no clareamento de dentes tratados endodonticamente (Rocha *et al*., 2023).

Estes compostos, por serem altamente instáveis, tendem a se dissociar, dando origem a radicais de oxigênio. O oxigênio oriundo dessa reação é o maior responsável pelo clareamento propriamente dito (Alkahtani *et al*., 2020), pois, graças ao seu baixo

peso molecular, ele apresenta um alto poder de penetração nas porosidades do esmalte dental e dentina, deixando-os mais largos e degradando as moléculas de pigmento, que são compostos de grandes quantidades de moléculas de carbono (Joiner; Luo, 2017).

Quando quebradas, essas moléculas são convertidas em compostos intermediários (cadeias menores), que são mais claros. Essa reação química altera o tipo, número e posição relativa dos átomos que compõem essas moléculas. Assim no decorrer do clareamento as cadeias de carbono são transformadas em CO^2 e H^2O, sendo gradualmente liberados junto com o oxigênio nascente, tornando as moléculas menores, pouco pigmentadas e até incolores (Epple *et al*., 2019, Rocha *et al.*, 2023).

O clareamento dental pode ser classificado em vital ou não vital, de acordo a situação de vitalidade pulpar do elemento dental que receberá o tratamento. Porém, a classificação que talvez seja mais utilizada é aquela que leva em consideração se o procedimento clareador será realizado totalmente sob supervisão profissional (clareamento de consultório), ou se esse será realizado através de aplicações do produto pelo próprio paciente (clareamento caseiro) (Alkahtani *et al*., 2020).

Na técnica caseira é fornecida moldeira individual plástica, através da qual o próprio paciente aplica em casa um gel clareador em baixa concentração, como o peróxido de hidrogênio de 1 a 10% e peróxido de carbamida de 10 a 22%, sob orientação do Cirurgião-Dentista. A técnica original do clareamento caseiro determina a aplicação do agente clareador de 6 a 8h por noite de 2 a 6 semanas. O clareamento caseiro apresenta como principais vantagens à facilidade de aplicação, requerendo menor concentração do peróxido, redução do custo e do tempo na cadeira odontológica (Rocha *et al*., 2023).

O clareamento em consultório utiliza agentes clareadores em maiores concentrações (de 35 a 37%) e tem como benefícios menor tempo para se atingir o resultado final, maior controle do tratamento e pode ser realizado em áreas restritas e pré-determinadas (Joiner; Luo, 2017).

Foi sugerida a associação das técnicas de consultório com a caseira, a fim de se melhorar o resultado do tratamento careador. Um estudo clínico randomizado mostrou que o clareamento combinado produziu melhores resultados do que os clareamentos de consultório ou caseiro realizados isoladamente. Nesse estudo, o clareamento combinado foi feito com clareamento de consultório (peróxido de hidrogênio a 37,5%, 3 aplicações de 8 minutos), seguido de clareamento caseiro

(peróxido de carbamida a 10%, 8 horas por dia, durante 14 dias). Os autores concluíram que a combinação entre as técnicas pode ser uma excelente opção para os pacientes que estiverem com os dentes bastante escurecidos (Kothari *et al*., 2020).

No final da década de 80, principalmente nos Estados Unidos, várias empresas introduziram no mercado produtos de clareamento dental para serem utilizados em casa que prometiam melhorias “milagrosas” na cor dos dentes. Dentre eles, ganharam destaque os dentifrícios com ação clareadora, que atualmente, têm apresentado grande destaque nas áreas de marketing comercial voltado à venda de produtos odontológicos de consumo caseiro (Lima *et al*., 2023). As pastas dentais clareadoras apresentam em sua formulação umectantes, surfactantes e alguns tipos de abrasivos como a sílica, carbonato de cálcio, bicarbonato de sódio, pirofosfato de cálcio, alumina, entre outros materiais. Em algumas formulações estão presentes também componentes dos clareamentos dentais utilizados em consultório, como peróxido de hidrogênio, que tem como objetivo prevenir e remover manchas extrínsecas presentes nas superfícies dos dentes (Simionato *et al*., 2023).

Alguns estudos mostram que a estrutura do esmalte dental pode ser alterada, de acordo com a técnica de clareamento utilizada (Salomão *et al*., 2014; Melo *et al*., 2022). Salomão *et al*. (2014) realizaram uma pesquisa com o objetivo de avaliar a susceptibilidade à desmineralização ácida do esmalte dental clareado e submetido a dois regimes diferentes de fluorterapia. Após o tratamento do esmalte com peróxido de hidrogênio e peróxido de carbamida, associado a um regime diário ou semanal de fluoreto, não aumentou a susceptibilidade do esmalte à desmineralização ácida. No entanto, o uso de PH a 35% e PC a 35% deve ser associado com um regime diário de fluorterapia, caso contrário, o clareamento de consultório pode deixar o esmalte clareado mais susceptível à desmineralização ácida (Salomão *et al*., 2014). Melo *et al*. (2022) avaliaram o efeito do gel clareador de peróxido de hidrogênio a 35% na morfologia e microdureza do esmalte. Os autores observaram que os agentes clareadores foram capazes de reduzir a dureza do esmalte, assim como promover irregularidades naquele tecido.

Recentemente, foram introduzidos no mercado dentifrícios à base de carvão ativado. O carvão ativado tem ganhado popularidade nos últimos anos como um agente clareador dental caseiro, especialmente com a crescente demanda por soluções naturais e de baixo custo. Este material, amplamente utilizado em diversos campos, é conhecido por suas propriedades capazes de reter impurezas e manchas.

No contexto do clareamento dental, o carvão ativado é frequentemente promovido por sua capacidade de remover manchas superficiais nos dentes, proporcionando uma aparência mais branca. Ele é comumente encontrado em produtos como pastas de dentes, pós e géis, sendo aplicado diretamente na superfície dental para promover a limpeza e o clareamento. Embora sua popularidade esteja em ascensão, é importante que os consumidores se informem sobre os diversos métodos de clareamento e suas características, a fim de tomar decisões fundamentadas sobre os tratamentos mais adequados para seus casos.

Apesar do aumento no uso do carvão ativado como agente clareador dental, ainda há poucas pesquisas sobre seus efeitos na estrutura dentária e nos materiais restauradores. Além disso, os impactos do uso prolongado do carvão sobre o esmalte dental e sua eficácia em comparação com outros agentes clareadores ainda não são totalmente compreendidos (Emídio *et al*., 2023). A literatura também apresenta algumas dúvidas sobre os efeitos da escovação com dentifrícios abrasivos durante os clareamentos caseiro e profissional. Por conta dessas incertezas, é importante realizar mais estudos para entender melhor como os agentes clareadores interagem com os tecidos dentais. A hipótese nula desses estudos seria de que a escovação com dentifrícios clareadores, realizada durante o clareamento, não teria impacto significativo nos resultados do tratamento.

2 OBJETIVOS

2.1 OBJETIVO GERAL

Comparar o potencial de remoção de manchamento de diferentes técnicas de clareamento dental, associadas ao uso de dentifrício clareador.

2.2 OBJETIVOS ESPECÍFICOS

Avaliar a alteração de cor do esmalte dental clareado pelas técnicas caseira, de consultório e combinada, associadas ao uso de dentifrício clareador.

Utilizar o espectrofotômetro de colorimetria para mensurar as alterações na cor do esmalte dental após a aplicação das diferentes técnicas de clareamento.

ARTIGO

Área Temática: Dentística

Evaluation of the Efficacy of Charcoal-Based Whitening Toothpaste During Dental Bleaching

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ABSTRACT

This study aimed to compare the stain removal effectiveness of various tooth whitening protocols in conjunction with a whitening toothpaste. A total of 120 bovine enamel specimens, measuring 6.0 mm × 6.0 mm × 2.0 mm, were prepared. The teeth were stained with coffee for 15 days and then whitened using three techniques: at-home (10% hydrogen peroxide) for 2 hours daily at 37°C for 21 days, in-office (35% hydrogen peroxide) in three 15-minute sessions, with the samples stored in distilled water at 37°C, with new whitening sessions performed after 7 and 14 days, and the combined technique (10% and 35% hydrogen peroxide), with one in-office whitening session followed by 14 days of at-home whitening. During the whitening procedures, each specimen was brushed with a soft-bristled electric toothbrush and a charcoal-based whitening toothpaste for 15 seconds, three times daily. Color measurements were taken before and after treatment using the CIELab system with standard D65 illumination and a VITA Easyshade spectrophotometer. The color differences (ΔE), along with the L*, a*, and b* values, were analyzed using two-way ANOVA followed by Tukey's post hoc test ($\alpha = 0.05$). The results showed that the combined use of 10% and 35% hydrogen peroxide was the most effective protocol, significantly reducing the yellow chroma and increasing tooth brightness. Activated charcoal, however, did not show significant improvements. Thus, the combined hydrogen peroxide method was the most effective, providing superior stain removal compared to the other techniques evaluated. In conclusion, combining hydrogen peroxide concentrations offers significantly enhanced clinical outcomes, while activated charcoal does not provide additional benefits in dental bleaching procedures.

Keywords: Dentifrices; Tooth Bleaching; Toothbrushing.

INTRODUCTION

Within health sciences, the field experiencing the most rapid development is arguably concerned with personal aesthetics. Socio-cultural pressures increasingly influence individuals to pursue medical and dental interventions aimed at achieving both enhanced well-being and improved aesthetic outcomes. Tooth discoloration, a significant detractor from perceived aesthetic appeal, frequently motivates patients to seek professional dental care[1].

The process of dental structure darkening arises from the formation of chemically stable chromophores, which contribute to the progressive development of stains on teeth[2]. These color alterations can be classified as either extrinsic or intrinsic discoloration. Extrinsic stains typically result from the consumption of chromogenic substances in food and beverages, such as coffee and wine, as well as biofilm accumulation and the use of certain medications. These stains are generally superficial and easily removed. Intrinsic discolorations, conversely, can be congenital, related to disturbances in tooth development, or acquired, resulting from dental trauma, significant pulpal pathology, or fluorosis[1]. The pigments responsible for these discolorations are molecules capable of reflecting light within the visible spectrum at an intensity greater than that reflected by the underlying tooth structure, thus resulting in a darkened appearance[3].

Tooth whitening is a widely employed procedure in dental practice, enabling the reduction of tooth discoloration and improvement of tooth shade. Successful whitening outcomes depend on a thorough understanding and mastery of the various materials, activation methods, and techniques available. Whitening procedures can be performed on both vital and non-vital teeth, and may be conducted in a clinical setting (in-office bleaching) or by the patient at home (at-home bleaching).

While the chemical mechanisms underlying the whitening process are complex, most whitening agents operate through oxidation reaction. This process involves the release of oxygen, which, in conjunction with mechanical cleaning action, facilitates stain removal by converting organic chromophores into carbon dioxide and water[4]. The primary active component of these agents is a peroxide, typically formulated as hydrogen peroxide or carbamide peroxide[5]. These peroxide compounds, due to their inherent instability, undergo dissociation, generating oxygen free radicals. The oxygen released during this reaction is the principal agent responsible for the whitening effect[3].

This is attributed to its low molecular weight, which allows for high penetration into the porous structure of enamel and dentin. The oxygen free radicals subsequently degrade the pigment molecules, which are complex carbon-based structures[1]. When broken down, these molecules are converted into intermediate compounds (smaller chains), which are lighter in color and easily removed during tooth brushing[5,6].

Dental bleaching can be classified considering whether the bleaching procedure will be performed entirely under professional supervision (in-office bleaching) or if it will be carried out through applications by the patients themselves (at-home bleaching)[3]. In the at-home technique, patient uses a custom-made plastic tray filled with a low-concentration bleaching gel at home, such as hydrogen peroxide (HP) of 1 to 10% and carbamide peroxide of 10 to 22%. The original at-home bleaching technique specifies the application of the bleaching agent for 6 to 8 hours per night for 2 to 6 weeks. The main advantages of at-home bleaching include ease of application, requiring lower peroxide concentration, cost reduction, and less time in the dental chair[5]. In-office bleaching uses bleaching agents at higher concentrations (35 to 37%) and has the benefits of achieving the result immediately or after a couple of sessions and the ability to be performed in specific areas[1].

Recently, the combination of in-office and at-home techniques has been suggested to improve the outcome of bleaching treatment. A randomized clinical trial showed that combined bleaching produced better results than in-office or at-home bleaching done separately. In this study, combined bleaching was done with in-office bleaching (37.5% hydrogen peroxide, 3 applications of 8 minutes), followed by at-home bleaching (10% carbamide peroxide, 8 hours per day for 14 days). The authors concluded that combining techniques could be an excellent option for patients with significantly darkened teeth[7].

In the late 80s, dentifrices with bleaching action were developed, which currently have gained significant attention in the commercial marketing areas aimed at selling over-the-counter dental products[8]. Whitening toothpastes contain humectants, surfactants, and various types of abrasives such as silica, calcium carbonate, sodium bicarbonate, calcium pyrophosphate, alumina, among other materials. Some formulations also include components used in in-office dental bleaching, like hydrogen peroxide, aimed at preventing and removing extrinsic stains present on tooth surfaces[9].

Recently, activated charcoal-based dentifrices have been introduced to the market, gaining popularity in recent years as a home dental whitening agent, especially

with the growing demand for natural and low-cost solutions[10]. The whitening mechanism of activated charcoal is mainly related to its adsorption capacity and porosity. The nanocrystalline form of charcoal in activated charcoal produces a large surface area and porosity that adsorbs pigments, chromophores, or stains responsible for the color change of natural teeth. Its adsorption property, combined with abrasive action, allows for the removal of extrinsic stains from the tooth surface. However, there is a scarcity of scientific evidence supporting the adsorptive action of vegetable charcoal, and its stain reduction mechanism is mainly attributed to its abrasive action[11]. Despite the increased use of activated charcoal as a dental whitening agent, there is still limited research on its effects on dental structure and restorative materials. Furthermore, the impacts of prolonged use of charcoal on dental enamel and its efficacy compared to other whitening agents are not fully understood[12]. The literature also raises some questions about the effects of brushing with abrasive dentifrices during at-home and professional bleaching.

Due to these uncertainties, it is important to conduct more studies to better understand how bleaching agents interact with dental tissues. The aim of this study was to compare the staining removal potential of different teeth bleaching techniques, when associated with a whitening toothpaste containing activated charcoal. The null hypothesis of this study would be that brushing with whitening dentifrices during bleaching would have no significant impact on the treatment outcomes.

MATERIAL AND METHODS

Enamel Fragments

A total of 120 bovine incisors from 3-year-old animals were selected, all of which showed no cracks, fractures, or other enamel defects. The teeth were cleaned using a rubber cup, pumice stone, and water, and then stored in a 0.1% thymol solution at 4°C for 30 days. Subsequently, the crowns were separated from the roots at the cemento-enamel junction using a diamond disc under water cooling, attached to a cutting machine (Minitom, Struers A/S, Copenhagen, DK-2610, Denmark). The same equipment was used to obtain 120 enamel fragments from the vestibular surface of the teeth, each measuring 6.0 mm in width, 6.0 mm in height, and 2.0 mm in depth. The samples were then waterproofed with clear nail polish (Colorama, São Paulo, Brazil),

except for the vestibular surface of the samples. The samples were randomly divided into 12 groups (Table 1) and subsequently labeled for color analysis.

Initial Color Analysis

The initial color of the specimens was analyzed according to the CIELab system, with standard D65 illumination on a white background using a colorimetric spectrophotometer (VITA Easyshade, Zahnfabrik, Bad Säckingen, Germany). The color of each specimen was measured by examining the L*, a*, and b* coordinates of the CIELab system. Prior to each reading, the specimens were washed with distilled water for one minute and dried with absorbent paper. A mark was made on the palatal surface of the samples to ensure all color readings were performed at the same area.

Staining of the Samples

The specimens were subjected to cycling in coffee (Nescafe Tradicional, Nestlé, Araras, SP, Brazil), chosen due to its high daily consumption, being one of the most common beverages contributing to dental staining. The specimens were immersed in coffee (1.5 mL/sample) for 15 minutes, 3 times a day, for 14 days. Between cycles, the specimens were kept immersed in distilled water at 37°C ± 1°C[13, 27]. The beverage was used at a consumption temperature between 58°C and 63°C.

Color Analysis After Staining

The color of the samples after staining was analyzed in the same manner as described previously.

Bleaching Protocols

The samples (n=10) were treated according to the procedures listed in Table 1.

Table 1 – Experimental groups.

Groups	Bleaching Technique	Bleaching Agent	Brushing

Group 1	At-home	10% HP	None
Group 2	At-home	10% HP	Conventional
Group 3	At-home	10% HP	Activated Charcoal
Group 4	At-home	10% HP	Without dentifrice
Group 5	In-office	37% HP	None
Group 6	In-office	37% HP	Conventional
Group 7	In-office	37% HP	Activated Charcoal
Group 8	In-office	37% HP	Without dentifrice
Group 9	Combined	10% HP and 37% HP	None
Group 10	Combined	10% HP and 37% HP	Conventional
Group 11	Combined	10% HP and 37% HP	Activated Charcoal
Group 12	Combined	10% HP and 37% HP	Without dentifrice

Source: Research data, 2025.

In groups 1, 2, 3, and 4, at-home bleaching was performed using a 10% hydrogen peroxide gel (White Class 10%, FGM Produtos Odontológicos, Joinville, SC, Brazil). The gel was applied directly to the enamel surface for 2 hours per day at 37°C for 21 days (according to the manufacturer's instructions). After each bleaching procedure, the samples were cleaned with air water spray and stored in distilled water for 24 hours at 37°C.

In groups 5, 6, 7, and 8, in-office bleaching was simulated. For this, a 37% hydrogen peroxide gel (WhitnessSuper, FGM Produtos Odontológicos) was applied directly to the enamel surface. The gel remained on the surface for 15 minutes, being periodically agitated with a micro applicator. After this time, the gel was removed and reapplied twice, following the same protocol. These procedures followed the

manufacturer's instructions. At the end of the treatment, the samples were stored in distilled water at 37°C. After 7 and 14 days, a new whitening session was performed on each fragment as recommended by the manufacturer[4,7].

In groups (9, 10, 11, and 12), a combined bleaching treatment was performed, consisting of an in-office whitening session followed by 14 days of at-home whitening, according to the protocol described above. At the end of the treatment, the samples were stored in distilled water in an incubator at 37°C.

In groups (1, 5, and 9), no brushing was performed on the samples, while in groups (2, 6, and 10), the samples were brushed using a conventional toothpaste (Colgate Maximum Protection Anti-Cavity, Colgate-Palmolive, São Paulo-SP, Brazil). In groups (3, 7, and 11), a whitening toothpaste (Oral-B 3D White Mineral Clean; Procter and Gamble, São Paulo-SP, Brazil) was used, and in groups (4, 8, and 12), brushing was conducted without toothpaste, utilizing only distilled water. Brushing was carried out daily for 21 days using an electric toothbrush (Oral-B Pro-Health Power, Procter and Gamble), mounted on a fixed, standardized support. The toothbrush head contained three sets of bristles arranged in distinct patterns and positioned at varying angles and heights. During each brushing session, the soft bristles made contact with the enamel surface of the samples for 15 seconds, performed three times daily, applying a force of 1.96 N at ambient temperature[14]. A slurry solution was prepared by mixing toothpaste and distilled water at a 1:2 weight ratio (200 mL of distilled water and 100 g of toothpaste – ISO Specification #145669-1), and was freshly prepared daily, 20 minutes prior to use. During brushing, 1.0 mL of the slurry was dispensed laterally onto the sample, between the tooth surface and the toothbrush. After brushing, any excess toothpaste was removed under running water, and the samples were subsequently cleaned in an ultrasonic bath with distilled water for 3 minutes. Following the cleaning procedure, the samples were stored in an incubator at 37°C."

Final Color Analysis

The samples were subjected to a new color analysis. The color difference was calculated using the formula $\Delta Eab^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]$ ½. The differences in luminosity (ΔL), a*, and b* were also calculated using the formulas $\Delta L^* = L^*(t) – L^*(0)$, $\Delta a^* = a^*(t) – a^*(0)$, and $\Delta b^* = b^*(t) – b^*(0)$, where (t) corresponds to the time and (0) corresponds to the baseline. The color change was analyzed by the ΔE values.

Statistical Analysis

The data on color differences at each stage were tabulated and subjected to a normality test. Statistical tests were determined after assessing the normal distribution pattern. The BioEstat 5.3 software was used, and the two-way ANOVA test was performed, followed by the Tukey test (α=5%).

RESULTS

The results demonstrated that, under all conditions, a color change occurred in the bovine dental enamel samples. This change was more pronounced in the comparisons between baseline and staining as well as between staining and treatment. Additionally, color alterations were observed when comparing the samples before and after treatments across all groups, albeit to a lesser extent than in the other comparisons ($p < 0.05$). The analysis of the baseline versus treatment condition revealed that the color difference was lower in the samples treated with the mixed bleaching technique (in groups 9, 10, 11, and 12) compared to the other treatment methods.

Table 2 – Mean (± standard deviation) of the ΔE values obtained from the comparisons: baseline versus staining; staining versus bleaching; and baseline versus bleaching across all groups.

	Delta E (ΔE)		
	Baseline x Staining	Staining x Bleaching	Baseline x Bleaching
Group 1 CS-H10%-SE	29.3±6.3Aa	28.4± 6.6Aa	8.7± 4.2Ab
Group 2 CS-H10%-CV	26.6±4.7Aa	24.6± 5.2Aa	8.8± 3.7Ab

Group 3 CS-H10%-CA	24.4±7.3Aa	26.3±4.9Aa	14.8± 5.8Bb
Group 4 CS-H10%-ESP	27.3±6.4Aa	28.3±5.6Aa	11.7± 5.0Bb
Group 5 CT-H37%-SE	29.9±8.2Aa	27.1±6.3Aa	6.4± 3.8Ab
Group 6 CT-H37%-CV	27.8±6.3Aa	28.1±5.3Aa	8.2± 5.9Ab
Group 7 CT-H37%-CA	28.3±6.7Aa	25.5±4.2Aa	5.2± 2.6Ab
Group 8 CT-H37%-ESP	32.5±6.1Aa	27.7±5.9Aa	5.0±1.8Ab
Group 9 CC-H10%37%-SE	25.7±5.8Aa	27.8±4.9Aa	3.7±2.1Cb
Group 10 CC-H10%-H37%-CV	23.8±3.6Aa	26.4±6.2Aa	3.2±2.3Cb
Group 11 CC-H10%-H37%-CA	29.1±7.0Aa	30.3±6.7Aa	3.0±1.8Cb
Group 12 CC-H10%-H37%-ESP	29.5±7.5Aa	31.1±6.5Aa	3.4±2.2Cb

Source: Research data, 2025.

Uppercase letters compare the data within the same column, while lowercase letters compare the data within the same row. Identical letters indicate statistically similar results (α = 5%).

Table 3 presents the results obtained from the analyses of the lightness (L) of the samples. In this context, lightness indicates whether the sample exhibits a darker or lighter shade, with L = 0 representing black and L = 100 representing white. Thus, it can be observed that, in all groups, the initial L values were statistically similar ($p > 0.05$). Similarly, the L values observed after immersing the samples in coffee were comparable, indicating that the staining of the samples was standardized. However, after treatment, the L values in groups 9 to 12 were different from those found in the

other groups. Within each group, the analysis revealed that the L value decreased after staining and returned to its initial value in groups 9 to 12, where a combination of at-home and in-office techniques was employed. In groups 1 to 8, the L values after treatment were lower than those observed at baseline, yet distinct from those observed after staining ($p > 0.05$).

Table 3 – Mean (± standard deviation) of the L values observed at baseline, after staining, and after treatments.

	L		
	Baseline	Staining	Bleaching
Group 1 CS-H10%-SE	85.6±3.7Aa	59.5±3.8Ab	80.4±3.6Ac
Group 2 CS-H10%-CV	87.7±2.5Aa	63.6±4.6Ab	81.6±3.0Ac
Group 3 CS-H10%-CA	86.9±4.3Aa	64.3±6.5Ab	81.1±3.4Ac
Group 4 CS-H10%-ESP	85.9±1.8Aa	61.1±6.2Ab	80.6±3.8Ac
Group 5 CT-H37%-SE	86.4±3.6Aa	58.3±4.6Ab	81.9±3.7Ac
Group 6 CT-H37%-CV	85.7±2.7Aa	60.3±4.3Ab	82.4±2.6Ac
Group 7 CT-H37%-CA	86.3±2.0Aa	63.4±3.5Ab	81.5±2.3Ac
Group 8 CT-H37%-ESP	86.7±2.2Aa	56.5±4.7Ab	82.4±2.9Ac
Group 9 CC-H10%37%-SE	85.3±3.8Aa	62.1±5.1Ab	86.8±2.8Ba
Group 10 CC-H10%-H37%-CV	84.3±2.4Aa	63.9±4.3Ab	87.2±3.1Ba
Group 11 CC-H10%-H37%-CA	84.8±2.1Aa	60.3±4.4Ab	86.6±3.5Ba
Group 12 CC-H10%-H37%-ESP	85.9±4.3Aa	59.7±4.7Ab	87.1±2.9Ba

Source: Research data, 2025.

*Uppercase letters compare the data within the same column, and lowercase letters compare the data within the same row. Identical letters represent statistically similar results.

The results presented in Table 4 pertain to the “a” coordinate, which reflects the chromatic saturation of the sample based on the color variation along the red–green axis (with positive values indicating red and negative values indicating green). According to the data, no statistically significant differences were observed among the groups at baseline, and the same was true after the fragments were immersed in coffee. However, in the post-treatment analysis, only group 7 (–1.16 ± 1.0) exhibited an “a” value that differed from those of the other groups ($p < 0.05$). Additionally, the intra-group comparison revealed that, in general, the “a” values after staining were higher than those observed at baseline and after treatment ($p < 0.05$).

Table 4 – Mean (± standard deviation) of the “a” values obtained at baseline, after staining, and after treatments.

	a		
	Baseline	Staining	Bleaching
Group 1 CS-H10%-SE	-0.97±0.9Aa	6.31±2.1Ab	-0.06±1.0Aa
Group 2 CS-H10%-CV	1.09±4.9Aa	8.54±9.3Ab	0.37±0.9Aa
Group 3 CS-H10%-CA	-0.52±0.8Aa	6.98±6.8Ab	0.20±0.7Aa
Group 4 CS-H10%-ESP	-0.67±0.6Aa	6.19±2.1Ab	0.18±0.8Aa
Group 5 CT-H37%-SE	-0.28±1.1Aa	6.41±1.9Ab	0.55±0.6Aa
Group 6 CT-H37%-CV	-1.49±0.6Aa	5.17±1.8Ab	-0.38±0.8Aa
Group 7 CT-H37%-CA	-2.04±0.5Aa	3.46±2.0Ab	-1.16±1.0Ba
Group 8 CT-H37%-ESP	-1.61±1.0Aa	4.68±2.3Ab	0.43±1.8Aa
Group 9 CC-H10%37%-SE	-1.22±0.9Aa	6.37±9.5Ab	0.37±1.3Aa

Group 10 CC-H10%-H37%-CV	-1.70±0.5Aa	3.58±1.7Ab	-0.48±0.8Aa
Group 11 CC-H10%-H37%-CA	-2.00±0.6Aa	6.85±6.4Ab	0.34±0.7Aa
Group 12 CC-H10%-H37%-ESP	-1.74±0.9Aa	5,32±2.3Ab	0.32±0.7Aa

Source: Research data, 2025.

*Uppercase letters compare data within the same column, while lowercase letters compare data within the same row. Identical letters represent statistically similar results (α = 5%).

Table 5 presents the results corresponding to the “b” coordinate, which refers to the chromatic saturation of the sample based on the color variation between blue and yellow. Positive “b” values predominantly indicate yellow, whereas negative values predominantly indicate blue. After analysis, it was observed that coffee staining rendered the samples more yellow, and that dental bleaching either restored (groups 5, 7, 8, 9, 10, 11, and 12) or reduced (groups 1, 2, 3, 4, and 6) the “b” value relative to the initial baseline. Furthermore, after treatment, the degree of yellowness was lower in group 3 (13.96 ± 5.6) compared to groups 5, 7, 8, and 9.

Table 5 – Mean (± standard deviation) of the “b” values observed at baseline, after staining, and after treatments.

	b		
	Baseline	Staining	Bleaching
Group 1 CS-H10%-SE	25.56±3.4Aa	36.70±3.7Ab	18.62±5.1c
Group 2 CS-H10%-CV	27.00±5.4Aa	35.40±4.0Ab	20.75±3.5c
Group 3 CS-H10%-CA	27.56±3.7Aa	33.03±3.8Ab	13.96±5.6Ac
Group 4 CS-H10%-ESP	27.03±3.1Aa	36.14±4.1Ab	16.58±5.4c

Group 5 CT-H37%-SE	27.32±4.5Aa	34.93±3.2Ab	22.88±4.6Ba
Group 6 CT-H37%-CV	24.02±3.6Aa	33.05±3.7Ab	16.58±5.6c
Group 7 CT-H37%-CA	25.90±3.1Aa	31.53±4.1Ab	22.19±5.3Ba
Group 8 CT-H37%-ESP	20.35±8.0Aa	30.54±4.6Ab	21.82±4.2Ba
Group 9 CC-H10%37%-SE	24.10±5.5Aa	32.21±4.4Ab	21.08±4.8Ba
Group 10 CC-H10%-H37%-CV	18.82±3.0Aa	29.99±6.1Ab	18.34±3.7a
Group 11 CC-H10%-H37%-CA	19.06±4.9Aa	32.08±4.5Ab	18.59±3.6a
Group 12 CC-H10%-H37%-ESP	21.72±4.1Aa	33.18±3.2Ab	19.25±4.4a

Source: Research data, 2025.

*Uppercase letters compare data within the same column, and lowercase letters compare data within the same row. Identical letters represent statistically similar results (α = 5%).

DISCUSSION

The analysis of the results obtained in this study indicated that the concomitant use of an activated charcoal-based whitening toothpaste with professional bleaching agents did not produce statistically significant improvements in dental bleaching outcomes. No observable alterations in tooth color were detected, thereby refuting the hypothesis that such toothpastes are effective adjuncts for bleaching.

Color changes on the tooth surface following bleaching procedures are typically assessed using a variety of methods. These include subjective visual techniques — such as standardized color scales — and objective instrument-based methods, such as spectrophotometry or colorimetry. Spectrophotometric analysis, in particular, is

considered more objective and precise because it quantifies the amount of light reflected by an object and converts this information into measurable data. Calibrated against visual color guides, this method generally yields more reliable results than subjective visual assessments[4,15].

Whitening toothpastes claim to remove extrinsic stains through a rapid, simple, and cost-effective approach. They generally contain bleaching agents—such as hydrogen peroxide and carbamide peroxide — combined with abrasives like activated charcoal. The abrasive particles can mechanically remove extrinsic stains during brushing, as they are retained between the brush bristles and the tooth surface, thereby scrubbing away the stain from the enamel[16]. Activated charcoal-based toothpastes are used similarly to conventional formulations. According to Greenwall, Greenwall-Cohen and Wilson (2019)[17] activated charcoal exhibits a high adsorption capacity, enabling it to bind both organic and inorganic compounds responsible for dental staining. Consequently, substances derived from foods, pigmented beverages (e.g., coffee, wine, tea), and tobacco are more readily removed due to the chemical affinity between these compounds and the porous structure of the charcoal[17].

Moreover, the abrasive action of activated charcoal may enhance tooth whiteness by removing superficial stains and biofilm from the tooth surface. However, it is important to note that, at high concentrations, the fine particles of activated charcoal can lead to enamel wear. Furthermore, these products do not modify the intrinsic color of the tooth, which is predominantly determined by the underlying dentin[10]. The literature also suggests that factors such as the type of toothbrush, brushing technique, and duration of brushing may play a more critical role in cleaning efficacy than the chemical composition of the toothpaste itself[18,19].

Several studies have evaluated the efficacy of whitening toothpastes as bleaching agents, but their findings have been inconsistent. While some investigations have reported significant changes in tooth color, others indicate that these products primarily facilitate superficial bleaching by removing extrinsic stains—thus acting more as stain removers than as effective bleaching agents[10,16,19]. Consequently, the adjunctive use of these toothpastes in professional bleaching protocols requires further investigation.

In the present study, color change (ΔE) was quantified using a digital spectrophotometer based on the CIELab system. Three distinct evaluations were performed: (1) prior to staining the samples with coffee, (2) following coffee staining,

and (3) after the application of the proposed bleaching treatments (Table 1). According to Paul, Peter, Pietrobon and Hämmerle (2002)[20], ΔE values below 1 are considered minimal and detectable only by instrumentation; values between 1.0 and 3.3 are perceptible only by trained observers; and values exceeding 3.3 are readily observable with the naked eye. It is important to emphasize that while ΔE values confirm the existence of a color difference, they do not indicate whether the color has become lighter or darker. Therefore, an analysis of the individual L*, a*, and b* components is essential to fully characterize the nature of the color change.

As illustrated in Table 2, the combined evaluation of ΔE and lightness (L*) data (Table 3) allowed for the determination of whether the samples experienced darkening or whitening. Coffee was selected as the staining agent due to its ubiquitous consumption and well-documented association with dental staining. Relative to the pre-staining condition, the coffee-stained samples exhibited a more pronounced yellowish hue and reduced lightness, thereby reinforcing the deleterious impact of coffee on dental color[21].

Subsequent to the bleaching procedures, significant intergroup differences were observed in both ΔE and lightness parameters. Treatments incorporating hydrogen peroxide—particularly the combination of 10% (at-home) and 35% (in-office) concentrations—significantly reduced darkening, improved lightness, and diminished the yellowish tint, as demonstrated in Table 3. Studies by Zhao, Pan, Malmstrom and Ren (2023)[22] and Faus-Matoses, Palau-Martínez, Amengual-Lorenzo, Faus-Matoses and Faus-Llácer (2024)[23] corroborate these findings, reporting that both 10% and 35% hydrogen peroxide yield comparable results when used individually. However, the combined protocol produced a more pronounced effect, presumably due to the synergistic interaction between the two concentrations, which accelerates the bleaching process and enhances treatment efficacy[4,8].

Conversely, the addition of activated charcoal did not result in statistically significant differences in bleaching outcomes when compared to treatments without its inclusion. Comparative analyses between groups with and without activated charcoal indicate that its incorporation does not substantially influence dental bleaching, thereby corroborating previous studies suggesting that, despite its widespread use, activated charcoal does not enhance bleaching outcomes in terms of color modification[10,24].

The lack of a significant effect from activated charcoal is attributable to its inability to modify the intrinsic color of dental enamel; its mechanism is primarily

abrasive, targeting only superficial (extrinsic) stains. In contrast, the intrinsic color of teeth is determined by the dentin, which remains unaffected by such mechanical action. Moreover, unlike chemical agents such as hydrogen peroxide—which degrade pigment molecules within the tooth structure—activated charcoal does not exert a chemical bleaching effect. Consequently, while it may transiently remove superficial stains, toothpaste formulations containing activated charcoal do not provide a sustained whitening effect[25,26].

These findings reinforce the conclusion that hydrogen peroxide, at various concentrations, is an effective bleaching agent, whereas activated charcoal does not confer additional benefits. Furthermore, the outcomes observed in groups treated with hydrogen peroxide alone were analogous to those in which activated charcoal was included, underscoring that the latter does not significantly enhance bleaching results[10,22,25].

Analyses of the a* and b* coordinates (Tables 4 and 5, respectively) further support these observations. In Table 4, significant differences in initial a* values after staining were noted across the groups; however, after treatment, only the group receiving in-office bleaching combined with activated charcoal toothpaste (group 7) exhibited statistically distinct results. The literature does not yet provide a definitive explanation for the interaction between 35% hydrogen peroxide and activated charcoal, and the scarcity of conclusive studies on this combination complicates interpretation. It is plausible that the initially more pronounced yellowish hue in group 7 facilitated a more perceptible bleaching effect upon hydrogen peroxide application, leading to statistical significance. Regarding the b* coordinate (Table 5), coffee staining markedly increased the yellow hue of the samples. Notably, groups 5, 7, 8, 9, 10, 11, and 12 did not display significant differences in b* values when compared to baseline, suggesting that the treatments—with or without the whitening toothpaste—effectively restored the specimens to a hue similar to the unstained condition[21].

Post-treatment, groups 1, 2, 3, 4, and 6 exhibited a reduction in the yellow hue relative to the stained condition; however, at-home bleaching protocols—whether combined with brushing or not—failed to fully restore b* values to baseline levels. Although group 3 demonstrated comparatively superior performance, the differences did not achieve statistical significance.

In summary, the data indicate that the inclusion of activated charcoal in whitening toothpastes does not significantly alter tooth hue, thereby reinforcing the

conclusion that, under the conditions evaluated, activated charcoal does not exert a meaningful impact on dental bleaching. These results are consistent with the literature, which suggests that while activated charcoal may facilitate the removal of superficial extrinsic stains, it does not effectuate substantive changes in the intrinsic color of teeth[10,16].

Based on the findings of this study, it can be concluded that, under the experimental conditions employed, whitening toothpastes did not produce significant improvements in dental bleaching outcomes. The combined use of hydrogen peroxide at concentrations of 10% and 35% proved to be the most efficacious protocol, aligning with the findings of Zhao, Pan, Malmstrom and Ren (2023)[22], which identify hydrogen peroxide as the principal bleaching agent. In contrast, activated charcoal did not confer additional benefits when integrated into professional bleaching regimens.

Some limitations of this study should be acknowledged. Although bovine teeth are commonly used in in vitro research due to their similarities to human teeth, differences in enamel thickness and dentin composition may affect the generalizability of the results. Moreover, the study was conducted under controlled laboratory conditions that did not account for variables such as saliva, oral biofilm interactions, and intraoral temperature—all of which may influence bleaching efficacy in vivo. Additionally, factors such as mastication and dietary intake, which could modulate bleaching effectiveness over time, were not evaluated. Future studies should incorporate these variables and assess additional properties (e.g., adhesion, microhardness, enamel morphology) through clinical trials with human subjects to provide a more comprehensive assessment applicable to clinical dental practice.

CONCLUSION

The findings of this study indicate that the combined application of hydrogen peroxide at 10% and 35% concentrations resulted in significantly enhanced bleaching efficacy, yielding a faster and more pronounced whitening effect compared to the individual use of each concentration. In contrast, the incorporation of activated charcoal did not produce any statistically significant improvement in bleaching outcomes, thereby confirming its negligible role in the whitening process. Collectively, these results substantiate that hydrogen peroxide, across its various concentrations,

is the principal agent driving the bleaching effect, while activated charcoal does not contribute meaningfully to the overall clinical outcomes in dental whitening procedures.

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3 CONCLUSÃO

Os resultados deste estudo mostraram que o clareamento dental com peróxido de hidrogênio a 10% e 35%, especialmente quando usados em conjunto, foi o método mais eficaz, proporcionando um clareamento mais rápido e eficiente em comparação com os tratamentos realizados separadamente. O carvão ativado não apresentou efeitos relevantes no clareamento dental, reforçando que ele não contribui de forma relevante para os resultados. Esses achados confirmam que o peróxido de hidrogênio, em suas diferentes concentrações, é o principal agente responsável pelo clareamento, enquanto o carvão ativado não se mostra eficaz nesse contexto.

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ANEXO

ANEXO 1 – APROVAÇÃO DO COMITÊ DE ÉTICA

Uniube Comitê de Ética em Experimentação Animal

Ofício CEEA–011/2023 Uberaba, 08 de novembro de 2023.

CERTIFICADO

Certificamos que o protocolo n° 017/2023 relativos ao projeto intitulado “Avaliação da Utilização de dentifrício clareador durante as técnicas de clareamento dental” que tem como responsável o Prof. Vinicius Rangel Geraldo Martins, está de acordo com os Princípios Éticos da Experimentação Animal, adotados pelo Comitê de Ética em Experimentação Animal (CEEA/UNIUBE) regido pela lei n° 11.794/08.

CERTIFICATE

We hereby certify that the protocol n° 017/2023 related to the project entitled “Effect of whitening toothpastes during in office and at home tooth bleaching” under the supervision of Prof. Ian Martin, is in agreement with the Ethical Principles in Animal Experimentation, adopted by the Ethics Committee in Animal Experimentation (CEEA/UNIUBE) according to the law n° 11.794/08.

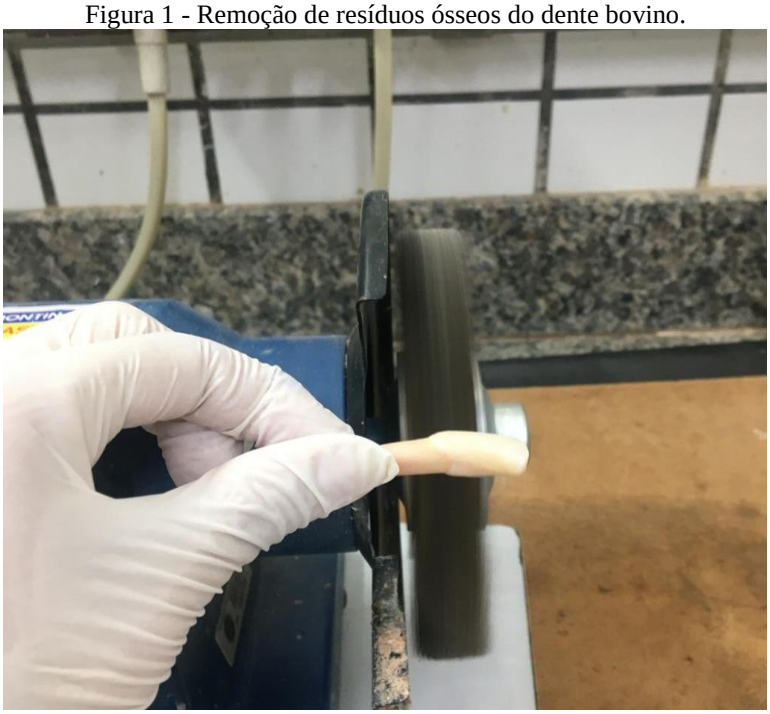
Atenciosamente,

Profa. Joely Ferreira Figueiredo Bittar
Coordenadora do CEEA-UNIUBE

APÊNDICE

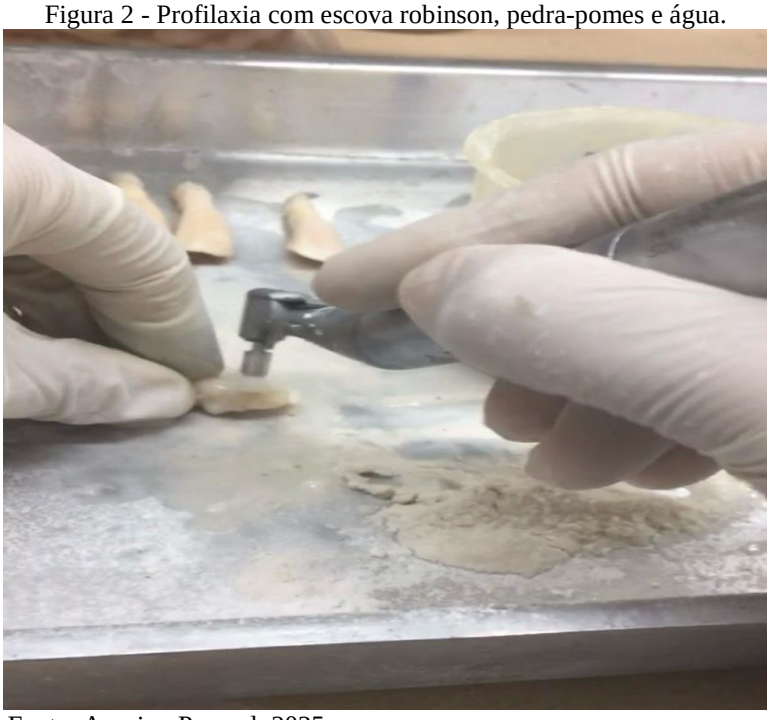
APÊNDICE 1 – FIGURAS ELABORADAS PELA AUTORA

Figura 1 - Remoção de resíduos ósseos do dente bovino.



Fonte: Arquivo Pessoal, 2025.

Figura 2 - Profilaxia com escova robinson, pedra-pomes e água.



Fonte: Arquivo Pessoal, 2025.

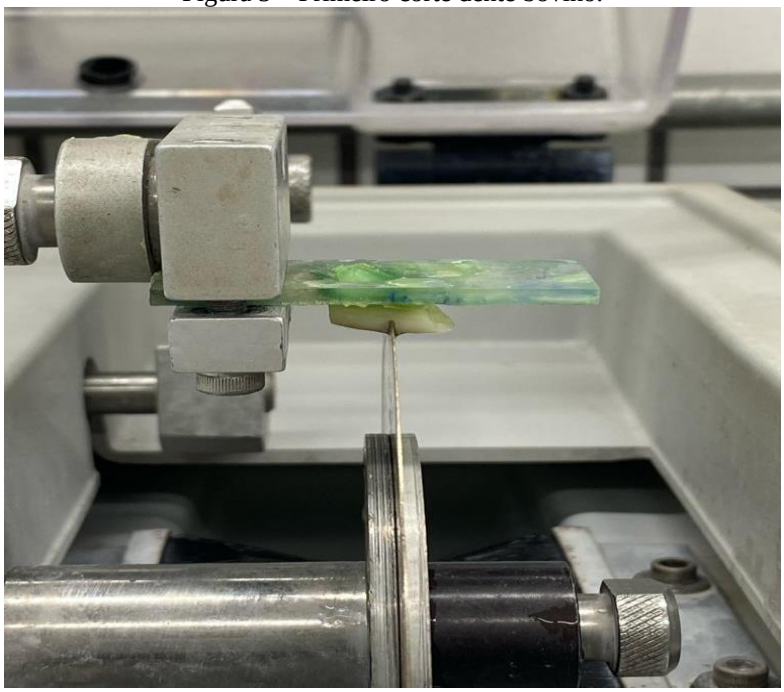
Figura 3 – Corte na junção amelo-cementaria para separação da raiz e da coroa.

Fonte: Arquivo Pessoal, 2025.

Figura 4 – Máquina de corte.

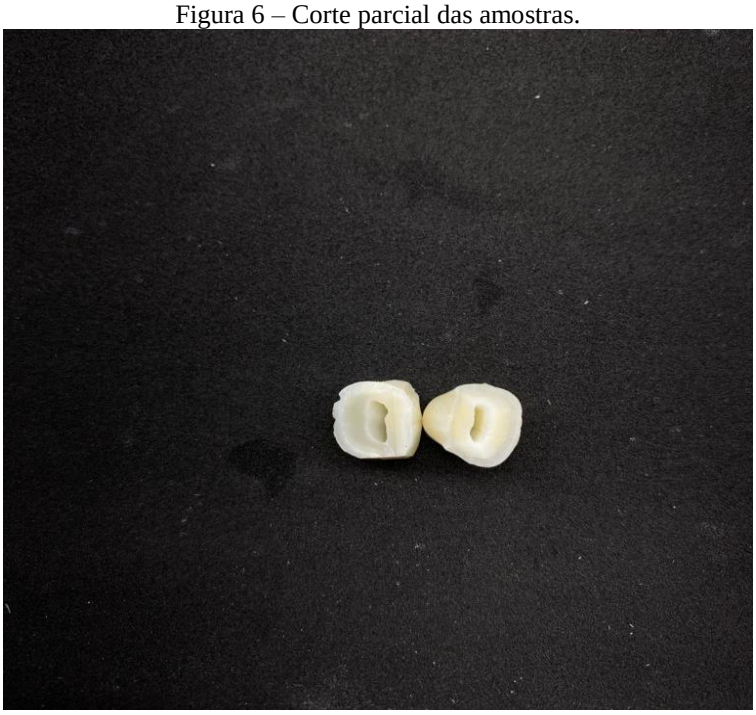
Fonte: Arquivo Pessoal, 2025.

Figura 5 – Primeiro corte dente bovino.



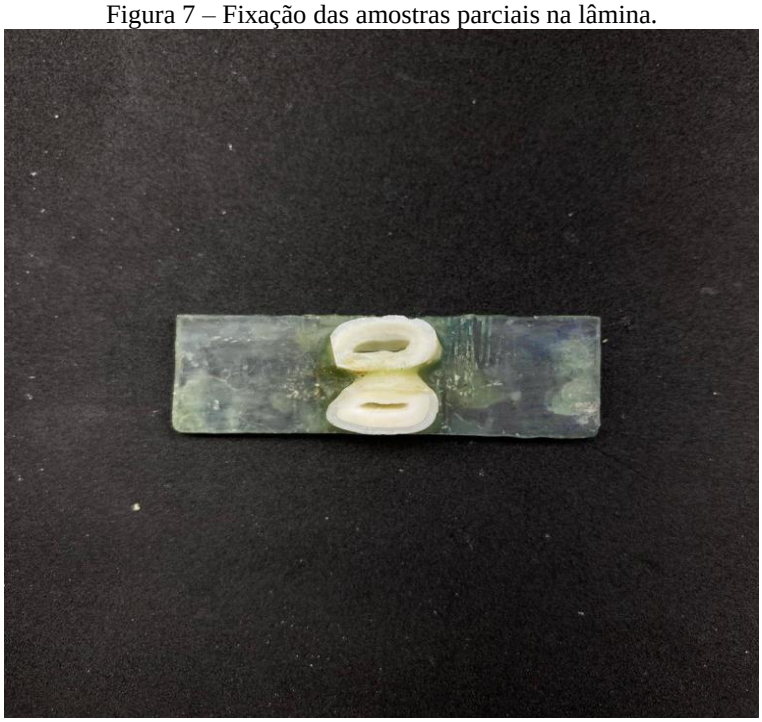
Fonte: Arquivo Pessoal, 2025.

Figura 6 – Corte parcial das amostras.



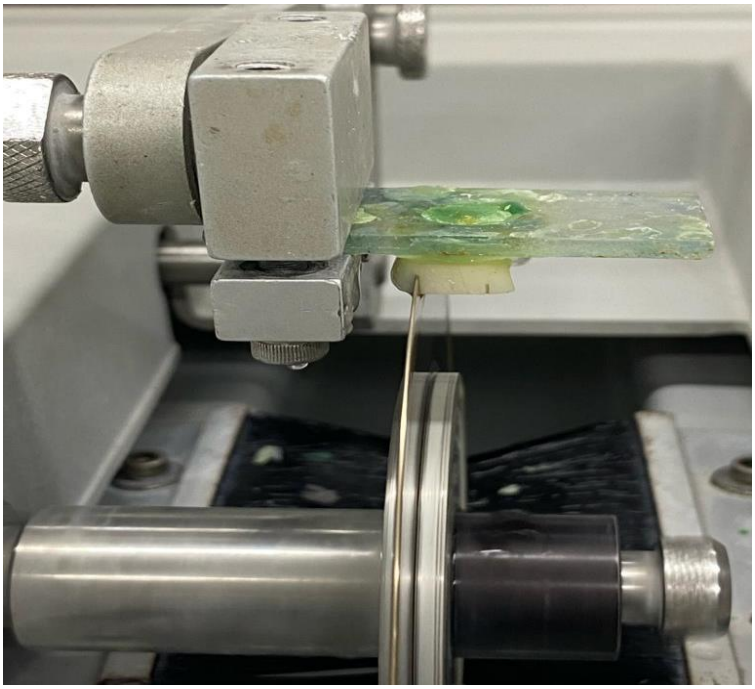
Fonte: Arquivo Pessoal, 2025.

Figura 7 – Fixação das amostras parciais na lâmina.



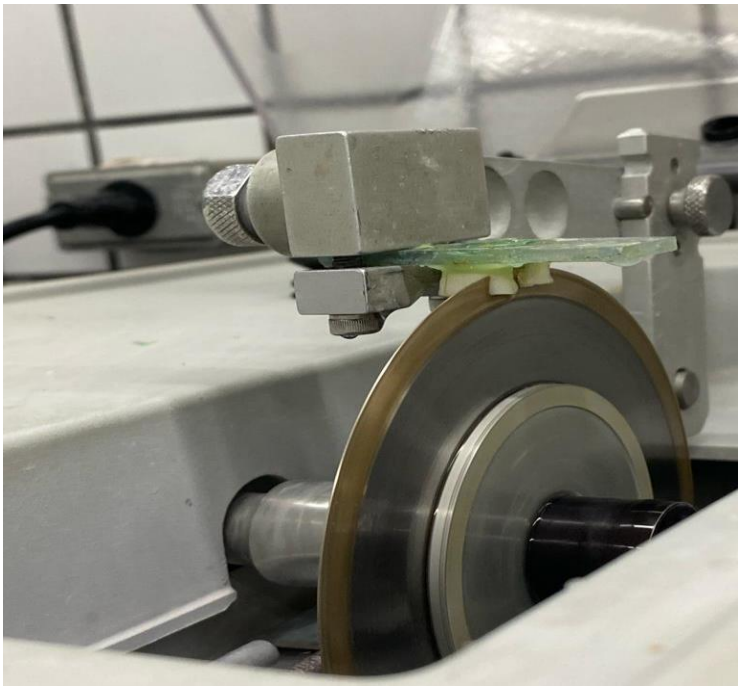
Fonte: Arquivo Pessoal, 2025.

Figura 8 – Primeiro corte das amostras parciais.



Fonte: Arquivo Pessoal, 2025.

Figura 9 – Segundo corte das amostras parciais.

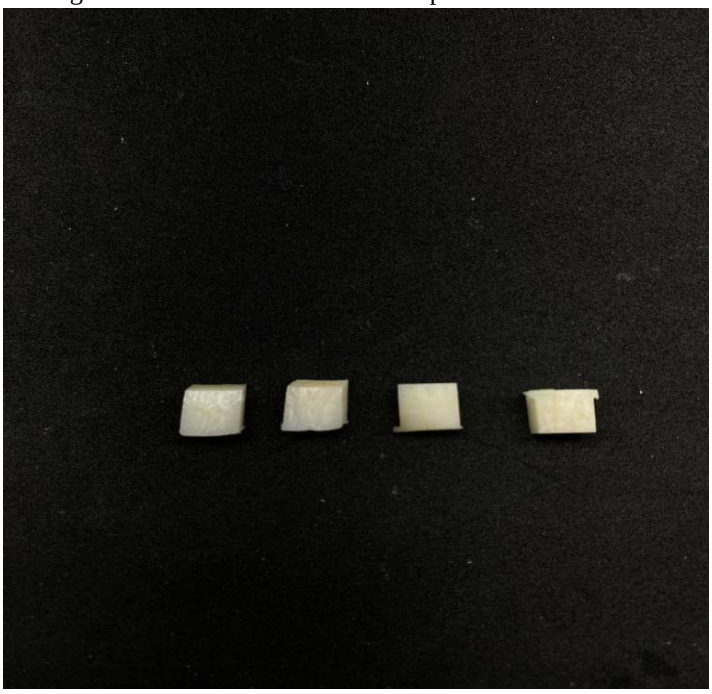


Fonte: Arquivo Pessoal, 2025.

Figura 10 – Corte de separação da palatina e da vestibular da amostra.

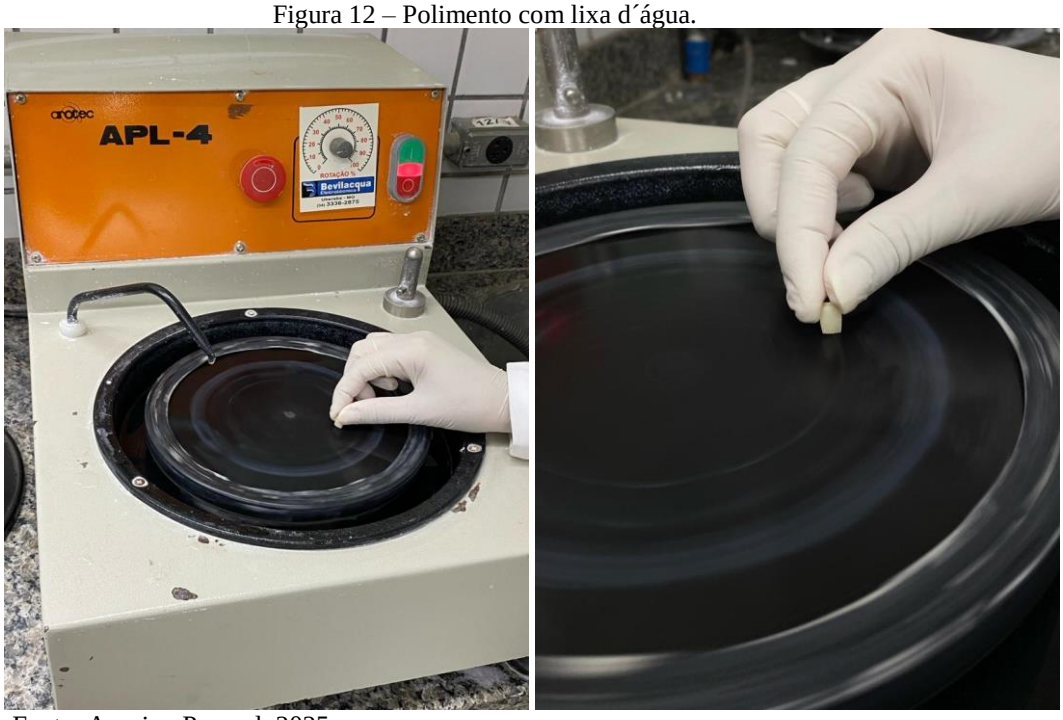
Fonte: Arquivo Pessoal, 2025.

Figura 11 – Amostras esmalte da superfície vestibular.



Fonte: Arquivo Pessoal, 2025.

Figura 12 – Polimento com lixa d´água.

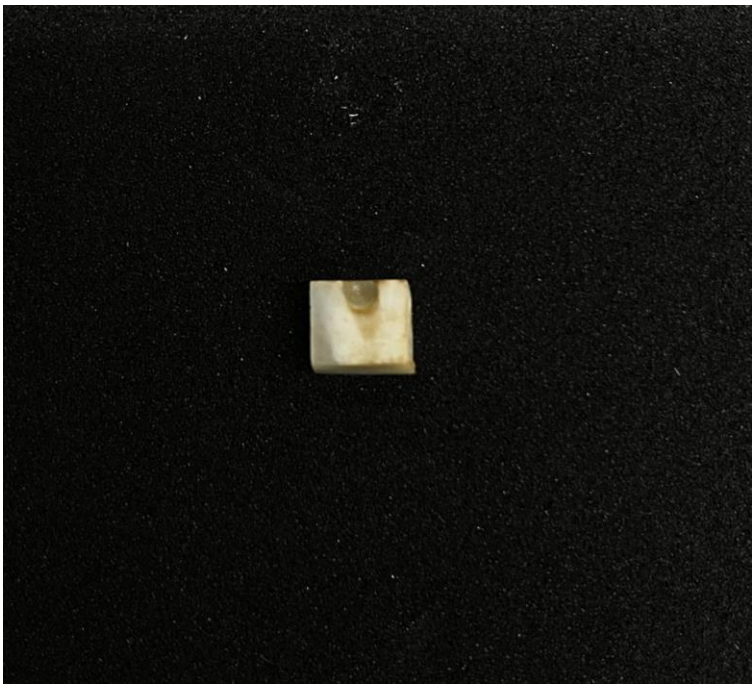


Fonte: Arquivo Pessoal, 2025.

Figura 13 – Tamanho das amostras: 6,0 mm x 6,0 mm.

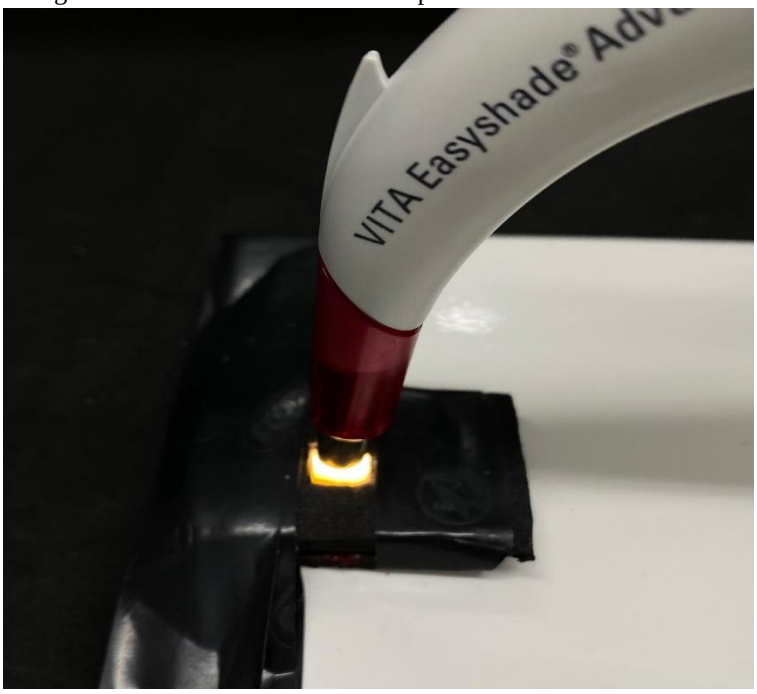
Fonte: Arquivo Pessoal, 2025.

Figura 14 – Marcação na superfície palatina das amostras.



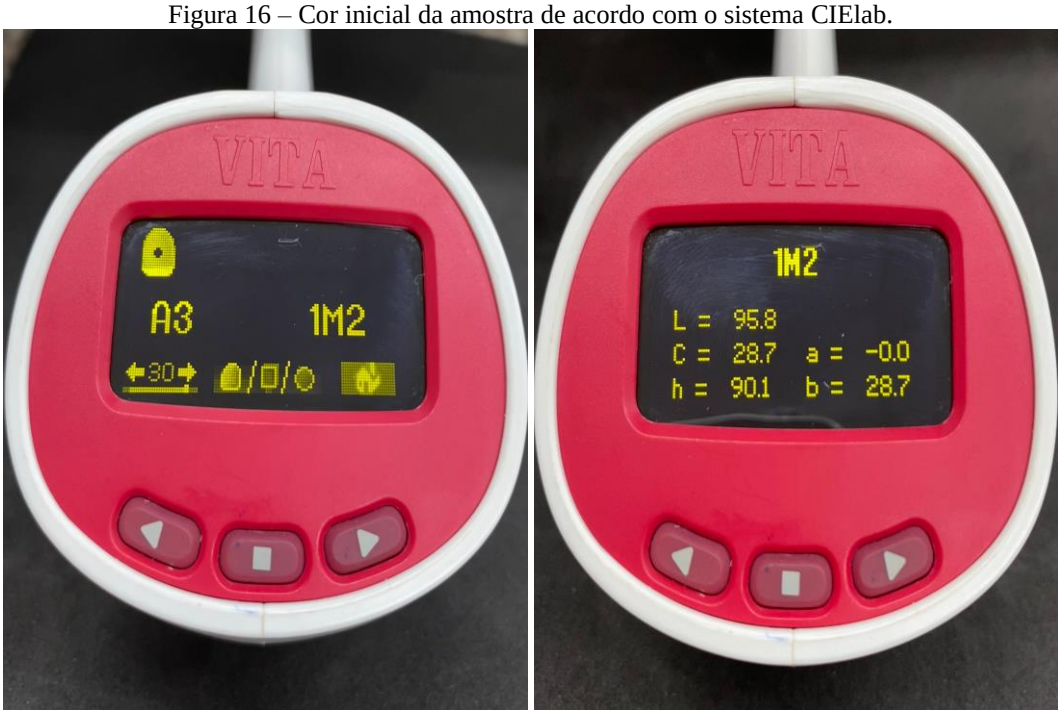
Fonte: Arquivo Pessoal, 2025.

Figura 15 – Análise inicial com o espectrofotômetro de colorimetria.



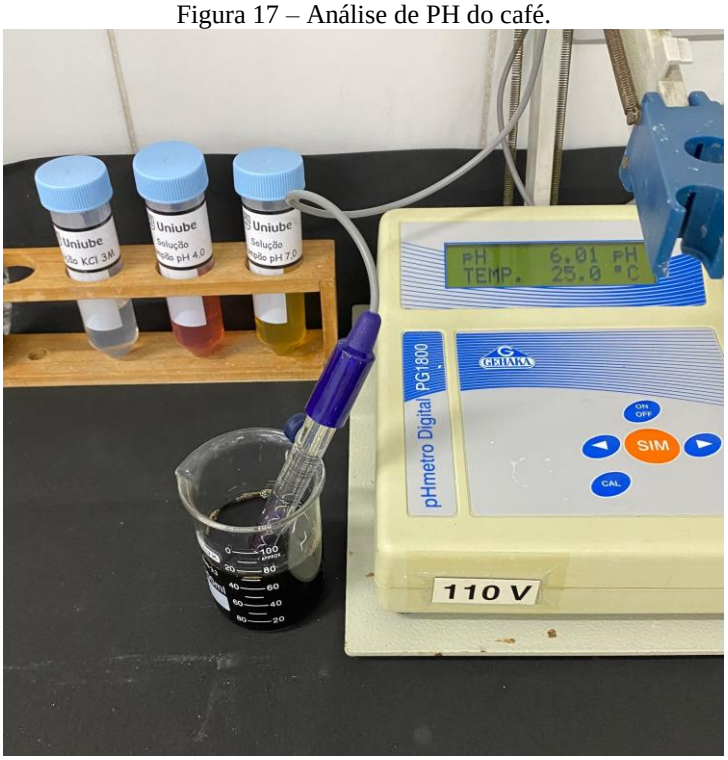
Fonte: Arquivo Pessoal, 2025.

Figura 16 – Cor inicial da amostra de acordo com o sistema CIElab.



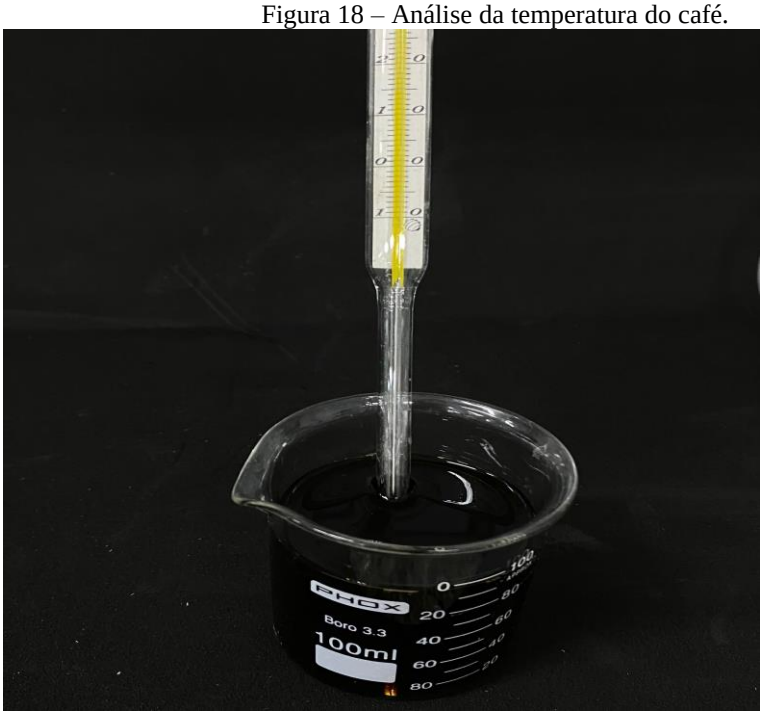
Fonte: Arquivo Pessoal, 2025.

Figura 17 – Análise de PH do café.



Fonte: Arquivo Pessoal, 2025.

Figura 18 – Análise da temperatura do café.



* O café foi empregado na temperatura de consumo.
Fonte: Arquivo Pessoal, 2025.

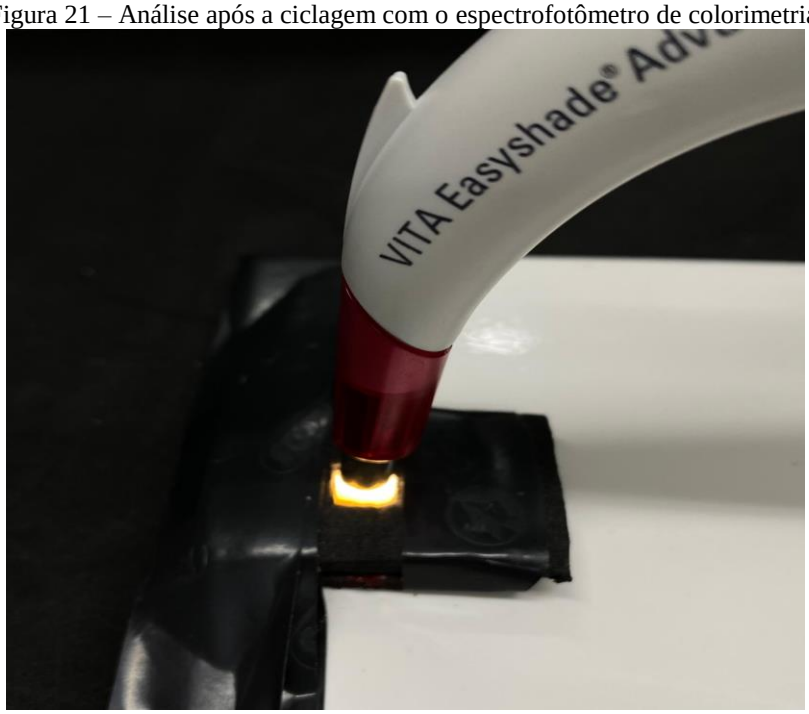
Figura 19 – Ciclagem em café (1,5mL/ espécime).

Fonte: Arquivo Pessoal, 2025.

Figura 20 – Amostra após 15 dias de ciclagem 3 vezes ao dia.

Fonte: Arquivo Pessoal, 2025.

Figura 21 – Análise após a ciclagem com o espectrofotômetro de colorimetria.



Fonte: Arquivo Pessoal, 2025.

Figura 22 – Clareamento Caseiro.

Fonte: Arquivo Pessoal, 2025.

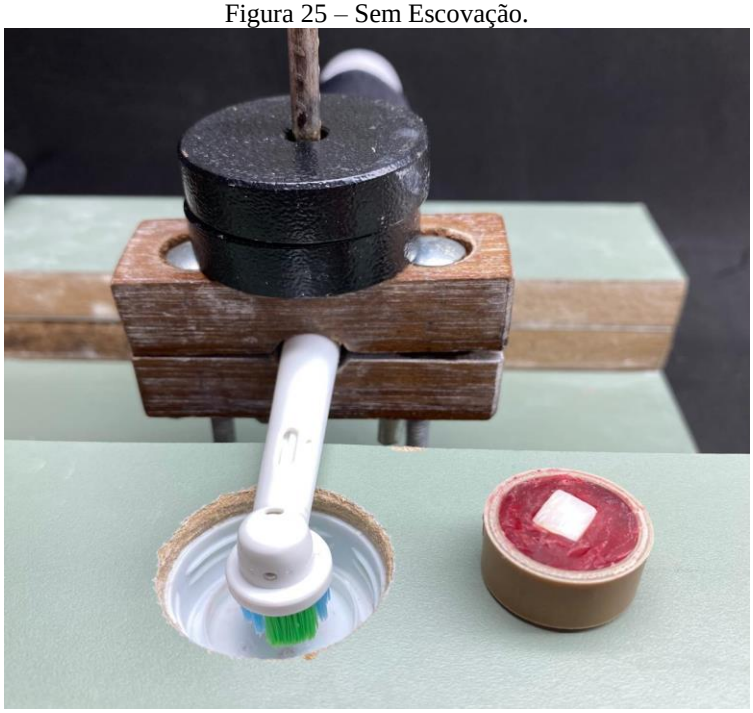
Figura 23 – Clareamento de Consultório.

Fonte: Arquivo Pessoal, 2025.

Figura 24 – Clareamento Combinado.

Fonte: Arquivo Pessoal, 2025.

Figura 25 – Sem Escovação.



Fonte: Arquivo Pessoal, 2025.

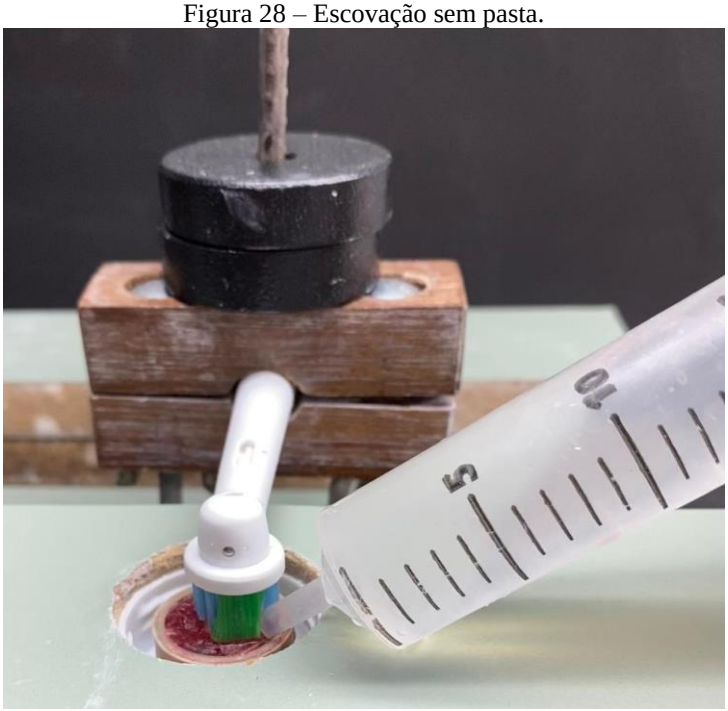
Figura 26 – Escovação com dentifrício Convencional.

Fonte: Arquivo Pessoal, 2025.

Figura 27 – Escovação com dentifrício com Carvão Ativado.

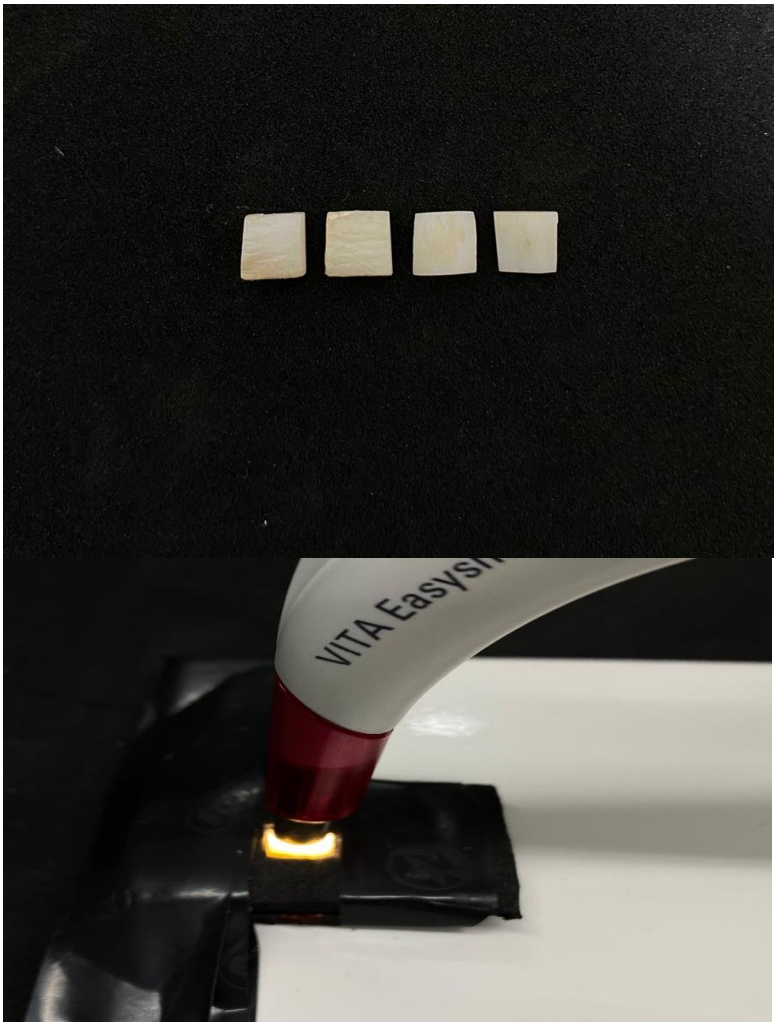
Fonte: Arquivo Pessoal, 2025.

Figura 28 – Escovação sem pasta.



Fonte: Arquivo Pessoal, 2025.

Figura 29 – Análise final com o espectrofotômetro de colorimetria.



Fonte: Arquivo Pessoal, 2025.