



Charcoal-based dentifrices and powders: analyses of product labels, Instagram engagement, and altmetrics

Laura D. Bauler ¹, Cinthia S. dos Santos ¹, Giana S. Lima ¹,
Rafael R. Moraes ¹

This study identified charcoal-based dentifrices and abrasive powders sold in Brazil and analyzed their label information. The products were searched in four online shopping platforms. The same products were searched on Instagram and their engagement metrics were investigated. Furthermore, a literature review of international publications assessing charcoal dentifrices and powders was conducted, and altmetrics were collected (Altmetric and PlumX). Thirty-six products were found with prices between \$0.4–22 USD. Most frequent words in product description were sodium, stain, whitening, oil, xylitol, and coconut. Only 3 products contained fluoride. Bactericidal, antiviral, antifungal, and anti-inflammatory activities were indicated, in addition to non-scientific claims such as calming teeth or increasing oral immunity. In total, 72% of products had Instagram profiles, which generally showed low engagement rates (81%) and medium audience quality scores (65%). Twenty-two articles were found in the literature, from which 21 were in vitro studies. The single clinical study was sponsored by a charcoal product and had no control group. In total, 23% of studies showed positive results and 55% reported negative results for the charcoal products, which included no whitening ability, increased roughness, surface alterations, and lower demineralization prevention ability. Altmetric scores for the included articles varied from 0 to 55, with 40.9% of studies mentioned online. In conclusion, charcoal-based products are using marketing strategies on Instagram but their current engagement with the public is not high. Consumers are being exposed to charcoal products whose potential risks to health are still unknown.

Introduction

Regular dentifrices contain abrasive particles for the purpose of facilitating the removal of biofilms and stains that accumulate on tooth surfaces. The abrasive particles are harder than the components of biofilms and stains, therefore, they could remove pigments and produce the appearance of lighter teeth (1). Although toothbrushing with the use of charcoal is a practice that has been reported for centuries (2), the world market was recently flooded with dentifrices containing activated charcoal (3,4). Most manufacturers indicate these dentifrices for tooth whitening, but their therapeutic uses may vary. Up to now, only one single clinical study on the subject has been published (5), and little is known about these products and their abrasive effects over teeth, periodontal tissues and restorative materials.

In Brazil, no regulatory document establishes limits for dentifrice abrasiveness, thus consumers may have no idea of the abrasive potential of charcoal products or the damage they could cause to dental tissues. By contrast, the American Dental Association (ADA) evaluates dentifrices by using a relative dentin abrasivity (RDA) scale, with the value of 250 RDA considered safe for limited wear on dentin and almost no wear on enamel (6,7). All ADA-approved dentifrices should also contain fluoride. This regulation has not avoided the introduction of charcoal-based dentifrices in the USA market, as shown in a recent study that evaluated the labels of 50 dental products containing charcoal (4).

Internet and social media are used in contemporary marketing practices. Dental products are commonly advertised via Instagram, a social network widely used in Brazil (8). Investigation into the formulation and online engagement could allow a more in-depth understanding of the charcoal-based dentifrices available on the market. A recent study (9) pointed out low awareness and knowledge of the use and sequelae of charcoal products among dental professionals. It has become increasingly relevant to collect information from social media, because medical misinformation and fake medical news may

¹ School of Dentistry, Universidade Federal de Pelotas, Brazil

Correspondence: Prof. Rafael R. Moraes School of Dentistry – Universidade Federal de Pelotas Rua Gonçalves Chaves 457, sala 505, 96015-560, Pelotas, RS, Brazil, Tel: +55 53 32602831 (rafael.moraes@ufpel.edu.br)

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have real repercussions on the health of consumers (10,11). The mention of scientific articles in digital environments also is increasingly relevant. Altmetrics or article level metrics are complementary to journal citations and have been used to calculate the online impact of research publications (12). Since charcoal products are commonly advertised online, it would be interesting to evaluate whether the articles studying those products also are mentioned in digital domains.

This study identified charcoal-based dentifrices and abrasive powders available on the Brazilian market and analyzed the information provided by manufacturers. The products were also searched on Instagram and their engagement metrics were investigated. Furthermore, this article conducted a literature search for peer-reviewed publications assessing charcoal-based products, and altmetrics data for the included studies were collected. An overall synthesis of evidence is presented to situate the reader on current scientific findings.

Methods

Study design

This study was composed by three phases: In phase I, a cross-sectional study identified all charcoal dentifrices and powders for online sale in Brazil and analyzed their label information and indications. In phase II, the same products were searched on Instagram and their engagement metrics were analyzed. Phase III involved a literature search for peer-reviewed research assessing charcoal-based dentifrices and powders; altmetrics data were collected for the included articles.

Search for charcoal-based dentifrices and powders

An internet search was made for charcoal-based dentifrices and powders available on the Brazilian market. The research was carried out using the following keywords (in Portuguese): dentifrice, toothpaste, charcoal, activated charcoal, and whitening. The terms were searched in the shopping tab of google.com and three other well-known e-commerce platforms in Brazil: Mercado Livre, Amazon, and Americanas. The last search was carried out on May 25, 2020 by two evaluators (LDB and RRM). Dentifrices or abrasive powders claiming to contain charcoal were included. Other charcoal products, products without information in Portuguese or that did not offer shipping in Brazil were excluded. The following information were collected independently by two evaluators: product name/brand, manufacturer, formulation, indications, price without shipping taxes (in Brazilian Reals, then converted to US Dollars), and other information. For duplicate products, the lowest price was recorded. Because the online sales platforms did not always provide all data of interest, the manufacturer's website and label of each product also were assessed. When there was no information accessible on any item, and manufacturers did not reply to e-mails requesting the details, data were recorded as not available.

Instagram engagement

A search was made on Instagram on May 26, 2020, using the names of products or manufacturers. This social network was chosen because it is widely used in Brazil (13). The following data were collected: product name, username (@), and number of followers. Two engagement metrics were evaluated using the HypeAuditor platform (Indianapolis, IN, USA): Engagement Rate (ER) and Audience Quality Score (AQS). The ER measures the level of engagement that a content is receiving from an audience, showing how people interact with the content and estimating its relevance (14,15). Factors that influence ER include followers, comments, post shares, and likes. ER can be low (<1%), medium (between 1% and 3.5%) or high (>3.5%) (16). HypeAuditor uses the last 12 posts as a parameter and the formula $ER = ((likes + comments) / followers) / post\ count * 100\%$. The AQS evaluates the profiles with scores from 1 to 100, taking into account the ER, an 'authentic' ER determined by artificial intelligence, and the ability to reach followers (17). The formula had 15 criteria divided into four main categories: commitment index, type of target audience, growth pattern of followers, and 'authentic' comments. The formula separates personal accounts from brands and compares only similar accounts (17). The ranges considered when evaluating AQS are <40 (low quality audience), between 40 and 70 (medium), and above 70 (high quality) (17,18).

Literature review and research altmetrics

A search for peer-reviewed articles investigating any charcoal-based dentifrice or powder in dentistry was carried out in 7 international databases by two investigators (LDB and CS): PubMed, EMBASE, Scopus, Web of Science, Cochrane Library, LIVIVO, and OpenGrey. The last search was carried out on May 10, 2021 using the following search strategy in PubMed and adapted to each other database:

(charcoal OR activated charcoal OR black powder OR abrasive powder) AND (dentifrice OR toothpaste OR powder) AND (dent* OR tooth OR teeth OR oral). Only articles written in English were selected. For each study, the following data were extracted: study design, charcoal products evaluated, outcomes, main findings, and sponsorship. The altmetrics for all articles included were assessed on the same day using two different tools: Altmetric Attention Score and PlumX Analytics. The Altmetric Attention Score is a weighted count of the attention that a research output received online based on volume of mentions, source of mention, and authors/audience. The scores were collected by installing the Altmetric bookmarklet in a web browser and visiting each paper at the publisher's website or PubMed. PlumX is another tool to provide insights into the online interaction of people with a research output. PlumX data were retrieved from the Scopus database restricted to social media citations.

Data analysis

Data were analyzed descriptively. Words used in the description of the products were recorded. Singular and plural words were grouped together and the number of times that the terms were mentioned, and number of products that mention each word, were registered.

Results

Analysis of products

Thirty-six charcoal dentifrices or powders were found (Table 1). In several cases, products from different manufacturers had the same or similar commercial names. Prices ranged between \$0.4 and \$22 USD (average = \$7 USD). The most frequent words in formulation were charcoal, sodium, oil, and natural. The most common indications were stain removal and whitening. Sodium bicarbonate (28%), silica (22%), and diatomaceous earth (3%) were additional abrasive components of products, which also included xylitol (39% of products), xanthan (22%), coconut oil (20%), and tea tree oil (14%). One product indicated that the label information was based on an in vivo study, the others did not quote any scientific evidence. Four products suggested that a dentist should be consulted. No fluoride content was present in for 55% of products, and 30% highlighted this absence as beneficial. Therapeutic properties such as bactericidal, antiviral, antifungal, and anti-inflammatory were reported (8%). Box 1 presents a list of selected statements retrieved from product information, including non-scientific claims. In several products, the information indicated an appeal to a niche market, including words and expressions such as natural, ecologically correct, cruelty-free, gluten-free, and vegan. In some cases, pertinent information was at least also found.

Table 1. Charcoal-based dentifrices and powders identified in the search (N=36), ordered by increasing number of followers, and Instagram engagement metrics

Product	Instagram @	Followers (×1000)*	ER%	AOS	ER / AOS**
Creme dental com carvão ativado Medicallis	medicallis	2.3	1.29	36	medium / low
Ecodenta clareador carvão ativado	ecodenta	2.6	3.32	64	medium / medium
Activated charcoal toothpaste Nelson Naturals	nelsonnaturals	8.5	0.62	42	low / medium
Oralgen creme dental de carvão ativado	oralgen	9.6	0.21	16	low / low
Creme dental carvão ativado Tuxedo	goldmountainbeauty	9.8	0.14	28	low / low
Creme dental natural Bhava	bhavabio	10.9	0.85	50	low / medium
Closeup White Attraction Natural Glow	closeupbrasil	13.9	0.54	55	low / medium
Pasta de dentes sólida natural Espanza	sabonetesspanza	14.6	1.53	63	medium / medium
Activated charcoal probiotic toothpaste Hyperbiotics	hyperbiotics	16.8	0.17	34	low / low
Gel dental clareador de carvão ativado natural e orgânico AhoAloe	ahoaloe	17.1	0.50	56	low / medium
Creme dental Bianco Carbon carvão ativado com xilitol	bianco.oralcare	19.3	0.25	34	low / low
Dentil Carbox gel dental	dentiloficial	24.6	3.18	50	medium / medium
Pasta dental branqueadora de carvão ativado, menta fresca Heritage	heritagestorenaturals	31.7	0.76	48	low / medium
Claybrite creme dental de carvão ativado livre de flúor	zionhealth	32.4	0.22	34	low / low
Oral-B 3D White therapy purification charcoal	oralb br	40.2	0.21	51	low / medium
Crest 3D White	crest	51.7	0.28	65	low / medium
Fluoride Free whitening toothpaste Hello	helloproducts	59.9	0.67	63	low / medium
Colgate Natural Extracts Charcoal	colgatebrasil	78.2	1.24	66	medium / medium
Creme dental nano action black Be Emotion	beemotion	88.5	0.38	56	low / medium
Curaprox Black is White	curaproxbrasil	98.9	0.36	48	low / medium
Creme dental Orgânico Natural	organiconatural	138.4	0.18	57	low / medium
WhiteMax clareador dental	whitemaxoficial	166.9	0.09	25	low / low
Carvvo	carvvo	231.5	0.09	39	low / low
Creme dental Natural Black carvão ativado Puravida	puravida.com.br	265.7	0.41	47	low / medium
New White	newwhitebr	403.4	0.08	49	low / medium
Hinode ProActive	hinodeoficial	575.8	0.33	74	low / high

NA: not available. ER: engagement rate; AQS: audience quality score. *Data collected in July, 2020. **Based on thresholds for low, medium, and high AQS and ER presented in the methods.

The following products were not found on Instagram: Active Whitening Charcoal Toothpaste Dental Expert, Bamboo Charcoal Home Use, Carvão Ativado em pó Bella Donna, Clareador dental com carvão ativado Natú, Creme dental clareador carvão ativado Farmasite, Creme dental clareador com carvão ativado Botica Erva Doce, Creme dental Premium Whitening Suavetex, Creme dental preto de carvão ativado Crystal Black, Pó carvão ativado clareador dental Carvo Teeth Whitening, White Prime Carvo.

Box 1. Selected statements present in the information of the charcoal-based products found on the market (N=36 products)

Statements not supported by scientific evidence

- absorbs harmful agents
- soothes the pain of teeth
- helps to eliminate gum inflammation
- increases oral immunity
- assists in the elimination of toxins
- controls the pH of mouth
- filters impurities that cause yellow teeth
- strengthens the enamel
- powerful magnet for plaque, bacteria, and tannins
- inhibits the proliferation of caries
- non-abrasive product, suitable even for sensitive teeth
- protects against future stains
- regenerates the enamel

Statements that appeal to a niche market

- 100% natural and vegan
- cruelty-free
- different, curious, and exotic
- indicated to eliminate heavy metals
- free of fluoride and dyes
- organic raw materials
- does not contain chemicals
- no toxic ingredients
- not tested on animals
- nature friendly
- gum nutrition
- no artificial preservatives
- gluten-free
- an alternative for you who cares about the environment

Minimally pertinent statements

- whitens teeth, but common sense is needed
 - brush your teeth gently
 - does not lighten crowns, restorations, amalgams, or artificial dentures
 - does not replace your dentist's appointment and directions
 - never use expired products
 - product use should be discontinued in case of hypersensitivity
 - use requires caution and should not be excessive
 - results vary from person to person
 - use as directed by a qualified professional
-

Instagram engagement

Out of the 36 products, 72% had Instagram profiles, among which 44% were drug or natural product stores, 32% manufacturers of dental products, 12% were profiles exclusively of the product, and 12% were classified as others. Table 1 presents Instagram engagement data. The number of followers varied between 2.3K and 576K (average = 96K, median = 32K). Analyses of engagement showed varied results. The ER varied between 0.08% and 3.32% (average = 0.7%, median = 0.4%). Low ER values were observed for 81% of profiles, whereas 19% had a medium ER. The AQS ranged from 16 to 74 (average = 48, median = 49). One manufacturer had high AQS, whereas 65% had medium and 31% had low AQS.

Literature review and altmetrics

From over 2K retrieved articles, 22 original studies were included: 21 in vitro and 1 clinical study (5,19-39). This clinical study was sponsored by the manufacturer of the product, had a short term follow up (8 weeks), and reported positive results, but no control group was present. In total, 27 different charcoal products were tested. The most prevalent outcomes assessed were tooth color or whitening ability (64%), surface roughness (36%), and surface morphology (32%). Five studies showed positive results for the charcoal products, 5 articles showed similar results compared to control products, and 12 (55%) reported negative results for the charcoal products, including no whitening ability, increased roughness, surface wear, reduced bonding ability, and lower demineralization prevention ability. As shown in Table 2, 40.9% of articles were mentioned on the internet and/or social media. The Altmetric Attention Scores varied from 0 to 55 (median = 1) and the PlumX between 0 and 28 (median = 0).

Table 2. Altmetrics data for the 22 articles found in the peer-reviewed literature search

Author, year	Altmetric Attention Score*	PlumX social media*
Pertiwi et al., 2017 (19)	43	14
Singh et al., 2017 (20)	1	0
Chirkova et al., 2018 (5)	NA	NA
Akbar, 2019 (21)	0	0
Franco et al., 2019 (22)	14	1
Febriani et al., 2019 (23)	NA	0
Vaz et al., 2019 (24)	55	28
Rodrigues et al., 2019 (25)	1	NA
Syamsurizal et al., 2019 (26)	NA	NA
Aydin et al., 2020 (27)	0	0
Dionysopoulos et al., 2020 (28)	0	0
Farghal & Elkafrawy, 2020 (29)	0	NA
Machla et al., 2020 (30)	0	NA
Palandi et al., 2020 (31)	24	3
Panariello et al., 2020 (32)	3	1
Sulaiman et al., 2020 (33)	0	0
Torres et al., 2020 (34)	1	0
Alofi, et al., 2021 (35)	0	0
Kadhim & Shalan, 2021 (36)	0	0
Senthilkumar & Ramesh, 2021 (37)	NA	0
Viana et al, 2021 (38)	0	NA
Vural et al., 2021 (39)	1	0

NA: not available. *Data collected on May 10, 2021.

Discussion

Results of this study showed that there were 36 different charcoal-based dentifrices and powders available on the market, a high number that suggested a current market trend directed toward dental care consumers. Prices varied substantially between brands, which may indicate that these products targeted varied audiences. Manufacturers used non-scientific claims in many instances, sometimes with little or no consideration of the health risks related to using their products. Sensationalist marketing strategies to promote sales were also observed on Instagram. The scientific literature reviewed indicated few beneficial health effects by charcoal-based products, whereas articles reported adverse effects on tooth surfaces and restorative materials. Most studies were laboratorial analyses and the general strength of evidence was low; a single product-sponsored, non-controlled clinical study was found. Therefore, it seems reasonable to suggest that consumers of charcoal-based dentifrices and powders are being exposed to products of unknown abrasivity, that may have no whitening or other beneficial effects, and that their potential risks to health are still unknown.

To our best knowledge, this study is the first in dentistry to analyze the social media engagement of healthcare products. The importance of studying this subject has been increasingly discussed due to the rapid growth of social media users worldwide. Instagram has recently passed the mark of 1B users, and digital influencers play a major role in advertising and selling products (40). Especially on Instagram, digital influencers may impact the public to a greater extent than brand accounts. In this type of marketing strategy, the advertisement becomes more personal and may lead to more connections with potential consumers (41). Today, the internet is a place of great diffusion among people due to the ease of sharing and saving information (42). In this scenario, attention should be paid to the type of information to which people are being exposed, including ways to check the veracity of allegations made concerning health care. The present study showed that non-scientific claims are used in the descriptions of many charcoal-based products, an issue that deserves attention from regulatory bodies, health surveillance agencies, and dental councils. The lack of requirement for proving scientific data to support allegations may lead to companies using misleading advertisements and disguising the potential harm that charcoal-based products may cause to health (2).

With the ease of promoting and boosting publications on social network services, products disclosed on Instagram may engage attention with the help of videos and photos to attract audiences, including paid digital influencers. In this study, many manufacturers of charcoal products had low engagement metrics, which may suggest the presence of ghost followers. Ghost followers are social media accounts that remain inactive or do not engage in activity with a user they follow, i.e., do not participate by liking, commenting, or posting on publications made by the said user. Ghost accounts could be followers acquired by users to boost their numbers of followers, or simply real users that no longer engage with the account. Nowadays, the quest for a high number of followers is a social pressure that results in the number of an individual's followers being considered a proxy for his/her popularity, or quality of the content displayed. Engagement on Instagram is not a matter of number of followers but rather, how ambient viewers interact with the content. A study pointed out that partnering with an influencer with a high number of followers might not be the best option for brands, as this may lower the brand's perceived uniqueness by the public (43). For most charcoal-containing products, the interaction with audiences was low. Nevertheless, there seems to be room for studying how dental care products are being marketed on social media and the impact that this may have on the practice of dentistry, including the current issue of aesthetic demands potentially overlapping the health aspects.

When analyzing the formulation of charcoal products, several potential oral health concerns were observed, including the absence of fluoride and lack of instructions on how to use the products safely. The absence of fluoride could be a strategy to indicate that the product is natural, but fluoride-free dentifrices are widely available on the market. In addition, although discussion on possible risks that fluorides offer to health are increasingly available online, compelling clinical evidence about the benefits of fluorides for human health is available (44). Presence of xylitol was reported with an anti-caries claim, but clinical trials on the anti-caries effect of xylitol have generally been poorly designed or reported, making it difficult to reach adequate conclusions (45). The presence of natural components seems to be a great part of their marketing strategies and suggested a focus on natural products and vegan niche markets. The global market for vegan foods alone was valued at \$12.7 billion USD in 2018 (46). Many products also described therapeutic properties such as antibacterial, antiviral, anti-inflammatory activities, with no evidence to support these effects (2), reinforcing a type of sensationalist advertisement and the ease of disseminating misleading information. Research studies were rarely quoted, which raises the question whether the manufacturers are actually concerned with the safety of patients.

An interesting finding was that 40.9% of the peer-reviewed articles that evaluated charcoal-based products have been cited on the internet, including social media. It may be considered a relevant result since it indicated that research results are somehow being mentioned on the same platforms as those used to reach consumers. There is increasing interest in altmetrics because of the timeliness related to the impact of research findings. Whereas it may take years for an article to be cited in other journal papers, the same article can be quoted and discussed many times on internet platforms in the meantime. Another positive aspect is that citations from social media may represent a different scenario than traditional journals citations, e.g., more oriented toward application of findings to the general population (12). The articles on charcoal-based products had Altmetric scores reaching up to 55. By comparison, a recent study evaluated a random sample of 1000 articles and reported an average score of 3.7 for articles published in dental journals (47). Future research on the mention of dental articles in social media and other online platforms is welcome.

In conclusion, the present study indicated that there was scarcely any evidence on the clinical implications of using charcoal-based dentifrices and abrasive powders, with early evidence suggesting no tooth whitening effect and increased risk of superficial damage to dental tissues and restorative materials. In addition, the manner by which these products are described and advertised can lead to increased distrust about fluorides, which are major allies of oral health. Although further studies are needed, it seems that manufacturers are using marketing strategies on Instagram to reach potential consumers, although their current engagement with the public was not high. A limitation of the present study is that the products found for sale were not evaluated regarding their positive or negative impacts on oral health, periodontal and dental tissues. Consumers should remain attentive to the health risks that may be associated with the use of charcoal products, and rather seek information based on scientific evidences. Under no circumstances should consultation with and guidance of a dental professional be waived. Brazilian regulatory bodies also are urged to direct attention to this matter. Finally, there seems to be room for further research on social media marketing practices and product advertisement relative to oral care products.

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Resumo

Este estudo identificou dentifrícios e pós abrasivos de carvão vendidos no Brasil e analisou suas informações de rótulo. Os produtos foram pesquisados em quatro plataformas de compras online. Os mesmos produtos foram pesquisados no Instagram e métricas de engajamento dos perfis foram investigadas. Além disso, foi realizada uma revisão da literatura buscando publicações internacionais que avaliaram dentifrícios e pós de carvão; dados de altmetria foram coletados (Altmetric e PlumX). Foram encontrados 36 produtos com preços entre US\$ 0,4–22. As palavras mais frequentes na descrição dos produtos foram sódio, mancha, clareamento, óleo, xilitol e coco. Apenas 3 produtos continham flúor. Foram indicadas atividades bactericidas, antivirais, antifúngicas e anti-inflamatórias, além de alegações não-científicas como acalmar dentes ou aumentar a imunidade oral. No total, 72% dos produtos tinham perfis no Instagram, que geralmente apresentavam baixas taxas de engajamento (81%) e média qualidade de audiência (65%). Vinte e dois artigos foram encontrados na literatura, dos quais 21 foram estudos in vitro. O único estudo clínico foi patrocinado por um produto de carvão e não tinha grupo controle. No total, 23% dos estudos apresentaram resultados positivos e 55% relataram resultados negativos para os produtos de carvão, que incluíram incapacidade de clareamento, aumento da rugosidade, alterações superficiais e menor capacidade de prevenção da desmineralização do esmalte. A altmetria dos artigos incluídos variou de 0 a 55, com 40,9% dos estudos sendo mencionados online. Em conclusão, os produtos à base de carvão estão usando estratégias de marketing no Instagram, mas seu engajamento atual com o público não é alto. Consumidores estão sendo expostos a produtos de carvão cujos potenciais riscos à saúde ainda são desconhecidos

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