

# The Potential Uses of Baobab Tree's Medicinal Effects in Dentistry: A Literature Review

Jameel A. Abuljadayel<sup>1</sup>

1. Preventive Dentistry, Umm Al-Qura University, Makkah, SAU

**Corresponding author:** Jameel A. Abuljadayel, jaabuljadayel@uqu.edu.sa

Review began 11/15/2023

Review ended 11/18/2023

Published 11/23/2023

© Copyright 2023

Abuljadayel. This is an open access article distributed under the terms of the Creative Commons Attribution License CC-BY 4.0., which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

## Abstract

*Adansonia digitata* (Baobab) tree is an African tree with a long history in traditional medicine. The local inhabitants of Africa have been using the different tree components to treat medical diseases, such as fever, diarrhea, malaria, cough, dysentery, and microbial infections. Recently, the tree gained the attention of scientists due to its medical and pharmaceutical properties and nutritional values, which generated a myriad number of investigations regarding its phytochemical and macro- and micronutrient contents. The fruit pulp is especially rich in vitamin C, pectin, fibers, and minerals such as calcium, magnesium, potassium, phosphorus, zinc, iron, and copper. Additionally, the leaves contain high levels of calcium, while the seeds are considered a good source of protein and fat. Altogether, they contain a variety of polyphenols, fatty acids, and amino acids. The tree extracts possess potent antioxidant, cell-protective, and anti-inflammatory activities. However, no information was found in the literature about the use of Baobab tree products in the dental field. The aim of this review is to discuss the well-documented medical effects and chemical and mineral components of the different Baobab tree parts from a dental point of view to open more areas of research concerning its potential applications in the dental field. Antioxidants and vitamin C are known to help in maintaining healthy periodontal and gingival tissues. They also help in wound healing and alveolar bone integrity. Moreover, phytochemicals and phenolic compounds have been utilized in controlling dental plaque and manufacturing intracanal medications as they manifest antimicrobial and anti-inflammatory activities. Furthermore, calcium and phosphorus incorporation in dental biomaterials is commonly used in vital pulp therapy and repairing bone defects. After reviewing the reported medicinal and pharmaceutical activities of the Baobab tree, it can be inferred that the tree extracts possess potential uses in the dental field, which requires further investigation for validation.

**Categories:** Dentistry

**Keywords:** anti-inflammatory, antioxidants, dentistry, *adansonia digitata*, dental biomaterials, baobab

## Introduction And Background

*Adansonia digitata* (AD/Baobab) is a native fruit that grows and originates in the sub-Saharan areas of Africa [1,2]. For example, it can be initially found in Sudan, Nigeria, Mali, Burkina Faso, Senegal, Kenya, Mozambique, etc. [1-6]. The tree itself is a part of the Malvaceae family, and it has an iconic shape and various common names, such as the upside-down tree, the monkey-bread tree, the small pharmacy tree, and the chemist tree [1,7].

The native population of Africa used the different parts of the tree throughout history in their diet and traditional medicine [1,2,5-8]. The whole components of the tree (fruit, leaves, seeds, and cortex) have been traditionally used as a medicine for several diseases, such as fever, diarrhea, malaria, cough, dysentery, hemoptysis, tuberculosis, microbial infections, and worms [2,4,5,7], while the seeds and oil are used to treat muscle wounds, dandruff, and other skin diseases [7,9]. These therapeutic uses were justified lately in the literature and linked to the immunostimulant, antioxidant, analgesic, antiviral, antimicrobial, anticarcinogenic, anti-depressive, hepatoprotective, cardioprotective, antidiabetic, and anti-inflammatory potentials of the tree's components [2,5,7,10-20].

Many reports have analyzed the chemical composition of the different tree components [1,2,7,8,21,22]. These components' medical and pharmaceutical effects are evident in the literature [23-27]. However, the literature needs more information about using Baobab tree products in the dental field. Thus, this review aims to discuss the published medical bioactive benefits of the various Baobab tree components from a dental point of view and then suggests the potential utilization areas of these extracts among the different dentistry disciplines.

## Review

### Mineral contents and chemical composition of the AD tree

The Baobab tree is believed to be rich in chemical compounds, vitamins, nutrients, and minerals, which possess pharmacological, medicinal, and bioactive features [2,4,5,7]. Regarding the mineral contents, reports have shown that the fruit pulp contains high amounts of Ca, Mg, K, P, Zn, Fe, and Cu [28-30]. Chadare et al.

#### How to cite this article

Abuljadayel J A (November 23, 2023) The Potential Uses of Baobab Tree's Medicinal Effects in Dentistry: A Literature Review. Cureus 15(11): e49304. DOI 10.7759/cureus.49304

have comprehensively reviewed the composition of the different parts of the AD tree and reported that the average calcium contents in the leaves, fruit pulp, and seeds were 1,582.3 mg/100 g, 301.8 mg/100 g, and 252 mg/100 g, respectively [8]. The same review has shown that phosphorus average levels were 453 mg/100 g, 274 mg/100 g, and 106 mg/100 g in the seeds, leaves, and pulp, respectively [8]. In an in vitro study that measured the mineral contents of the root tubers of the Baobab tree, calcium was shown to be the highest available mineral (42.91 mg/100 g) [1]. Additionally, Evang et al. showed that calcium content in the Baobab fruit pulp is equal to 408 mg/100 g in their sample [28]. Another investigation has completely replaced the skimmed milk in their ice cream contents with the pulp flour of the Baobab fruit and still got a considerable amount of calcium. In contrast, phosphorus has directly increased with the consequent increase of the Baobab fruit pulp percentages as an ingredient [30]. In addition, a published report has investigated the calcium and phosphorus amounts in cake manufacturing after the partial replacement of wheat flour with Baobab fruit pulp flour and reported a significant increase of both elements levels when the Baobab fruit pulp is incorporated [29].

Regarding vitamin C, many reports have shown that Baobab fruit pulp is tremendously rich in vitamin C [10,28,31]. It was reported that the average level of vitamin C in the pulp of AD is up to 290 mg/100 g [8], which is considered up to 10 times higher than vitamin C levels in orange pulp and significantly higher than in other different fruits [2,7]. In other words, consuming 20 g of the Baobab pulp would cover 140%-240% and up to 40%-70% of the recommended daily intake for a child and pregnant women, respectively [8].

Chemically, the Baobab tree components (fruit pulp, fruit shell, leaves, seeds, seed oil, stem bark) were thoroughly investigated and shown to be extremely rich in phytochemicals and polyphenols, such as hydroxybenzoic acid, protocatechuic acid, dihydrocaffeic acid, hydroxycinnamic acid, gallic acid, catechin, flavonoids, saponin derivatives, and terpenoids [21,23-26]. Additionally, fatty acids such as linoleic, palmitic, and oleic acids were found in tree extracts [21,25]. Investigations have also shown that considerable amounts of amino acids were found, such as methionine, L. arginine, lysine, and proline [8,10,18,23-27,29,30,32-37]. With such components, it is no wonder that the tree has been known as "the chemist tree" as these compounds possess countless medicinal and pharmaceutical benefits.

## Potent and bioactive compounds of AD and their medicinal activities

All AD tree components are traditionally widely known for their medicinal potency [1]. Despite that, the reported level of activity is affected by several factors, such as the area and the way of harvesting, the storage process, the age of samples, the soil type, genes, and the methodology of analysis [8]. However, there is a consensus in the literature that Baobab/AD possesses a high level of antioxidant activity [4,5,7,8,11,12,14,17,22,26]. Antioxidant activity was reported concerning every part of the Baobab tree component (fruit pulp, shell, leaves, seeds, and stem bark), and it was linked to the phytochemical, polyphenolic, and vitamin C contents of the tree components [10,24,26,35]. It was reported that the integral antioxidant capacity of the pulp is up to 100 times higher than that of the orange pulp [8]. Moreover, Baobab leaves show higher antioxidant capacity than other widely known fruits for their antioxidant activities, such as kiwi, strawberries, and apples [8]. Recent animal studies showed the protective effect of Baobab pulp extracts through their potent antioxidant activity against testicular damage induced by cotton seed extract and cadmium chloride in Wistar rats [33,34]. Additionally, another study showed that by suppressing oxidative stress, aqueous Baobab leaf extract reduced the cortical neurodegeneration caused by lead acetate in rats [27]. Baobab pulp has been shown to have a significant cardioprotective effect when used as a treatment for isoproterenol-induced myocardial oxidative stress in experimental rats, as it was able to reduce oxidative stress and blocks the increase of cardiac marker enzymes, which in turn reduces the extent of myocardial damage [14].

The antidiabetic, anti-inflammatory, and anti-dyslipidemia potency of Baobab tree extracts were also reported in the literature [10,13,18,23]. It was shown that Baobab can reduce the blood sugar response to meals high in carbohydrates both in vitro and in vivo [13]. Furthermore, the antidiabetic action of Baobab fruit extracts was tested in a model of diabetic rats, and results showed that they significantly improved lipid and glucose metabolism in addition to exerting an antioxidant effect [24]. Another animal study has shown that the fruit pulp of AD exhibited hypoglycemic, anti-inflammatory, and antilipidemic properties, which were reflected in a lower plasma atherogenic index [10]. Furthermore, it restored the stability of hepatic and renal biomarkers and acted as a restoring agent on the pathological damage of the tissues of the heart, liver, and kidneys [10]. Another in vivo study has examined the effect of incorporating 30 mg of Baobab fruit pulp powder into the medication protocol of dyslipidemia patients and found a significant reduction in total cholesterol and triglycerides after four weeks in comparison with the control group who were on medication only [38]. It is worth mentioning that the mechanisms of all these medicinal effects are not yet fully understood; however, they are linked synergistically to the antioxidant and anti-inflammatory potency of the Baobab fruit [10]. Findings of common AD compounds, elements, and minerals are summarized along with their medical effect in Table 1.

Part of the tree	Elements or compounds	Reported medicinal effects
Fruit	Phytochemicals	Hepatic and renoprotective [10,25].
	Phenolic compounds	Antioxidant [10,26,30,33,34,39,40], hypoglycemic and antidiabetic effects [13,24,39-41]. Also enhances cognitive performance [31,42].
	Vitamin C, Ca, and Mg	Anti-inflammatory effect (vitamin C) [10], and potentially improve anemia cases[28].
	Amino acids (e.g., methionine, L. arginine, lysine, proline)	Building up protein, antioxidants, inducing collagen and elastin, and enhancing vascular integrity [10].
	Pectin fibres	Anti-Hyper cholesterol [24,38].
Fruit shell	Phenolic compounds	Antidiabetic and antioxidant [23].
Seeds oil	Phenolic compounds	Antioxidant and cell protective[43].
	Fatty acids (e.g., linoleic, palmitic, and oleic acid)	Hydrating, moistening, and non-irritant to the skin[44].
Leaves	Phytochemicals	Anthelmintic activity [37].
	Phenolic compound	Neuroprotective and antioxidant effect [27,32]. Antihypertensive, Anti-dyslipidemia, and Anti-metabolic syndrome effects [18]. Hepatoprotective [32].
Stem bark	Phenolic compounds	Antihypertensive, Antioxidant, Cardiovascular Protective and Hepato-protective [35,36].

**TABLE 1: The most prominent compounds of AD and their medicinal impact.**

### Potential uses of AD (Baobab) extracts in dentistry according to its published compounds

On a cellular level, the oxidation process will form free radicals, which in turn initiate destructive reactions in human cells [45]. Antioxidant compounds are responsible for inhibiting oxidation reactions, as they are adapted to halt free radicals before they attack human cells [45]. The antioxidant effect of Baobab tree components is well-documented in the literature, as previously discussed. This feature would be critical in dentistry and dental medicine, as cell oxidation can occur in many oral, gingival, and periodontal diseases. In a recent systematic review with meta-analysis, Castro et al. have shown that using antioxidants as an adjunctive treatment with non-surgical periodontal therapy would significantly help control the periodontal status in patients with periodontitis [46]. Moreover, Woelber et al. demonstrated that rich antioxidants in dietary habits could significantly decrease gingivitis [47]. In addition, Alpan et al. have tested a potent antioxidant (taxifolin) and found that it can decrease cell death and improve the alveolar bone formation in their periodontitis rats model [48].

Having both potent antioxidant activity and high levels of vitamin C suggests more dental applications of the Baobab extracts. Several in vivo and in vitro studies [49-55] have suggested that vitamin C utilization would greatly benefit tissue, wound, and bone healing after surgical procedures and implant placement. Moreover, a recent investigation has revealed a novel potential of vitamin C as an anti-cariogenic agent [56].

Phytochemicals and phenolic compounds are widely used in dentistry as they are known for their antiseptic, antibacterial, analgesic, and anti-inflammatory properties [57]. They were reported to be incorporated in the mouthwash and toothpaste industry, as they show plaque control abilities [58-60], and potency against cariogenic bacteria [61-64]. Additionally, phenol and phenolic derivatives are used as intracanal medications and pulp therapy medicaments [65-67], impression disinfectants [68,69], and in pain control and anesthesia [57]. In addition, it was reported that polyphenols would improve the biological and mechanical stability of dentine structure and matrix [70], which would enhance the restorative and adhesive properties of dental materials.

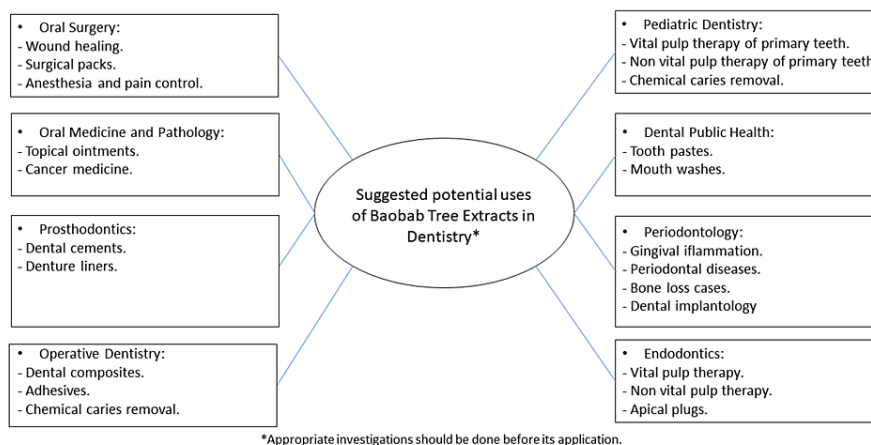
Fatty acids are known as components that might exist as a part of a molecule or act separately in the body, and the body organisms utilize them for metabolic operations in general and physical cell growth [71]. Regarding dentistry, several reports have shown that fatty acids have a role in improving periodontal health by reducing inflammatory mediators, decreasing clinical attachment loss, diminishing bone resorption [72-75], and exhibiting an antibacterial effect [76]. On the other hand, some fatty acids in the gingival fluids

could be used as a biomarker to determine the periodontal health status and diagnose periodontal diseases [77,78].

Amino acids are known to play an essential role as the building blocks of protein in the human body; they are also needed to maintain good health and function of body organs [79]. It was reported that amino acids correlate with caries experience in humans. Masoudi et al. have shown that amino acid concentrations in saliva could be used as a biomarker for caries [80]. Moreover, it was reported that different amino acids are utilized to fabricate chemical caries removal products, such as Caridex and Carisolv [81]. Another application of amino acids was investigated, as it has been reported that novel dental restorative materials and cements were made by incorporating different amino acids [82-85]. Zilm et al. showed that D-amino acids can reduce the bacterial biofilm of *Enterococcus faecalis* in the presence of other antibacterial agents in an in vitro model [86].

Regarding calcium, phosphorus, and dentistry, a very long list of applications could be made as these minerals have an essential role in teeth and bone formation [79]. The tooth's chemical structure (enamel and dentin) is mainly composed of Ca and P [87]. The calcium phosphate family of dental materials, including types of cement, restorations, and coatings, is broadly used and well-known for its bioactivity, biocompatibility, and osteoconductive abilities [87]. This family of materials were extensively reported to be utilized in pulp and root canal treatments [88-90], perforations repair [91-93], formation of dentine bridge [94,95], and periapical deformations and bone repair [96].

Based on the previously discussed components of the Baobab tree and their medical effects, Figure 1 shows suggestions for its applications in dentistry per dental discipline, which are considered areas for further research.



**FIGURE 1: Potential uses of different Baobab tree extracts in dentistry.**

## Conclusions

Under the limitations of this review, the AD tree parts possess bioactive components that have a promising potential to be used in dentistry and dental medicine after proper in vitro investigations. The present review could not find information in the literature regarding using Baobab tree components in dentistry. However, the medical use and pharmaceutical effects of Baobab extracts are evident in the literature. The broad and diverse documented medical and pharmaceutical properties of Baobab tree extracts are mainly correlated to their antioxidant, cell-protective, and anti-inflammatory properties. These effects were attributed to the different tree parts' phytochemical, vitamin C, and phenolic contents. These effects are suggested for further research in multiple areas of the dental field, such as periodontology, endodontology, oral medicine, and dental public health. Furthermore, the high levels of calcium and phosphorus in the tree components could play a role in the regenerative dental biomaterials industry, which demands further studies.

## Additional Information

### Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

**Concept and design:** Jameel A. Abuljadayel

**Acquisition, analysis, or interpretation of data:** Jameel A. Abuljadayel

**Drafting of the manuscript:** Jameel A. Abuljadayel

**Critical review of the manuscript for important intellectual content:** Jameel A. Abuljadayel

## Disclosures

**Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

## References

1. Kamanula M: Mineral and phytochemical composition of baobab (*Adansonia digitata* L.) root tubers from selected natural populations of Malawi. *Malawi Med J.* 2018, 30:250-5. [10.4314/mmj.v30i4.7](https://doi.org/10.4314/mmj.v30i4.7)
2. Braca A, Sinisgalli C, De Leo M, et al.: Phytochemical profile, antioxidant and antidiabetic activities of *Adansonia digitata* L. (baobab) from Mali, as a source of health-promoting compounds. *Molecules.* 2018, 23:3104. [10.3390/molecules23123104](https://doi.org/10.3390/molecules23123104)
3. Magaia T, Uamusse A, Sjöholm I, Skog K: Proximate analysis of five wild fruits of Mozambique. *ScientificWorldJournal.* 2013, 2013:601435. [10.1155/2013/601435](https://doi.org/10.1155/2013/601435)
4. Lamien-Meda A, Lamien CE, Compaoré MM, et al.: Polyphenol content and antioxidant activity of fourteen wild edible fruits from Burkina Faso. *Molecules.* 2008, 13:581-94. [10.3390/molecules13030581](https://doi.org/10.3390/molecules13030581)
5. Makawi AB, Mustafa AI, Adiamo OQ, Mohamed Ahmed IA: Physicochemical, nutritional, functional, rheological, and microbiological properties of sorghum flour fermented with baobab fruit pulp flour as starter. *Food Sci Nutr.* 2019, 7:689-99. [10.1002/fsn3.913](https://doi.org/10.1002/fsn3.913)
6. Mathieu G, Meissa D: Traditional leafy vegetables in Senegal: diversity and medicinal uses. *Afr J Tradit Complement Altern Med.* 2007, 4:469-75. [10.4314/ajtcam.v4i4.31239](https://doi.org/10.4314/ajtcam.v4i4.31239)
7. Li XN, Sun J, Shi H, et al.: Profiling hydroxycinnamic acid glycosides, iridoid glycosides, and phenylethanoid glycosides in baobab fruit pulp (*Adansonia digitata*). *Food Res Int.* 2017, 99:755-61. [10.1016/j.foodres.2017.06.025](https://doi.org/10.1016/j.foodres.2017.06.025)
8. Chadare FJ, Linnemann AR, Hounhouigan JD, Nout MJ, Van Boekel MA: Baobab food products: a review on their composition and nutritional value. *Crit Rev Food Sci Nutr.* 2009, 49:254-74. [10.1080/10408390701856350](https://doi.org/10.1080/10408390701856350)
9. Zahid A, Despres J, Benard M, et al.: Arabinogalactan proteins from Baobab and acacia seeds influence innate immunity of human keratinocytes in vitro. *J Cell Physiol.* 2017, 232:2558-68. [10.1002/jcp.25646](https://doi.org/10.1002/jcp.25646)
10. Suliman HM, Osman B, Abdoon IH, Saad AM, Khalid H: Ameliorative activity of *Adansonia digitata* fruit on high sugar/high fat diet-simulated metabolic syndrome model in male Wistar rats. *Biomed Pharmacother.* 2020, 125:109968. [10.1016/j.biopha.2020.109968](https://doi.org/10.1016/j.biopha.2020.109968)
11. Ebaid H, Bashandy SA, Alhazza IM, Hassan I, Al-Tamimi J: Efficacy of a methanolic extract of *Adansonia digitata* leaf in alleviating hyperglycemia, hyperlipidemia, and oxidative stress of diabetic rats. *BioMed Res Int.* 2019, 2019:10.1155/2019/2835152
12. Adeoye AO, Bewaji CO: Chemopreventive and remediation effect of *Adansonia digitata* L. Baobab (*Bombacaceae*) stem bark extracts in mouse model malaria. *J Ethnopharmacol.* 2018, 210:31-8. [10.1016/j.jep.2017.08.025](https://doi.org/10.1016/j.jep.2017.08.025)
13. Coe SA, Clegg M, Armengol M, Ryan L: The polyphenol-rich baobab fruit (*Adansonia digitata* L.) reduces starch digestion and glycemic response in humans. *Nutr Res.* 2013, 33:888-96. [10.1016/j.nutres.2013.08.002](https://doi.org/10.1016/j.nutres.2013.08.002)
14. Ghoneim MA, Hassan AI, Mahmoud MG, Asker MS: Protective effect of *Adansonia digitata* against isoproterenol-induced myocardial injury in rats. *Anim Biotechnol.* 2016, 27:84-95. [10.1080/10495398.2015.1102147](https://doi.org/10.1080/10495398.2015.1102147)
15. Mumtaz T, Rizwani GH, Shareef H: Analgesic activities of crude ethanolic extract and various fractions of *Adansonia digitata* L. grown at the Sindh province of Pakistan. *PJPS.* 2017, 30:1657-63.
16. Shehu A, Magaji MG, Yau J, Ahmed A: Methanol stem bark extract of *Adansonia digitata* ameliorates chronic unpredictable mild stress-induced depression-like behavior: involvement of the HPA axis, BDNF, and stress biomarkers pathways. *J Basic Clin Physiol Pharmacol.* 2019, 30:20180153. [10.1515/jbcpp-2018-0153](https://doi.org/10.1515/jbcpp-2018-0153)
17. Tabit FT, Komolafe NT, Tshikalange TE, Nyila MA: Phytochemical constituents and antioxidant and antimicrobial activity of selected plants used traditionally as a source of food. *J Med Food.* 2016, 19:324-9. [10.1089/jmf.2015.0099](https://doi.org/10.1089/jmf.2015.0099)
18. Cicolari S, Dacrema M, Tsetegho Sokeng AJ, et al.: Hydromethanolic extracts from *Adansonia digitata* L. edible parts positively modulate pathophysiological mechanisms related to the metabolic syndrome. *Molecules.* 2020, 25:2858. [10.3390/molecules25122858](https://doi.org/10.3390/molecules25122858)
19. Dzoyem JP, Kuete V, McGaw LJ, Eloff JN: The 15-lipoxygenase inhibitory, antioxidant, antimycobacterial activity and cytotoxicity of fourteen ethnomedicinally used African spices and culinary herbs. *J Ethnopharmacol.* 2014, 156:1-8. [10.1016/j.jep.2014.08.007](https://doi.org/10.1016/j.jep.2014.08.007)
20. Anani K, Hudson J, De Souza C, et al.: Investigation of medicinal plants of Togo for antiviral and antimicrobial activities. *Pharm Biol.* 2000, 38:40-5. [10.1076/1388-0209\(200001\)3811-BFT040](https://doi.org/10.1076/1388-0209(200001)3811-BFT040)
21. Tsetegho Sokeng AJ, Sobolev AP, Di Lorenzo A, Xiao J, Mannina L, Capitani D, Daglia M: Metabolite characterization of powdered fruits and leaves from *Adansonia digitata* L. (baobab): a multi-methodological approach. *Food Chem.* 2019, 272:93-108. [10.1016/j.foodchem.2018.08.030](https://doi.org/10.1016/j.foodchem.2018.08.030)

22. Ismail BB, Guo M, Pu Y, Wang W, Ye X, Liu D: Valorisation of baobab (*Adansonia digitata*) seeds by ultrasound assisted extraction of polyphenolics. Optimisation and comparison with conventional methods. *Ultrason Sonochem.* 2019, 52:257-67. [10.1016/j.ultsonch.2018.11.023](https://doi.org/10.1016/j.ultsonch.2018.11.023)
23. Ismail BB, Pu Y, Fan L, Dandago MA, Guo M, Liu D: Characterizing the phenolic constituents of baobab (*Adansonia digitata*) fruit shell by LC-MS/QTOF and their in vitro biological activities. *Sci Total Environ.* 2019, 694:153387. [10.1016/j.scitotenv.2019.07.193](https://doi.org/10.1016/j.scitotenv.2019.07.193)
24. Mohammed MA, Attia HN, El-Gengaihi SE, Maklad YA, Ahmed KA, Kachlicki P: Comprehensive metabolomic, lipidomic and pathological profiles of baobab (*Adansonia digitata*) fruit pulp extracts in diabetic rats. *J Pharm Biomed Anal.* 2021, 201:114139. [10.1016/j.jpba.2021.114139](https://doi.org/10.1016/j.jpba.2021.114139)
25. Baky MH, Badawy MT, Bakr AF, Hegazi NM, Abdellatif A, Farag MA: Metabolome-based profiling of African baobab fruit (*Adansonia digitata* L.) using a multiplex approach of MS and NMR techniques in relation to its biological activity. *RSC Adv.* 2021, 11:39680-95. [10.1039/d1ra08277a](https://doi.org/10.1039/d1ra08277a)
26. Ismail BB, Pu Y, Guo M, Ma X, Liu D: LC-MS/QTOF identification of phytochemicals and the effects of solvents on phenolic constituents and antioxidant activity of baobab (*Adansonia digitata*) fruit pulp. *Food Chem.* 2019, 277:279-88. [10.1016/j.foodchem.2018.10.056](https://doi.org/10.1016/j.foodchem.2018.10.056)
27. Atuadu V, Benneth B-A, Oyem J: *Adansonia digitata* L leaf extract attenuates lead-induced cortical histoarchitectural changes and oxidative stress in the prefrontal cortex of adult male Wistar rats. *Drug Metab Pers Ther.* 2020, 36:63-71. [10.1515/dmpt-2020-0116](https://doi.org/10.1515/dmpt-2020-0116)
28. Evang EC, Habte TY, Owino WO, Krawinkel MB: Can the supplementary consumption of baobab (*Adansonia digitata* L.) fruit pulp improve the hemoglobin levels and iron status of schoolchildren in Kenya? Findings of a randomized controlled intervention trial. *Eur J Nutr.* 2021, 60:2617-29. [10.1007/s00394-020-02447-2](https://doi.org/10.1007/s00394-020-02447-2)
29. Barakat H: Nutritional and rheological characteristics of composite flour substituted with baobab (*Adansonia digitata* L.) Pulp flour for cake manufacturing and organoleptic properties of their prepared cakes. *Foods.* 2021, 10:716. [10.3390/foods10040716](https://doi.org/10.3390/foods10040716)
30. Sakr SS, Mohamed SH, Ali AA, et al.: Nutritional, physicochemical, microstructural, rheological, and organoleptic characteristics of ice cream incorporating *Adansonia digitata* pulp flour. *Foods.* 2023, 12:553. [10.3390/foods12030533](https://doi.org/10.3390/foods12030533)
31. Docherty S, Haskell-Ramsay C: The acute effect of baobab fruit on cognitive performance, cerebral blood flow and blood glucose levels. *Proc Nutr Soc.* 2020, 79: [10.1017/S0029665120002773](https://doi.org/10.1017/S0029665120002773)
32. Khamis G, Hassan M, Morsy M, et al.: Innovative application of helium-neon laser: enhancing the germination of *Adansonia digitata* and evaluating the hepatoprotective activities in mice. *Environ Sci Pollut Res Int.* 2020, 27:26520-51. [10.1007/s11356-020-09036-0](https://doi.org/10.1007/s11356-020-09036-0)
33. Babatunde DJ, Tope OO, Fidelis OE, Enevwo OG, Olugbenga E: Aqueous extract of *Adansonia digitata* reversed cotton seed extract-induced testicular damage in Wistar rats. *JBRA Assist Reprod.* 2021, 25:257-65. [10.5935/1518-0557.20200092](https://doi.org/10.5935/1518-0557.20200092)
34. Dare BJ, Olaniyan OT, Oyeniyi OI, Okotie GE, Lawal IA, Eweoya O: Aqueous extract of *Adansonia digitata* prevents cadmium chloride-induced testicular damage in Wistar rats. *J Basic Clin Physiol Pharmacol.* 2021, 33:347-53. [10.1515/jbcpp-2020-0222](https://doi.org/10.1515/jbcpp-2020-0222)
35. Adegoke A, Gbadegesin MA, Odunola OA: Hepato-genoprotective activities of methanol extract of the stem bark of *Adansonia digitata* Linn. In Wistar rats challenged with sodium arsenite. *Niger J Physiol Sci.* 2020, 35:173-9.
36. Ntchapda F, Bonabe C, Atsamo AD, et al.: Effect of aqueous extract of *Adansonia digitata* stem bark on the development of hypertension in L-NAME-induced hypertensive rat model. *Evid Based Complement Alternat Med.* 2020, 2020:3678469. [10.1155/2020/3678469](https://doi.org/10.1155/2020/3678469)
37. Tchetan E, Olounladé PA, Azando EV, et al.: Anthelmintic activity, cytotoxicity, and phytochemical screening of plants used to treat digestive parasitosis of small ruminants in Benin (West Africa). *Animals (Basel).* 2022, 12:2718. [10.3390/ani12192718](https://doi.org/10.3390/ani12192718)
38. Gadour MO, Khidir HB, Adam I, Gasim GI: Effects of a powder of the fruit of *Adansonia digitata* (Tabaldia, Gongolase, or baobab tree) on serum lipids. *J Herb Med.* 2017, 8:14-6. [10.1016/j.hermed.2017.03.004](https://doi.org/10.1016/j.hermed.2017.03.004)
39. Rita K, Moncada M, Pintão A, Bernardo A, Silva L, Mesquita F: Effect of *Adansonia digitata* L. fruit on postprandial glycaemia in non-diabetic adults. *Ann Med.* 2019, 51:159. [10.1080/07853890.2018.1562004](https://doi.org/10.1080/07853890.2018.1562004)
40. Rita K, Bernardo MA, Silva ML, Brito J, Mesquita MF, Pintão AM, Moncada M: *Adansonia digitata* L. (baobab fruit) effect on postprandial glycemia in healthy adults: a randomized controlled trial. *Nutrients.* 2022, 14:398. [10.3390/nu14020398](https://doi.org/10.3390/nu14020398)
41. Coe S, Ryan L: White bread enriched with polyphenol extracts shows no effect on glycemic response or satiety, yet may increase postprandial insulin economy in healthy participants. *Nutr Res.* 2016, 36:193-200. [10.1016/j.nutres.2015.10.007](https://doi.org/10.1016/j.nutres.2015.10.007)
42. Bycroft A, Coe S: The acute effect of a baobab fruit (*Adansonia digitata*) smoothie on cognitive function in healthy adults. *Proc Nutr Soc.* 2017, 76: [10.1017/S0029665117000167](https://doi.org/10.1017/S0029665117000167)
43. Raphaelalani Z, Ramukhithi F, Ndhkala R, Nephawe K, Nedambale T: 26 Baobab oil supplemented extender preserves post-thaw bull sperm quality parameters. *Reprod Fertil Dev.* 2020, 32:139. [10.1071/RDv32n2Ab26](https://doi.org/10.1071/RDv32n2Ab26)
44. Komane BM, Vermaak I, Kamatou GP, Summers B, Viljoen AM: Beauty in Baobab: a pilot study of the safety and efficacy of *Adansonia digitata* seed oil. *Rev Bras Farmacogn.* 2017, 27:1-8. [10.1016/j.bjp.2016.07.001](https://doi.org/10.1016/j.bjp.2016.07.001)
45. Aksakalli S: Antioxidants in dentistry: review of literature. *Dentistry.* 2013, 4:181. [10.4172/2161-1122.1000181](https://doi.org/10.4172/2161-1122.1000181)
46. Castro MM, Duarte NN, Nascimento PC, et al.: Antioxidants as adjuvants in periodontitis treatment: a systematic review and meta-analysis. *Oxid Med Cell Longev.* 2019, 2019:9187978. [10.1155/2019/9187978](https://doi.org/10.1155/2019/9187978)
47. Woelber JP, Gärtner M, Breuning L, et al.: The influence of an anti-inflammatory diet on gingivitis. A randomized controlled trial. *J Clin Periodontol.* 2019, 46:481-90. [10.1111/jcpe.13094](https://doi.org/10.1111/jcpe.13094)
48. Lektemur Alpan A, Kızıldağ A, Özdede M, Karakan NC, Özmen Ö: The effects of taxifolin on alveolar bone in experimental periodontitis in rats. *Arch Oral Biol.* 2020, 117:104823. [10.1016/j.archoralbio.2020.104823](https://doi.org/10.1016/j.archoralbio.2020.104823)
49. Li X, Tang L, Lin YF, Xie GF: Role of vitamin C in wound healing after dental implant surgery in patients treated with bone grafts and patients with chronic periodontitis. *Clin Implant Dent Relat Res.* 2018, 20:793-8. [10.1111/cid.12647](https://doi.org/10.1111/cid.12647)

50. Min KK, Neupane S, Adhikari N, et al.: Effects of resveratrol on bone-healing capacity in the mouse tooth extraction socket. *J Periodontal Res.* 2020, 55:247-57. [10.1111/jre.12710](https://doi.org/10.1111/jre.12710)
51. DePhillipo NN, Aman ZS, Kennedy MI, Begley JP, Moatshe G, LaPrade RF: Efficacy of vitamin C supplementation on collagen synthesis and oxidative stress after musculoskeletal injuries: a systematic review. *Orthop J Sports Med.* 2018, 6: [10.1177/2325967118804544](https://doi.org/10.1177/2325967118804544)
52. Varela-López A, Navarro-Hortal MD, Giampieri F, Bullón P, Battino M, Quiles JL: Nutraceuticals in periodontal health: a systematic review on the role of vitamins in periodontal health maintenance. *Molecules.* 2018, 23:1226. [10.3390/molecules23051226](https://doi.org/10.3390/molecules23051226)
53. Tahamtan S, Shirban F, Bagherniya M, Johnston TP, Sahebkar A: The effects of statins on dental and oral health: a review of preclinical and clinical studies. *J Transl Med.* 2020, 18:155. [10.1186/s12967-020-02326-8](https://doi.org/10.1186/s12967-020-02326-8)
54. Zieniewska I, Maciejczyk M, Zalewska A: The effect of selected dental materials used in conservative dentistry, endodontics, surgery, and orthodontics as well as during the periodontal treatment on the redox balance in the oral cavity. *Int J Mol Sci.* 2020, 21:9684. [10.3390/ijms21249684](https://doi.org/10.3390/ijms21249684)
55. Pietropaoli D, Ortu E, Severino M, Ciarrocchi I, Gatto R, Monaco A: Glycation and oxidative stress in the failure of dental implants: a case series. *BMC Res Notes.* 2013, 6:296. [10.1186/1756-0500-6-296](https://doi.org/10.1186/1756-0500-6-296)
56. Eydou Z, Jad BN, Elsayed Z, Ismail A, Magaogao M, Hossain A: Investigation on the effect of vitamin C on growth & biofilm-forming potential of *Streptococcus mutans* isolated from patients with dental caries. *BMC Microbiol.* 2020, 20:231. [10.1186/s12866-020-01914-4](https://doi.org/10.1186/s12866-020-01914-4)
57. Tsuchiya H, Mizogami M: Comparative interactions of anesthetic alkylphenols with lipid membranes. *Open J Anesthesiol.* 2014, 4:308. [10.4236/ojanes.2014.412044](https://doi.org/10.4236/ojanes.2014.412044)
58. Grossman E, Meckel AH, Isaacs RL, et al.: A clinical comparison of antibacterial mouthrinses: effects of chlorhexidine, phenolics, and sanguinarine on dental plaque and gingivitis. *J Periodontol.* 1989, 60:435-40. [10.1902/jop.1989.60.8.435](https://doi.org/10.1902/jop.1989.60.8.435)
59. Chang Y-S: Clinical test for gingival effect on dentifrice containing with isopropyl methyl phenol and bamboo salt. *Int J Clin Prev Dent.* 2015, 11:73-8.
60. Raja M, Saha S, Reddy VK, Mohd S, Kumari M: Mouthwashes-an overview of current knowledge. *Int J Oral Health Res Rev.* 2013, 1:24-8.
61. Shetty SB, Mahin-Syed-Ismail P, Varghese S, et al.: Antimicrobial effects of *Citrus sinensis* peel extracts against dental caries bacteria: An in vitro study. *J Clin Exp Dent.* 2016, 8:e71-7. [10.4317/jced.52493](https://doi.org/10.4317/jced.52493)
62. Gregoire S, Singh AP, Vorsa N, Koo H: Influence of cranberry phenolics on glucan synthesis by glucosyltransferases and *Streptococcus mutans* acidogenicity. *J Appl Microbiol.* 2007, 103:1960-8. [10.1111/j.1365-2672.2007.03441.x](https://doi.org/10.1111/j.1365-2672.2007.03441.x)
63. Setyorini D, Rahayu YC, Sistyanningrum T: The effects of rinsing red beet root (*Beta vulgaris* L.) juice on streptococcus sp. dental plaque. *J Dentomaxillofacial Sci.* 2017, 2:18-22. [10.15562/jdmfs.v2i1.460](https://doi.org/10.15562/jdmfs.v2i1.460)
64. Philip N, Walsh LJ: Cranberry polyphenols: natural weapons against dental caries. *Dent J (Basel).* 2019, 7:20. [10.3390/dj7010020](https://doi.org/10.3390/dj7010020)
65. Hauman CH, Love RM: Biocompatibility of dental materials used in contemporary endodontic therapy: a review. Part 1. Intracanal drugs and substances. *Int Endod J.* 2003, 36:75-85. [10.1046/j.1365-2591.2003.00631.x](https://doi.org/10.1046/j.1365-2591.2003.00631.x)
66. Ahangari Z, Naseri M, Vatandoost F: Propolis: chemical composition and its applications in endodontics. *Iran Endod J.* 2018, 13:285-92. [10.22037/iej.v13i3.20994](https://doi.org/10.22037/iej.v13i3.20994)
67. Anamura S, Dohi T, Shirakawa M, Okamoto H, Tsujimoto A: Effects of phenolic dental medicaments on prostaglandin synthesis by microsomes of bovine tooth pulp and rabbit kidney medulla. *Arch Oral Biol.* 1988, 33:555-60. [10.1016/0003-9969\(88\)90129-X](https://doi.org/10.1016/0003-9969(88)90129-X)
68. Chidambaranathan AS, Balasubramaniam M: Comprehensive review and comparison of the disinfection techniques currently available in the literature. *J Prosthodont.* 2019, 28:e849-56. [10.1111/jopr.12597](https://doi.org/10.1111/jopr.12597)
69. Herrera SP, Merchant VA: Dimensional stability of dental impressions after immersion disinfection. *J Am Dent Assoc.* 1986, 113:419-22. [10.14219/jada.archive.1986.0214](https://doi.org/10.14219/jada.archive.1986.0214)
70. Vidal CM, Leme AA, Aguiar TR, et al.: Mimicking the hierarchical functions of dentin collagen cross-links with plant derived phenols and phenolic acids. *Langmuir.* 2014, 30:14887-95. [10.1021/la5034383](https://doi.org/10.1021/la5034383)
71. de Carvalho CC, Caramujo MJ: The various roles of fatty acids. *Molecules.* 2018, 23:2583. [10.3390/molecules23102583](https://doi.org/10.3390/molecules23102583)
72. Van Ravensteijn MM, Timmerman MF, Brouwer EA, Slot DE: The effect of omega-3 fatty acids on active periodontal therapy: a systematic review and meta-analysis. *J Clin Periodontol.* 2022, 49:1024-37. [10.1111/jcpe.13680](https://doi.org/10.1111/jcpe.13680)
73. Yang M, Li L, Soh Y, Heo SM: Effects of omega-3 fatty acids and aspirin on *Porphyromonas gingivalis*-induced periodontitis in rats. *J Periodontol.* 2019, 90:1307-19. [10.1002/JPER.19-0063](https://doi.org/10.1002/JPER.19-0063)
74. Azuma MM, Cardoso CB, da Silva CC, de Oliveira PH, Jacinto RC, Andrada AC, Cintra LT: The use of omega-3 fatty acids in the treatment of oral diseases. *Oral Dis.* 2022, 28:264-74. [10.1111/odi.13667](https://doi.org/10.1111/odi.13667)
75. Castro Dos Santos NC, Furukawa MV, Oliveira-Cardoso I, Cortelli JR, Feres M, Van Dyke T, Rovai ES: Does the use of omega-3 fatty acids as an adjunct to non-surgical periodontal therapy provide additional benefits in the treatment of periodontitis? A systematic review and meta-analysis. *J Periodontal Res.* 2022, 57:435-47. [10.1111/jre.12984](https://doi.org/10.1111/jre.12984)
76. Huang CB, Alimova Y, Myers TM, Ebersole JL: Short- and medium-chain fatty acids exhibit antimicrobial activity for oral microorganisms. *Arch Oral Biol.* 2011, 56:650-4. [10.1016/j.archoralbio.2011.01.011](https://doi.org/10.1016/j.archoralbio.2011.01.011)
77. Hatanaka K, Shirahase Y, Yoshida T, et al.: Enzymatic measurement of short-chain fatty acids and application in periodontal disease diagnosis. *PLoS One.* 2022, 17:e0268671. [10.1371/journal.pone.0268671](https://doi.org/10.1371/journal.pone.0268671)
78. Sete MR, Lira Júnior R, Fischer RG, Figueredo CM: Serum adipokine levels and their relationship with fatty acids in patients with chronic periodontitis. *Braz Dent J.* 2015, 26:169-74. [10.1590/0103-6440201300297](https://doi.org/10.1590/0103-6440201300297)
79. Mangaiyarkarasi SP, Manigandan T, Elumalai M, Cholan PK, Kaur RP: Benefits of aloe vera in dentistry. *J Pharm Bioallied Sci.* 2015, 7:S255-9. [10.4103/0975-7406.155943](https://doi.org/10.4103/0975-7406.155943)
80. Masoudi Rad H, Rabiei M, Sobhani A, Sadegh Khanjani M, Rahbar Taramsar M, Kazemnezhad Leili E: Free amino acids in stimulated and unstimulated whole saliva: advantages or disadvantages. *J Oral Rehabil.* 2014, 41:759-67. [10.1111/joor.12197](https://doi.org/10.1111/joor.12197)

81. Jingarwar M, Bajwa N, Pathak A: Minimal intervention dentistry - a new frontier in clinical dentistry . J Clin Diagn Res. 2014, 8:ZE04-8. [10.7860/CDR/2014/9128.4583](https://doi.org/10.7860/CDR/2014/9128.4583)
82. Xie D, Faddah M, Park JG: Novel amino acid modified zinc polycarboxylates for improved dental cements . Dent Mater. 2005, 21:739-48. [10.1016/j.dental.2005.01.008](https://doi.org/10.1016/j.dental.2005.01.008)
83. Xie D, Park JG, Faddah M, Zhao J, Khanijoun HK: Novel amino acid-constructed polyalkenoates for dental glass-ionomer restoratives. J Biomater Appl. 2006, 21:147-65. [10.1177/0885328206059797](https://doi.org/10.1177/0885328206059797)
84. Minamikawa H, Yamada M, Iwasa F, et al.: Amino acid derivative-mediated detoxification and functionalization of dual cure dental restorative material for dental pulp cell mineralization. Biomaterials. 2010, 31:7213-25. [10.1016/j.biomaterials.2010.06.018](https://doi.org/10.1016/j.biomaterials.2010.06.018)
85. Matsuura T, Komatsu K, Ogawa T: N-acetyl cysteine-mediated improvements in dental restorative material biocompatibility. Int J Mol Sci. 2022, 23:15869. [10.3390/ijms232415869](https://doi.org/10.3390/ijms232415869)
86. Zilm PS, Butnejski V, Rossi-Fedele G, Kidd SP, Edwards S, Vasilev K: D-amino acids reduce Enterococcus faecalis biofilms in vitro and in the presence of antimicrobials used for root canal treatment. PLoS One. 2017, 12:e0170670. [10.1371/journal.pone.0170670](https://doi.org/10.1371/journal.pone.0170670)
87. Al-Sanabani JS, Madfa AA, Al-Sanabani FA: Application of calcium phosphate materials in dentistry . Int J Biomater. 2013, 2013:876132. [10.1155/2013/876132](https://doi.org/10.1155/2013/876132)
88. Osmond MJ, Krebs MD: Tunable chitosan-calcium phosphate composites as cell-instructive dental pulp capping agents. J Biomater Sci Polym Ed. 2021, 32:1450-65. [10.1080/09205063.2021.1925390](https://doi.org/10.1080/09205063.2021.1925390)
89. Mahgoub N, Alqadasi B, Aldhorae K, Assiry A, Altawili ZM, Tao Hong: Comparison between iRoot BP plus (EndoSequence root repair material) and mineral trioxide aggregate as pulp-capping agents: a systematic review. J Int Soc Prev Community Dent. 2019, 9:542-52. [10.4103/jispcd.JISPCD\\_249\\_19](https://doi.org/10.4103/jispcd.JISPCD_249_19)
90. Howard J, Gardner L, Saifee Z, et al.: Synthesis and characterization of novel calcium phosphate glass-derived cements for vital pulp therapy. J Mater Sci Mater Med. 2020, 31:12. [10.1007/s10856-019-6352-5](https://doi.org/10.1007/s10856-019-6352-5)
91. Raghavendra SS, Jadhav GR, Gathani KM, Kotadia P: Bioceramics in endodontics - a review . J Istanbul Univ Fac Dent. 2017, 51:128-37.
92. Noetzel J, Ozer K, Reissbauer BH, Anil A, Rössler R, Neumann K, Kielbassa AM: Tissue responses to an experimental calcium phosphate cement and mineral trioxide aggregate as materials for furcation perforation repair: a histological study in dogs. Clin Oral Investig. 2006, 10:77-83. [10.1007/s00784-005-0032-1](https://doi.org/10.1007/s00784-005-0032-1)
93. Chau JY, Hutter JW, Mork TO, Nicoll BK: An in vitro study of furcation perforation repair using calcium phosphate cement. J Endod. 1997, 23:588-92. [10.1016/S0099-2399\(06\)81129-5](https://doi.org/10.1016/S0099-2399(06)81129-5)
94. Gu Y, Xie X, Zhuang R, et al.: A biphasic calcium phosphate cement enhances dentin regeneration by dental pulp stem cells and promotes macrophages M2 phenotype in vitro. Tissue Eng Part A. 2021, 27:1113-27. [10.1089/ten.TEA.2020.0257](https://doi.org/10.1089/ten.TEA.2020.0257)
95. Jose B, Ratnakumari N, Mohanty M, Varma H, Komath M: Calcium phosphate cement as an alternative for formocresol in primary teeth pulpotomies. Indian J Dent Res. 2013, 24:522.
96. Zhang W, Wang N, Yang M, et al.: Periosteum and development of the tissue-engineered periosteum for guided bone regeneration. J Orthop Translat. 2022, 33:41-54. [10.1016/j.jot.2022.01.002](https://doi.org/10.1016/j.jot.2022.01.002)