Research, Society and Development, v. 10, n. 15, e259101522809, 2021
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v10i15.22809

Whitening effect of brushing with activated charcoal-based products on enamel: integrative review

Efeito branqueador da escovação com produtos a base de carvão ativado no esmalte: revisão integrativa

Efecto blanqueador del cepillado con productos a base de carbón activado sobre el esmalte: revisión integradora

Received: 11/04/2021 | Reviewed: 11/11/2021 | Accept: 11/16/2021| Published: 11/26/2021

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Abstract
Objective: The purpose in this study was to analyze in the literature whether toothbrushing with charcoal-based products promotes a whitening effect. Methodology: An integrative literature review was carried out in the PubMed/MEDLINE database, which had as its guiding question: Does brushing with activated charcoal-based products have a whitening effect on the tooth? The search strategy was performed through the use of terms (charcoal AND "dentifrice OR toothpaste OR toothbrushing" AND "bleaching OR whitening" AND tooth), and only articles published in English in any period were included. Result: From a total of 34 scientific articles identified, 6 articles were included in the study, between the years 2019 and 2021. According to the evidence, three articles did not observe an advantage in performing brushing with activated charcoal-based products and another three observed a slight whitening effect, generally inferior when compared to other whitening agents. In addition, most articles recommend attention to the use of these products for oral hygiene containing charcoal, since many of these studies observed an increase on the roughness of tooth enamel, which is directly related to the inherent abrasiveness of each product and which depends on the source and the methods used to prepare and mill charcoal. Conclusion: From the studies analyzed so far, it is observed that brushing products based on activated charcoal have few effectiveness of tooth whitening, often lower when compared to other abrasive agents present in whitening dentifrices.
Keywords: Activated charcoal; Oral health; Dental abrasion.

Resumo
Objetivo: O propósito neste estudo foi analisar na literatura se a escovação dental com produtos a base de carvão promove efeito branqueador. Metodologia: Foi desenvolvida uma revisão integrativa da literatura, realizada na base de dados PubMed/MEDLINE, que teve como questão norteadora: A escovação com produtos a base de carvão ativado tem efeito branqueador no dente? A estratégia de busca foi realizada por meio do uso de termos (charcoal AND "dentifrice OR toothpaste OR toothbrushing" AND "bleaching OR whitening" AND tooth), sendo incluídos somente artigos publicados na língua inglesa em qualquer período. Resultado: Do total de 34 artigos científicos identificados, 6 artigos foram incluídos no estudo, compreendidos entre os anos 2019 e 2021. De acordo com as evidências, três artigos não observaram vantagem em se realizar a escovação com produtos a base de carvão ativado e os outros três observaram ligeiro efeito branqueador, geralmente inferior quando comparado a outros agentes de branqueamento. Além disso, a maioria dos artigos recomendam atenção ao uso destes produtos para higienização bucal contendo carvão, uma vez que muitos destes estudos observaram aumento da rugosidade do esmalte dental, que está diretamente relacionado à abrasividade inerente de cada produto e que depende da fonte e dos métodos usados para

preparar e triturar o carvão. Conclusão: A partir dos estudos analisados até o momento, observa-se que os produtos para escovação a base de carvão ativado possuem baixa efetividade de branqueamento dental, muitas vezes menor quando comparado a outros agentes abrasivos presentes em dentifrícios branqueadores.
Palavras-chave: Carvão ativado; Saúde bucal; Abrasão dentária.

Resumen
Objetivo: El propósito de este estudio fue analizar en la literatura si el cepillado con productos a base de carbón promueve un efecto blanqueador. Metodología: Se realizó una revisión integradora de la literatura en la base de datos PubMed/MEDLINE, que tenía como pregunta orientadora: ¿El cepillado con productos a base de carbón activado tiene un efecto blanqueador en el diente? La estrategia de búsqueda se realizó mediante el uso de términos (carbón Y "dentífrico O pasta de dientes O cepillado de dientes" Y "blanqueamiento O blanqueamiento" Y diente), y solo se incluyeron artículos publicados en inglés en cualquier período. Resultado: De un total de 34 artículos científicos identificados, se incluyeron 6 artículos en el estudio, entre los años 2019 y 2021. Según la evidencia, tres artículos no observaron ventaja en realizar cepillado con productos a base de carbón activado y otros tres observó un ligero efecto blanqueador, generalmente inferior en comparación con otros agentes blanqueadores. Además, la mayoría de artículos recomiendan prestar atención al uso de estos productos para la higiene bucal que contienen carbón, ya que muchos de estos estudios observaron un aumento de la rugosidad del esmalte dental, lo cual está directamente relacionado con la abrasividad inherente de cada producto y que depende de la fuente y los métodos utilizados para preparar y moler carbón vegetal. Conclusión: De los estudios analizados hasta el momento, se observa que los productos de cepillado a base de carbón activado tienen una baja efectividad de blanqueamiento dental, muchas veces menor en comparación con otros agentes abrasivos presentes en los dentífricos blanqueadores.
Palabras clave: Carbón activado; Salud bucal; Abrasión dental.

1. Introduction

The use of activated charcoal in medicine is an ancient practice that over the years has served to treat skin infections, individuals intoxicated by chemicals, poisons, and drugs (Brooks et al., 2017; Greenwall et al., 2019; Franco et al., 2020; Ghajari et al., 2021). Activated charcoal is the product of burning organic matter, such as wood, coconut husk, nutshell, and bamboo, which basically results in a material rich in carbon that is later compacted with high porosity and capable of adsorbing liquids, gases, and impurities to the interior of its pores, thus having the power to clarify, deodorize, purify liquids and gases (Greenwall et al., 2019).

The use of charcoal for oral hygiene purposes was first recorded in ancient Greece by Hippocrates (Brooks et al., 2017; Greenwall et al., 2019; Ghajari et al., 2021; Koc Vural et al., 2021). Currently, there are records of the use of this substance in oral health care in several countries around the world (Brooks et al., 2017), in addition to its use in the food industry as an ingredient and coloring in some countries (Franco et al., 2020). However, due attention is needed to a possible increase in the incidence of caries with brushing using activated charcoal-based products, since supposedly the use of any of these products can increase the surface roughness of enamel, favoring the installation of biofilm, in addition to fact that the vast majority of toothpastes that contain charcoal do not have fluoride or possibly inactivate it, reducing resistance to caries and tooth wear (Brooks et al., 2017; Greenwall et al., 2019; Dionysopoulos et al., 2020; Franco et al., 2020).

Due to its high capacity to adsorb and retain pigments, chromophores, and stains responsible for changing the color of teeth (Greenwall et al., 2019; Vaz et al., 2019), a few years ago a few charcoal-based products were disseminated as an alternative to conventional bleaching techniques (Franco et al., 2020). However, for tooth bleaching to occur, peroxide-based products are needed to break down the chromophores present inside the dental tissues, through an oxidation-reduction process (Dionysopoulos et al., 2020; Palandi et al., 2020; Silva et al., 2021). With carbamide peroxide and hydrogen peroxide being the bleaching agents commonly used in low and high concentration, at-home and in-office techniques, respectively (Dionysopoulos et al., 2020; Ghajari et al., 2021; Silva et al., 2021). Thus, products containing activated charcoal act only by removing extrinsic stains by the abrasion process caused by brushing, which could promote a certain degree of tooth whitening (Vaz et al., 2019; Dionysopoulos et al., 2020; Franco et al., 2020; Ghajari et al., 2021).

The current standard of beauty is associate with the concern for good eating habits, which in recent years has caused

major changes in the diet of thousands of people. Several studies show a relationship between acidic diet and lesions not caused by caries, leading to loss of dental structures caused by chemical actions, with the cervical region of the teeth being the most affected by non-carious lesions resulting from the ingestion of industrialized beverages, fruits, and citrus juices (Lussi et al., 2012; Barbour et al., 2011; Rios, 2018). Thus, cleaning performed with products containing charcoal may not be the best option to achieve desirable oral health, let alone reach society's desire for a white smile, as some studies suggest the high abrasive capacity of these products (Dionysopoulos et al. , 2020; Palandi et al., 2020; Koc Vural et al., 2021), which, when associated with an acidic diet, can result in greater loss of dental structures by mechanical (abrasion) and chemical (biocorrosion) actions (Barbour et al., 2011; Rios, 2018).

Thus, given the growing interest of the population in purchasing activated charcoal-based products for toothbrushing in order to obtain whiter teeth, the purpose in this study was to analyze in the scientific literature whether toothbrushing with charcoal-based products promotes a whitening effect, through an integrative review.

2. Methodology

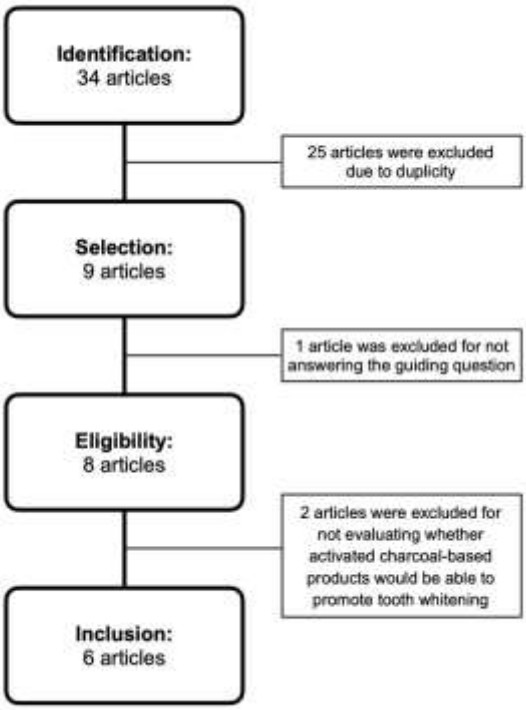
The integrative review was carried out through the following steps: 1) definition of the research's guiding question, 2) literature search, extraction and organization of information, 3) analysis of selected studies, 4) interpretation of results, and 5) presentation of the integrative review (Souza et al., 2010). Initially, the articles found in the searches were evaluated according to title and abstract. Then, the full text available was read and selected according to the inclusion criteria. Then, the following data were extracted from the articles: authors/year/type of study, objectives, methods, and evidence relevant to the research question.

Data collection was carried out in September 2021, through document analysis of bibliographic production obtained from the PubMed/MEDLINE database. The search strategy was performed using the terms: charcoal AND “dentifrice OR toothpaste OR brushing” AND “bleaching OR whitening” AND tooth. Only scientific articles published in the English language, at any period, that answered the established guiding question were included: Does brushing with activated charcoal-based products have a whitening effect on the tooth?

3. Results

The bibliographic search resulted in a total of 34 identified articles. Nine articles were selected for reading the abstracts, and 1 article was excluded for not answering the guiding question, as it evaluated the association between esophageal squamous cell carcinoma and the use of charcoal to whiten teeth (Mmbaga et al., 2020). In the eligibility stage, 8 articles were selected to be read in full, 2 more articles were excluded, as in these studies there was no assessment of whether activated charcoal products would be able to promote a whitening effect on the tooth, 1 study being a research opinion on the knowledge of professionals on the subject (Umanah et al., 2020) and 1 literature review and did not directly assess the bleaching effect of charcoal (Greenwall et al., 2019). Thus, 6 scientific articles were included to carry out the synthesis, between the years 2019 and 2021 (Figure 1).

Figure 1. Flowchart of selection of articles included in the integrative review.



Source: Authors.

According to the articles included in this review, three articles (Franco et al., 2020; Palandi et al., 2020; Koc Vural et al., 2021) did not observe an advantage in brushing with activated charcoal-based products and another three (Vaz et al., 2019; Dionysopoulos et al., 2020; Ghajari et al., 2021) observed a slight whitening effect, generally inferior when compared to other bleaching agents (Table 1).

Table 1. Data from the articles included in the integrative review according to authors/year of publication/type of study, objectives, methods, and relevant evidence to the research question.

Authors/year/type of study	Objectives	Methods	Relevant evidence
Vaz *et al*. 2019 *In vitro*	To compare the performance of whitening dentifrices with different technologies (activated charcoal, blue covarine, hydrogen peroxide, microspheres, and optimized abrasives) with conventional dentifrices, after initial and continued use	Assessment of color difference (ΔSGU) using the VITA Classical scale performed by a calibrated examiner	The dentifrice containing activated charcoal showed a whitening effect after continuous use, but with worse performance compared to whitening dentifrices containing blue covarine, hydrogen peroxide, and microspheres
Dionysopoulos *et al*. 2020 *In vitro*	To evaluate the effectiveness of a whitening dentifrice and a mouthwash containing charcoal in changing tooth color and enamel surface that can be induced after brushing	Evaluation of color change (ΔE) by spectrophotometry and surface morphology in confocal microscopy	Dentifrices containing activated charcoal can improve teeth whitening, but they should be used with care due to the changes that can be caused to the enamel surface
Franco *et al*. 2020 *In vitro*	To evaluate the whitening properties of a charcoal-based dental powder compared to a conventional fluoridated toothpaste and 10% carbamide peroxide	Evaluation of color change (ΔE) by spectrophotometry, mean roughness (Ra) and surface morphology in scanning electron microscopy	Charcoal-based dental powder was not effective in promoting a significant whitening effect. There were changes in surface roughness and morphology, but these were similar to the other groups
Palandi *et al*. 2020 *In vitro*	To evaluate the effect of activated charcoal powder combined with conventional and whitening dentifrices on the color and surface of the enamel compared to 16% carbamide peroxide	Evaluation of color change (ΔE_{00}) by spectrophotometry, mean roughness (Ra) and surface morphology in scanning electron microscopy	Activated charcoal powder did not increase color change when combined with conventional and whitening dentifrices, the 16% carbamide peroxide resulted in greater color change than charcoal powdered, and charcoal powder alone increased enamel roughness, in addition to exhibit more pronounced porosities and visible depressions
Ghajari *et al*. 2021 *In vitro*	To determine the level of whitening and abrasiveness of three whitening dentifrices, two of which are based on activated charcoal	Avaliação da alteração de cor (ΔE) por espectrofotometria e rugosidade média (Ra)	Todos os dentifrícios branqueadores testados causaram alterações no perfil da superfície e mudanças significativas na cor dos dentes antes e após a escovação, indicando sua abrasividade e capacidade de branqueamento
Koc Vural *et al*. 2021 *In vitro*	Comparar os efeitos de diferentes dentifrícios branqueadores à base de carvão na cor, rugosidade de superfície e dureza do esmalte humano	Evaluation of color change (ΔE) by spectrophotometry, mean roughness (Ra), and Vickers hardness	Activated charcoal-based whitening dentifrices and conventional fluoridated dentifrice had similar effects on color. Surface roughness was increased for most dentifrices, while hardness was not affected by charcoal containing dentifrices

Source: Authors.

4. Discussion

Recently, activated charcoal-based oral hygiene products have attracted the interest of the general population and several researchers due to their high porosity and extensive surface area, which theoretically is capable of adsorbing and retaining pigments, chromophores, and darkening stains teeth color, they can be an effective and progressive cleaning agent (Greenwall et al., 2019; Vaz et al., 2019). However, the effectiveness of charcoal-containing products for brushing teeth is questionable and controversial, intriguing researchers and patients as to their benefits and raising awareness of possible tooth surface wear. These products can be found in powder form to be used alone with direct application to the toothbrush or to be mixed with conventional and whitening dentifrices (Palandi et al., 2020), in addition to ready-to-use dentifrices with activated charcoal in its composition (Ghajari et al., 2021).

In 2019, Vaz et al. compared the performance of whitening dentifrices with different technologies after the first use and its continuous use, it was observed that only the dentifrices containing blue covarine and microspheres showed immediate whitening results, but after continuous use all the whitening dentifrices tested showed greater effectiveness than the group control (conventional dentifrice with traditional abrasive particles). The dentifrice that contains activated charcoal in its composition also proved to be effective, but in a more subtle way, promoting a certain degree of tooth whitening when used for

a continuous period that improves its performance. However, doubts and questions about possible damage caused by activated charcoal, its abrasiveness and power of action on the dental surface are still relevant. In addition, it is noteworthy that the color analysis was subjectively measured using a color scale.

Already Dionysopoulos et al. (2020) observed effectiveness in tooth whitening using a dentifrice containing charcoal in brushing, with an increase in color change by 40.5% when compared to brushing with deionized water and by 17.7% when compared to brushing with conventional toothpaste. Likewise, Ghajari et al. (2021) also reported the whitening capacity of whitening dentifrices, two of which were charcoal-based. However, studies warn about the abrasiveness of these products and the possible changes caused on the surface of the dental enamel (Dionysopoulos et al., 2020; Ghajari et al., 2021).

On the other hand, Palandi et al. (2020) did not observe significant whitening efficacy in brushing using an activated charcoal-based dental powder combined with conventional or whitening toothpastes, with less color change when compared to whitening with 16% carbamide peroxide, in addition to the isolated use of the powder to increase the roughness, exhibited more pronounced porosities, and visible depressions. As well as, Franco et al. (2020) and Koc Vural et al. (2021), who found no benefit in whitening when evaluating a dental powder and activated charcoal-based dentifrices, respectively; in addition to increased roughness and changes in enamel surface morphology.

The surface of tooth enamel should be as smooth as possible to avoid impregnation of pigments that can lead to staining, but enamel may have its roughness increased when placed in contact with abrasive substances and exposed to acidic diets (Shellis & Addy, 2014; Shamel et al., 2019). The activated charcoal of vegetable origin that is present in the composition of several products for brushing teeth has great potential to be abrasive, which could result in loss of healthy superficial tooth structures. The nature, method of preparation, concentration, and size of particles present can define the abrasive potential of each product, as well as the application time, force applied during brushing, and consistency of the brush bristles, which also influence the abrasiveness (Greenwall et al. al., 2019; Aydin et al., 2021).

Depending on the extent of abrasion suffered by the tooth surface, several negative consequences for the individual's oral health can be generated, it increasing the susceptibility to caries due to the possibility of generating an accumulation of pathogenic microorganisms (Brooks et al., 2017; Ghajari et al., 2021). The dentinal tubules travel through the entire dentin in a sinuous way towards the pulp, are responsible for the transmission of stimuli that reach the pulp, which can cause a sensation of pain or discomfort and even generate an inflammatory response, knowing that it is necessary to pay attention to the possible loss of tooth enamel caused by the indiscriminate use of these dentifrices, which can lead to greater exposure of dentinal tubules, resulting in hypersensitivity reactions in the patient (West et al., 2014; Jud et al., 2016; Felix & Ouanounou; , 2019), in addition to the fact that dentin is a darker tissue with a yellowish tint and its exposure would lead to an unwanted change in the color of the tooth, contrary to the whitening principle proposed by the manufacturers of these dentifrices that contain activated charcoal (Brooks et al ., 2017).

In addition, during brushing with products containing charcoal, the resulting dark foam tends to adhere and stain structural defects in the teeth, accumulate in gingival pockets, darken the tongue, and pigment the brush bristles, one of the possible reasons for the appearance of brushes black. Marginal defects and deficiencies along the cavosurface margin of resin composite restorations can be impregnated by charcoal particles and compromise their esthetics in esthetic regions, as well as the supragingival margins of metal-free crowns and veneers, requiring repair or replacement in many cases (Greenwall et al., 2019).

The majority of toothpastes that contain charcoal do not contain fluoride in their composition, being present in only about 8% (Brooks et al., 2017). However, even though fluoride is famously known for its preventive action against caries in the remineralization process of hard dental tissues, this leads us to another question which is about the adsorption potential of activated charcoal, which can inactivate or minimize the action of fluoride, and due to this possible interaction between the

compounds, their association would not be viable, but there is a lack of studies and scientific evidence to support these propositions (Bijle et al., 2018). The tooth whitening provided by abrasion during brushing caused by the abrasive particles of toothpastes removes extrinsic stains giving the sensation of "whitening" of the teeth, but unlike bleaching performed with peroxide-based agents that remove intrinsic stains, which in practice it means that the product applied on the dental surface has the power to diffuse through the dental structures (Tredwin et al., 2006). Furthermore, extrinsic stains, even those that are difficult to remove, can be removed through professional prophylaxis in a more conservative way.

Many people are influenced by the label of the product they are buying, as they usually present a consistent language that promises what the consumer most desires, in the case of products containing activated charcoal for toothbrushing, we can find words such as natural, organic, white, among others; which lead us to believe that the product only has good properties for oral health, but recognizing the abrasiveness of activated charcoal, it is necessary to be alert to the possible risks of its use on the dental surface (Greenwall et al., 2019). The caries susceptibility could be greater for those who use this type of dentifrice, due to the potential loss of enamel, which makes the tooth surface rougher, favoring the installation of biofilm and the development of pathogenic microorganisms. Users of these products can be led to believe that a more rigid brushing and application of greater force can improve the possible whitening action that is advocated by the advertising of manufacturing companies, it being up to professionals in the area to guide their patients about the possible harm of a traumatic brushing (Greulin et al., 2021; Koc Vural et al., 2021).

The available scientific evidence is still insufficient to assess the effectiveness of activated charcoal-based products for oral hygiene, despite the majority of manufacturers claiming the whitening capacity of these dentifrices (Brooks et al., 2017; Vaz et al., 2019). Thus, the sale of these products has been questioned by many professionals, as what exists in the current market is a selection of information that theoretically would be beneficial to the consumer, thus becoming a more favored and less scientifically based approach. The growing market for these products can also stimulate the production of new scientific data that help to prove their possible benefits and harms, it being up to dentists to assess the individual needs of each patient and guide them to maintain good oral hygiene habits (Franco et al., 2020; Torres et al., 2013). In addition, randomized clinical trials are needed to assess the real effects of activated charcoal for dental purposes.

5. Conclusion

Based on the studies analyzed, it can be concluded that brushing products based on activated charcoal have low tooth whitening effectiveness, often lower when compared to other abrasive agents present in whitening dentifrices.

Disclosure

This work was done in partial fulfillment of the requirements of undergraduate degree in Dentistry of Ruiz and Miola of the Faculty of Health Sciences - Unoeste. The authors declare any conflicts of interest.

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