IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 24, Issue 10 Ser. 6 (October. 2025), PP 38-44
www.iosrjournals.org

Flavonoids: Harnessing Nature's Potential For Advanced Pulp Capping Therapies - A Review

Dr Swetha Geervani V, Dr Kiran Kumar Neelakantappa, Dr Savitha B Naik, Dr Biji Brigit, Dr Abhishek M, Dr Manimozhi M
(Department Of Conservative Dentistry & Endodontics, Government Dental College & Research Institute, Bangalore, India)

Abstract:
Background: *Maintaining the vitality of the dental pulp is pivotal to preserving tooth function and longevity. Conventional pulp capping agents such as calcium hydroxide and MTA primarily promote reparative dentin formation but fall short in controlling inflammation—an essential factor in successful pulp healing. Flavonoids, naturally occurring plant-based polyphenols, have emerged as exciting bioactive compounds due to their anti-inflammatory, antioxidant, and dentinogenic properties, offering a promising alternative in vital pulp therapy.*
Aim: *To explore and critically evaluate the role of flavonoids in enhancing pulp healing and dentinogenesis, with a focus on their biological mechanisms and potential as next-generation pulp capping agents.*
Materials and Methods: *A comprehensive electronic search was conducted using PubMed, Google Scholar, and the Cochrane Library to identify relevant in vivo and in vitro studies involving flavonoids in vital pulp therapy. Studies were selected based on the PICO framework, focusing on outcomes related to dentin bridge formation, inflammation control, and pulp regeneration.*
Results: *Out of 209 initially identified articles, seven were included after full-text screening. Flavonoids such as* ***hesperidin****,* ***baicalin****,* ***epigallocatechin gallate (EGCG)****,* ***icariin****, and* ***quercetin*** *were shown to significantly promote odontogenic differentiation of dental pulp stem cells and suppress key pro-inflammatory cytokines including TNF-α, IL-1β, and IL-6. These effects were mediated through critical signaling pathways such as NF-κB, Wnt/β-catenin, and MAPK. Animal studies reported enhanced dentin bridge formation, reduced pulpal inflammation, and preservation of pulp vitality following flavonoid application.*
Conclusion: *Flavonoids represent a powerful fusion of nature and science, showing dual functionality in controlling inflammation and stimulating odontogenesis. Their incorporation into pulp capping protocols could revolutionize conservative dentistry. However, more robust preclinical and clinical trials are needed to translate these findings into everyday practice.*
Keywords: *Flavonoids, pulp capping, vital pulp therapy, dental pulp inflammation, dentinogenesis, hesperidin, EGCG, baicalin*

Date of Submission: 20-10-2025 Date of Acceptance: 30-10-2025

I. Introduction

Dental pulp, a vascularized and innervated tissue, plays a crucial role in maintaining the homeostasis and physiological vitality of teeth by facilitating the transport of oxygen and nutrients[1]. The vitality of the pulp is essential for the long-term health and effectiveness of the tooth against occlusal forces[2]. Comprising fibroblasts, preodontoblasts, odontoblasts, immune cells, ectomesenchymal cells, and dental pulp stem cells (DPSCs), the dental pulp is capable of responding to injuries[3].

In cases of pulpal injury, the initial three days of acute pulpitis involve extensive hemorrhagic necrosis and a significant accumulation of inflammatory cells, progressing to almost complete tissue necrosis within five days[4]. Managing damaged pulp through vital pulp therapy (VPT) has a good effect on prognosis of pulpal disease[5]. Direct pulp capping is a treatment approach where a biocompatible pulp capping material is directly applied to the exposed site, followed by a restoration. This inhibits disease progression and aids in the healing and repair process[6]. The formation of a dentin bridge is considered indicative of a positive prognosis following pulp-capping treatment[7].

Currently, materials like MTA, $Ca(OH)_2$, and Biodentin that are used for vital pulp therapy are antibacterial and capable of inducing dentin bridge formation[8,9], however they lack anti-inflammatory properties[10]. Inflammation of dental pulp caused by caries or dental trauma often involves infiltration of inflammatory cells and secretion of inflammatory cytokines by various cells which negatively impacts the pulpal healing[11].

There is a growing interest in the use of natural materials for disease treatment[12], with flavonoids emerging as a significant class of plant secondary metabolites. Found in fruits, vegetables, and certain beverages, flavonoids are polyphenolic structures that exhibit a range of health-promoting effects[13]. These effects include anti-inflammatory, anti-oxidative, anti-carcinogenic, and anti-mutagenic properties, as well as the ability to regulate key cellular enzyme function[14]. With over 10,000 flavonoid compounds identified, they are widely distributed in nature[15].

Flavonoids, which encompass flavones, flavanones, isoflavones, flavonols, chalcones, flavanols, and anthocyanins, have diverse chemical structures[13,14]. Flavonoids have been linked to a remineralizing effect on dentin, further highlighting their potential applications in dentistry[16,17].

Direct pulp capping gaining attention nowadays for its conservative nature and ease of application. . Unfortunately, the and anti-inflammatory effects of pulp-preserving materials are often overlooked, impeding the recovery of inflamed pulp tissue. Exploring the use of anti-inflammatory materials in pulpotomy to manage pulp inflammation and achieve pulp preservation emerges as a promising avenue for investigation. This review aims to explore the effects of various flavonoids and their impact on pulp health in inducing odontogenesis

II. Material And Methods

Focus question(s)

The following focus questions were developed according to the population, intervention, comparison, and outcome (PICO) study design (Table 1):

"Is there an improvement in dentinogenesis when flavonoids are used for vital pulp therapy ?"

Information sources

A comprehensive search of PubMed/Medline and EMBASE databases was undertaken. The language was restricted to English, and no restrictions were placed on the year of publication. The results were limited to human studies. A manual search of reference lists of all included articles was performed (Table 1, Supplementary file 1).

Table 1: Search strategy, database search, and selection criteria

		Details
Search strategy	**Participants**	• Subjects with vital pulp exposure or inflamed • dental pulp stem cells.
	Intervention	Administration of flavonoids in vital pulp therapy.
	Comparator	Standard pulp therapy without flavonoids
	Outcome	Dentinogenesis and pulp tissue healing
Database	**Electronic**	PubMed, Google scholar and Cochrane library
Selection cr Criteria	**Inclusion criteria**	Randomised control trials, • In-vivo Human observational studies, • In-vivo Human inferential studies, • In vivo Animal studies • Studies in the English language
	Exclusion criteria	• Review articles. • In vitro studies • Studies in languages other than English

Study selection

Studies retrieved from the search databases were imported into a citation manager and screened for duplicates using an automated system. Two authors, Dr. Swetha Geervani V and Dr. Manimozhi M, independently screened the title and abstract for eligibility. The full text was consulted if sufficient information could not be extracted from titles and abstracts. Items deemed irrelevant by both reviewers were excluded. A third author, Dr Abhishek M, monitored screening and data extraction and supported resolving queries, ensuring protocol adherence.

The full texts of potentially relevant articles were obtained and reviewed in detail by both reviewers, Dr.swetha Geervani V and Dr.Manimozhi M. The final list of articles was selected for further analysis after the second screening. Whole articles were inspected for data extraction and quality assessment. A database for information retrieval was created in Microsoft Excel 365 v.17 for Microsoft spreadsheets (Microsoft, Redmond, WA, USA). The data extraction was pilot-tested before final data retrieval.

Quality assessment

Two authors, Dr.swetha Geervani V and Dr.Manimozhi M, independently and in duplicate, assessed all the selected studies. Differences were resolved by consensus. The SYRCLE tool was used to critically appraise the eligible studies.

Articles were searched in PubMed, Google Scholar and Cochrane Library using the keywords "pulpitis", "flavonoids", "Vital pulp therapy", and "pulp capping"

III. Result

Articles were searched in PubMed, Google Scholar and Cochrane Library using the keywords "pulpitis" and "flavonoids" and "Vital pulp therapy" and "pulp capping". All keywords were combined with a Boolean logic strategy ("AND" ", OR"). The reference lists of papers were also searched manually to retrieve potential results. A total of 209 articles were obtained through the search.195 articles were excluded in the title screening, and 15 articles were eligible after the title screening for abstract screening. 7 articles were selected after full-text screening

Table 2: Brief description of included studies

Study	Sample size and Sample	Materials compared	Study design	Analysis done	Results
Odontogenic Effect of Icariin on the Human Dental Pulp Cells. Guo Liu[1]	Pulp cells of human third molars	Icariin at different concentrations 0.1 M, 1 M, 10 M, 100 M	In Vitro	Cell viability assay alkaline phosphatase (ALP) staining, alizarin red S (ARS) staining, real-time PCR, and Western blot	Icariin can upregulate odontogenic differentiation of HDPCs by triggering the MAPK signalling pathway.
Baicalin can enhance odontogenic/osteogenic differentiation of inflammatory dental pulp stem cells by inhibiting the NF-κB and β-catenin/Wnt signalling pathways. Mengyuan Li[3]	iDPSCs: Inflammatory dental pulp stem cells. nDPSCs: Normal dental pulp stem cells.	Different concentrations of baicalin 10 μM, 20 μM, 50 μM, 100 μM	In Vitro	(MTT) assay and flow cytometry. Alkaline phosphatase (ALP) activity assay, alizarin red staining, Real-time reverse transcription-polymerase chain reaction (RT-PCR) and Western blot assay	Baicalin can promote odontogenic/osteogenic differentiation of iDPSCs through inhibition of NF-κB and β-catenin/ Wnt pathways, thus providing direct evidence that baicalin may be effective in repairing pulp with early irreversible pulpitis.
Effect of Topical Epigallocatechin-Gallate on Lipopolysaccharide-induced Pulpal Inflammation in Rat Models Kun Ismiyatin[4]	28 male wiser rats	Negative control Positive control 25 ppm and 75 ppm of EGCG hydrogels	Animal studies	Histological analysis	The application of 75 ppm topical EGCG hydrogels to the tooth cavities of Wistar rats with 6 h of pulpal inflammation has the optimal result in reducing the expression of TNF-α and CGRP
Histologic Comparison of Formocresol, Platelet-Rich Fibrin, and Hesperidin in Pulpotomy: A Randomised Trial in Dogs	48 teeth in three mongrel dogs	Formocresol PRF Hisperidin	Animal studies	Histological analysis	Hesperidin and platelet-rich fibrin proved histologically far better than formocresol in pulpotomy, showing dentin bridge formation, less inflammation, and more

NI Metwally et al[5]					preservation of pulpal tissues in dogs' teeth.
Stimulating effects of quercetin and Phenamil on the differentiation of human dental pulp cells Kim JG[7]	Human dental pulp cells were isolated from incisors	quercetin, genistein baicalin phenamil	In vitro	4-nitrophenyl phosphate colourimetric assay, Real-time PCR Western blotting.	Results of the study suggest that osteogenic small molecules, such as quercetin and Phenamil is able to induce dentinogenic differentiation of dental pulp cells
Effects of epigallocatechin gallate (EGCG) on the biological properties of human dental pulp stem cells and inflammatory pulp tissue Yongtao Li[11]	In vitro Third molar N=5 In vivo Twelve 6-week-old male SD rats	EGCG concentrations of 0, 10, 25, 50, or 75 μg/mL	In vitro and Animal studies	Flow cytometry CCK-8 assay Alizarin red staining Real-time PCR analysis Western blotting analysis Micro-computed tomography (micro-CT) analysis Histological analysis	The CCK-8 assay showed that cells grew well. The results of real-time PCR revealed that expression of OCN was significantly increased in the EGCG group. EGCG inhibited the expression of IL-1β, IL-6, and TNF-α. • In vivo, reduced inflammatory cell accumulation was observed in the coronal pulp in the EGCG group, while in the control group, diffuse inflammatory cells were observed in the radicular pulp.
Biological evaluation of hesperidin for direct pulp capping in dogs' teeth Abo El-Mal[12]	126 dogs	Hesperidin, MTA-Angelus and Dycal.	Animal studies	Histological analysis	Hesperidin is a promising pulp capping material, inducing mild inflammation and Good dentine bridge formation.
Direct and transdentinal biostimulatory effects of grape seed extract rich in proanthocyanidin on pulp cells A.F. dos Santos[18]	Human molars were used to obtain the primary pulp-cell culture and 0.5 mm dentine discs.	In the first phase, concentrations of 6.5%, 0.65%, 0.065% and 0.0065%	In vitro	MTT assay ELISA Histological analysis alkaline phosphatase test alizarin red	Treatment with grape seed extract, even at the highest concentration and longest period, caused no direct or transdentinal cytotoxic effects in human pulp cells. Grape seed extract components may play a biostimulatory role and protect dental pulp cells when in direct contact.

IV. Discussion

Dental pulp therapy is a critical aspect of oral healthcare, and recent studies have delved into the potential applications of various natural compounds in this field. One of the primary culprits in dental pulp inflammation is lipopolysaccharide (LPS), a factor that induces severe inflammation and poses risks of tissue necrosis. Recognising the need for interventions to mitigate LPS-induced inflammation is crucial to prevent adverse consequences.[4]

Calcium hydroxide, which is normally used as a pulp capping agent, does not by itself cause reparative dentin formation but causes the defence cells of pulp to cause an inflammatory reaction and subsequent reparative dentin formation[6,12].

MTA also acts in a similar fashion, except that there is no initial necrosis of the pulp like calcium hydroxide. Although histological studies have shown that MTA has a significant reparative dentin bridge formation than calcium hydroxide, human studies have shown that there is no significant difference in the inflammatory response of pulp and reparative dentin bridge formation between the two[6]. The current pulp capping agents only focus on the reparative dentin bridge formation, but anti-inflammatory action is equally important for better survival of the pulp.

Flavonoids, a diverse group of secondary metabolites found abundantly in fruits, vegetables, herbs, and seeds, have emerged as promising candidates for dental pulp therapy[13,15]. Their widespread distribution in nature and extensive biological and pharmacological activities make them invaluable in various applications, including nutraceuticals, pharmaceuticals, medicines, and cosmetics [15]. The subclasses of flavonoids, such as flavones, flavonones, isoflavones, flavonols, chalcones, flavanols, and anthocyanins, contribute to their multifaceted benefits.[14]

Chemically, flavonoid molecules consist of carbon atoms assembled in two aromatic rings that are connected by a three-carbon "bridge", C6-C3-C6, thus forming a diphenylpropane structure with the central unit

being a benzo-ϒ-pyrone (chromone). Multiple hydroxyl groups, sugar, oxygen, or methyl groups are attached to this core structure. A group of flavonoids is differentiated in several classes according to the degrees of oxidation and unsaturation of the heterocyclic C ring [19]

Several flavonoids have been tested in vitro for their dentin-stimulating activities. Although these studies did not meet the inclusion criteria in this systematic review, these compounds are noteworthy as candidates for further studies in the development of a pulp capping agent.

The compounds found in tea polyphenols, particularly epigallocatechin gallate (EGCG), exhibit diverse biological activities, including antioxidant, antimicrobial, immune regulatory, and anti-tumour effects[4,11]. Yongtao Li's study focused on the impact of EGCG on human dental pulp stem cells (hDPSCs), revealing inhibitory effects on inflammatory markers in vitro and in vivo. It inhibited the expression of inflammatory markers such as IL-1β, IL-6, and TNF-α.[11] Kun Ismiyatin's study demonstrated the efficacy of topical EGCG hydrogels in reducing inflammation in rat pulpal tissue by reducing the expression of TNF-α and CGRP[4].

Baicalin, extracted from Scutellaria baicalensis, shows antibacterial and anti-inflammatory effects, promoting dental pulp health[3]. Mengyuan Li found that baicalin promotes odontogenic/osteogenic differentiation of inflammatory dental pulp stem cells (iDPSCs) by inhibiting NF-κB and β-catenin/Wnt pathways[3].

Various signalling pathways, including TLR4/NF-κB and MAPK, influence inflammatory dental pulp cells and odontogenic differentiation. Proanthocyanidins (PACs) exhibit antibacterial properties and potential in restorative dentistry. Grape seed extract (GSE) biostimulates and protects dental pulp cells[18].

Many studies highlight the importance of gene expression, specifically focusing on dentin sialophosphoprotein (DSPP) and dentin matrix protein 1 (DMP-1), in the development of the pulp-dentin complex. Osteoblasts and odontoblasts, which exhibit shared gene expressions like RUNX2, ALP, OCN, and BSP, play essential roles in both bone and dentin formation. The orchestration of signalling pathways, particularly the MAPK signalling cascade, is identified as a critical factor that positively impacts the odontogenic differentiation of dental pulp cells1,[24].

Icariin induces odontogenic differentiation through the MAPK pathway.[1] Small molecules like quercetin and genistein promote osteogenesis, with quercetin showing the highest dentinogenic activity in human dental pulp cells[7]. In Kim JG's study, quercetin induced increased DSPP mRNA expression and mineral deposition was seen[7]. These studies collectively underscore the versatility of natural compounds in dental pulp therapy, providing insights into their varied mechanisms and potential applications.

Hesperidin

Hesperidin (HPN), a flavonoid known for its anti-inflammatory properties, is highlighted as a key player in preserving dental pulp. Along with other flavonoids, hesperidin is well-known for its anti-inflammatory and antioxidant qualities [2,6,12,19,22].

Hesperidin was tested by Pinho-Ribeiro et al. in a mouse model to reduce pain related to inflammation. Furthermore, the healing qualities of this ingredient were discovered when hesperidin, the hesperetin glycoside, was applied to skin injuries.[23]

Hesperidin treatment decreased inflammatory mediators and exerted significant antioxidant effects. The molecular basis for its anti-inflammatory effects seems to be mediated by signalling pathways, especially the nuclear factor κβ pathway.[6,22] Hesperidin treatment inhibited the production of vascular endothelial growth factor (VEGF). Hesperidin also suppressed the expression of TNF-α, IL-1β, IL-6, and IL-8[22]. Its ability to modulate immune responses by downregulating hyperactive macrophages and upregulating dysfunctional T lymphocytes positions it as a potential therapeutic agent[2]. Additionally, HPN's antioxidant properties, attributed to its content of ascorbic acid, but its slightly acidic pH is a challenge[17].

In the study conducted by NI Metwally et al, the objective was to evaluate and compare the effectiveness of formocresol (FC), platelet-rich fibrin (PRF), and hesperidin (HPN) as pulpotomy agents in dogs. Cavities were randomly assigned to three groups based on the pulpotomy agent used: FC(formocresol) (control), PRF, and HPN. After two months, histological assessments were conducted, revealing that HPN exhibited superior dentin bridge formation compared to Formocresol and minimal signs of inflammation and pulp disorganisation. Both HPN and PRF demonstrated significant differences compared to FC, which showed no dentin bridging and more pronounced inflammation, necrosis, and pulp disorganisation. The dentin bridge formation in the hesperidin group showed a normal odontoblastic layer and normal pulp tissue with collagen fibres in most samples, but in some samples, a disorganised odontoblastic layer and oedematous pulp tissue were seen. The study concluded that HPN and PRF could be viable substitutes for FC in the dog model[5].

In another investigation by Abo El-Mal, Hesperidin, Mineral Trioxide Aggregate (MTA)-Angelus, and calcium hydroxide were compared for direct pulp capping in dogs' teeth. The study found that all three materials induced mild to moderate inflammation at 2 weeks, with no significant differences between various intervals of

time. At 4 and 8 weeks, there were no notable distinctions either. Hesperidin, specifically, was observed to induce mild inflammation and promote good dentine bridge formation[4].

The purpose of a study by Mona Essam Aliwa et al was to evaluate, in rats, the histological and biological pulp. The pulp capping materials (calcium hydroxide, hesperidin, and eggshell powder nanoparticles) were used to separate the eighteen rats into three groups. Each group was split into two categories, two or four weeks. Using one of the three materials, the pulp tissue of the maxillary first molars was immediately capped. After that, the cavities were restored with glass ionomer. Animals were slaughtered at each interval, and their teeth were taken out for histological examination. Disparities between the inflammatory response and dentin bridge formation of the exposed pulp between the three groups were statistically evaluated. A significant difference was seen across all the groups. Eggshell powder had the least amount of pulp inflammation at both the 2- and 4-week periods, according to the results of the inflammatory cell count. Hesperidin had the highest reported thickness for the dentin bridge in the first interval, whereas eggshell powder had the highest thickness after 4 weeks. However, there were no appreciable differences between hesperidin and eggshell powder at 4-week intervals in terms of the pulp inflammatory response and the production of calcified bridges. The dentin bridge thus formed was thick, amorphous and non-tubular in both groups at 4 4-week intervals. The study concluded that Hesperidin and eggshell powder nanoparticles are superior to calcium hydroxide in terms of dentin bridge development and pulp preservation[6].

While only three animal studies have investigated the induction of odontogenesis, numerous in vitro studies have explored various flavonoids, examining their anti-inflammatory properties and mineralisation-inducing abilities. These studies delve into the different pathways through which flavonoids combat inflammation. Despite not meeting the inclusion criteria for the review, future research on these flavonoids, especially with in vivo studies, holds potential for developing more effective and pulp-friendly pulp-capping agents.

Table 3: Classification of flavonoids with examples

Flavonoid Subclass	Examples
Flavones	Apigenin and luteolin
Flavonols	Quercetin, galangin, kaempferol, and myricetin
Flavanones	Aringin, naringenin, hesperidin, hesperetin, pinocembrin, likvirtin, and eriodictyol
Isoflavones	Genistein, daidzein, and glycitein
Flavanols	Catechin, gallocatechin 3-gallate, gallocatechin, epicatechin, epicatechin 3-gallate, catechin 3-gallate, and epicatechin 3-gallate
Anthocyanins	Cyanidin, delphinidin, malvidin, Pelargonidin and peonidin
Chalcones	Xanthohumol and isbavirachalone

Mechanism of action	Flavonoid
Src/Ras/ ERK signalling pathway	Quercetin
NF-κB and β-catenin/Wnt pathway	Baicalein
Reducing the expression of TNF-α and CGRP	Epigallocatechin gallate
MAPK signalling pathway	Icariin
Biomodulatory effect and increased collagen deposition	Proanthrocyanin
Downregulating T lymphocytes and immune response, the NF-κB pathway	Hisperidin

V. Conclusion

In conclusion, this comprehensive review underscores the pivotal role of natural compounds, particularly Hesperidin, in dental pulp therapy. The studies collectively unravel the diverse mechanisms of action, from anti-inflammatory and antioxidant properties to their impact on gene expressions and signalling pathways involved in odontogenesis. The potential applications of these natural compounds in preserving dental pulp viability and promoting dentin regeneration open promising avenues for future research and therapeutic interventions in dentistry. It is unclear in the histological studies whether hesperidin induced odontogenesis by the formation of disorganised osteodentin or organised odontoblastic layer. As the field continues to evolve, further exploration of these natural compounds holds great promise for enhancing dental pulp health and

advancing the frontiers of dental care. More studies with human trials are to be done to explore and understand the therapeutic effects of flavonoids as a pulp capping agent.

References

[1]. Liu G, Yang Y, Min KS, Lee BN, Hwang YC. Odontogenic Effect Of Icariin On The Human Dental Pulp Cells. Medicina. 2022 Mar 16;58(3):434.

[2]. Metwally NI, Mohamed EA, Ahmed NA, Zaghloul SA. Histologic Comparison Of Formocresol, Platelet Rich Fibrin, And Hesperidin In Pulpotomy: A Randomized Trial In Dogs. Nigerian Journal Of Clinical Practice. 2023 Oct 26;26(7):856-62.

[3]. Li M, Wang Y, Xue J, Xu Q, Zhang Y, Liu J, Xu H, Guan Z, Bian C, Zhang G, Yu Y. Baicalin Can Enhance Odonto/Osteogenic Differentiation Of Inflammatory Dental Pulp Stem Cells By Inhibiting The NF-Kb And B-Catenin/Wnt Signaling Pathways. Molecular Biology Reports. 2023 May;50(5):4435-46.

[4]. Ismiyatin K, Wahluyo S, Purwanto DA, Rahayu RP, Soetojo A, Mukono IS. Effect Of Topical Epigallocatechin-Gallate On Lipopolysaccharide-Induced Pulpal Inflammation In Rat Models. Iranian Endodontic Journal. 2018;13(4):528.

[5]. Bjørndal L, Simon S, Tomson PL, Duncan HF. Management Of Deep Caries And The Exposed Pulp. International Endodontic Journal. 2019 Jul;52(7):949-73.

[6]. Eliwa ME, Riad D, Hamoda MA, Farouk H. A Comparative Study Of The Biological And Histological Response Of Eggshell Nanoparticles, Hesperidin, And Calcium Hydroxide As Direct Pulp Capping Materials: An In Vivo Study On Rat Molars. Advanced Dental Journal. 2023 Oct 1;5(4):768-84

[7]. Kim JG, Son KM, Park HC, Zhu T, Kwon JH, Yang HC. Stimulating Effects Of Quercetin And Phenamil On Differentiation Of Human Dental Pulp Cells. European Journal Of Oral Sciences. 2013 Dec;121(6):559-65.

[8]. Paula A, Carrilho E, Laranjo M, Abrantes AM, Casalta-Lopes J, Botelho MF, Marto CM, Ferreira MM. Direct Pulp Capping: Which Is The Most Effective Biomaterial? A Retrospective Clinical Study. Materials. 2019 Oct 16;12(20):3382.

[9]. Alqaderi HE, Al-Mutawa SA, Qudeimat MA. MTA Pulpotomy As An Alternative To Root Canal Treatment In Children's Permanent Teeth In A Dental Public Health Setting. Journal Of Dentistry. 2014 Nov 1;42(11):1390-5.

[10]. Paula AB, Laranjo M, Marto CM, Paulo S, Abrantes AM, Casalta-Lopes J, Marques-Ferreira M, Botelho MF, Carrilho E. Direct Pulp Capping: What Is The Most Effective Therapy?—Systematic Review And Meta-Analysis. Journal Of Evidence Based Dental Practice. 2018 Dec 1;18(4):298-314.

[11]. Li Y, Zhao Y, Han J, Wang Y, Lei S. Effects Of Epigallocatechin Gallate (EGCG) On The Biological Properties Of Human Dental Pulp Stem Cells And Inflammatory Pulp Tissue. Archives Of Oral Biology. 2021 Mar 1;123:105034.

[12]. Abo El-Mal EO, Abu-Seida AM, El Ashry SH. Biological Evaluation Of Hesperidin For Direct Pulp Capping In Dogs' Teeth. International Journal Of Experimental Pathology. 2021 Feb;102(1):32-44.

[13]. Panche AN, Diwan AD, Chandra SR. Flavonoids: An Overview. Journal Of Nutritional Science. 2016;5:E47.

[14]. Chen S, Wang X, Cheng Y, Gao H, Chen X. A Review Of Classification, Biosynthesis, Biological Activities And Potential Applications Of Flavonoids. Molecules. 2023 Jun 25;28(13):4982.

[15]. Ullah A, Munir S, Badshah SL, Khan N, Ghani L, Poulson BG, Emwas AH, Jaremko M. Important Flavonoids And Their Role As A Therapeutic Agent. Molecules. 2020 Nov 11;25(22):5243.

[16]. Elasser DM, Niazy MA, Jamil WE, Elsharkawy DA, A Anani HA. Evaluation Of The Remineralizing Effect Of Natural Versus Synthetic Materials On Deep Carious Dentin. Al-Azhar Dental Journal For Girls. 2022 Oct 1;9(4):581-91.

[17]. El-Mal EO, Abu-Seida AM, El Ashry SH. A Comparative Study Of The Physicochemical Properties Of Hesperidin, MTA-Angelus And Calcium Hydroxide As Pulp Capping Materials. The Saudi Dental Journal. 2019 Apr 1;31(2):219-27.

[18]. Dos Santos AF, Pacheco JM, Silva PA, Bedran-Russo AK, Rezende TM, Pereira PN, Ribeiro AP. Direct And Transdentinal Biostimulatory Effects Of Grape Seed Extract Rich In Proanthocyanidin On Pulp Cells. International Endodontic Journal. 2019 Apr;52(4):424-38.

[19]. Kuntić V, Brborić J, Holclajtner AI, Uskoković MS. Evaluating The Bioactive Effects Of Flavonoid Hesperidin: A New Literature Data Survey. Vojnosanitetski Pregled. 2014;71(1):60-5.

[20]. Faggion Jr CM, Giannakopoulos NN, Listl S. Risk Of Bias Of Animal Studies On Regenerative Procedures For Periodontal And Peri-Implant Bone Defects–A Systematic Review. Journal Of Clinical Periodontology. 2011 Dec;38(12):1154-60.

[21]. Hooijmans CR, Rovers MM, De Vries RB, Leenaars M, Ritskes-Hoitinga M, Langendam MW. SYRCLE's Risk Of Bias Tool For Animal Studies. BMC Medical Research Methodology. 2014 Dec;14:1-9.

[22]. Tejada S, Pinya S, Martorell M, Capó X, Tur JA, Pons A, Sureda A. Potential Anti-Inflammatory Effects Of Hesperidin From The Genus Citrus. Current Medicinal Chemistry. 2018 Nov 1;25(37):4929-45.

[23]. Jagetia GC, Rao KV. Topical Application Of Hesperidin A Citrus Bioflavanone Accelerates Healing Of Full Thickness Dermal Excision Wounds In Mice Exposed To 6 Gy Of Whole Body Γ-Radiation. Clin. Res. Dermatol. 2017;4(3):1-8.

[24]. Alipour M, Sharifi S, Samiei M, Shahi S, Aghazadeh M, Dizaj SM. Synthesis, Characterization, And Evaluation Of Hesperetin Nanocrystals For Regenerative Dentistry. Scientific Reports. 2023 Feb 6;13(1):2076.