



EGGSHELL IN DENTISTRY

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ABSTRACT Eggshells, rich in calcium carbonate and organic compounds, have garnered attention in the field of dentistry for their potential applications. This review explores the innovative use of eggshells in various dental practices, emphasizing their benefits as a sustainable and cost-effective alternative to conventional materials. The primary component of eggshells, calcium carbonate, is highly similar to hydroxyapatite, the main mineral found in human teeth and bones. This makes eggshells a promising option for various dental applications, including bone grafting, dental implants, and enamel remineralization. In bone grafting, eggshells can be processed into a fine powder and utilized as a biocompatible material to support bone regeneration. Studies have demonstrated that eggshell-derived calcium carbonate can promote osteoblast activity and enhance bone healing, potentially reducing the need for synthetic bone graft materials. Additionally, the organic matrix of eggshells contains proteins and growth factors that may aid in tissue regeneration. For dental implants, eggshell-derived calcium carbonate has been explored as a substitute for synthetic calcium phosphates. Its biocompatibility and similarity to natural bone tissue offer promising prospects for improving implant integration and longevity. Furthermore, eggshells are being used in enamel remineralization, where their calcium content can contribute to the repair of early-stage dental caries and strengthen enamel. Overall, the utilization of eggshells in dentistry not only leverages a readily available and environmentally friendly resource but also holds significant promise for advancing dental materials and treatments. Future research should focus on optimizing the processing techniques and exploring additional applications to fully harness the potential of eggshells in dental science.

KEYWORDS : Eggshell, Dental Implant, Remineralization, Bone Grafting

INTRODUCTION

Eggshells have found intriguing applications in dentistry due to their unique properties. Calcium, a major component of eggshells, makes them beneficial for dental purposes. Crushed eggshells can be used in toothpaste formulations as a natural source of calcium carbonate, aiding in remineralizing tooth enamel and potentially reducing tooth sensitivity. Additionally, eggshell membranes contain proteins like collagen, which may have applications in promoting gum tissue regeneration or as a scaffold for tissue engineering in oral surgery. These uses highlight the innovative potential of natural materials in enhancing dental care.

Furthermore, eggshells have been explored for their potential in various aspects of dental care:

Eggshells are increasingly recognized for their potential in advancing dental care across several fronts. Firstly, their rich calcium carbonate content makes them valuable for remineralizing tooth enamel, a process crucial for reversing early tooth decay and fortifying enamel strength.

Crushed eggshells have also been utilized in dental products to alleviate tooth sensitivity, forming a protective shield over sensitive tooth surfaces. Moreover, eggshell membranes contain biocompatible proteins like collagen, which are conducive to applications in oral surgery, particularly in promoting guided tissue regeneration. Additionally, research indicates that eggshell membranes exhibit natural antibacterial properties, suggesting potential benefits in preventing oral infections and enhancing overall oral health.

Furthermore, integrating eggshells into dental practices contributes to sustainability efforts by repurposing a natural byproduct that would otherwise be discarded, thereby reducing waste and environmental impact. As ongoing research continues to uncover more uses and benefits, eggshells are poised to offer effective and sustainable solutions to various dental challenges.

Overall, while research into eggshell applications in dentistry is ongoing, these natural materials show promise in providing effective and sustainable solutions for various dental concerns.

Eggshell Composition

The eggshell comprises the hard-outer shell and an inner membrane rich in well-documented components like collagen, osteopontin, and fibronectin, known to promote bone formation. These substances play crucial roles in the development and upkeep of skeletal integrity across different organisms.¹⁾

The shell composition is essentially mineral and this part represents 95.1% of the constituents, Water (1.6%) and proteins (3.3%) are the other chemical components of the shell. Calcium is the main mineral component, representing 37.3 % of the total weight of the shell. Most of the calcium is present in a crystalline form. Calcite or calcium carbonate (CaCO₃) is the most represented form (93.6 %) followed by calcium triphosphate (0.8%) and magnesium carbonate²⁾.

Preparation Of Eggshell

The high cost of commercially available hydroxyapatites (HAs) stems from the use of expensive, high-purity reagents. As an alternative, researchers have developed a new method that converts discarded eggshells into nanocrystalline hydroxyapatite (HA) using microwave processing. This study aims to showcase the benefits of using eggshells as a calcium source for synthesizing HA (OHA), comparing it with HA derived from synthetic calcium hydroxide (SHA) and commercially available pure HA (CHA).³⁾

Siva Rama Krishna et al in 2007 have recently produced hydroxyapatite with outstanding properties using eggshell-derived materials. In which all hydroxyapatites (HAs) underwent comprehensive characterization using multiple analytical techniques including X-ray powder diffraction (XRD), Fourier transform infrared (FT-IR) spectroscopy, scanning electron microscopy (SEM), transmission electron microscopy (TEM), and specific surface area measurements. The nanocrystalline structure of OHA was identified through distinct broad peaks observed in XRD patterns, platelet-shaped particles with dimensions ranging from 33 to 50 nm in length and 8 to 14 nm in width as observed in TEM images, and size calculations derived from specific surface area measurements. FT-IR spectra exhibited characteristic HA bands along with additional peaks corresponding to carbonate ions. Cell parameter calculations indicated the formation of B-type carbonated HA.³⁾

The enhanced sinterability of OHA in terms of hardness and density compared to both SHA and CHA could potentially stem from the larger surface area of its spherulite structure. Furthermore, findings from the in vitro dissolution study indicate prolonged stability in phosphate buffer solutions, while the biocompatibility of OHA has been established through cell culture tests using osteoblast cells.³⁾

Applications Of Eggshell In Dentistry

Eggshell As Remineralizing Agent:

Hydroxyapatite, characterized by its chemical formula Ca₁₀(PO₄)₆(OH)₂, is a naturally occurring substance appreciated for its advantageous attributes. These include its resemblance to the mineral

composition of human hard tissues, excellent biocompatibility, and resilience to dissolution in moist conditions, making it widely utilized in both medical and dental applications.⁴⁾

Nano-hydroxyapatite (NHA) particles exhibit distinctive characteristics such as enhanced solubility, elevated surface energy, and optimal biocompatibility when compared to conventional hydroxyapatite. Furthermore, studies have indicated that NHA particles demonstrate superior bioactivity compared to larger crystals. Synthetic NHA mirrors the physicochemical properties of enamel apatite, showing a strong attraction to tooth surfaces and effective adsorption capability on enamel surfaces.⁴⁾

R., Haghgoo A et al in 2008 undertook a study aimed at evaluating the influence of NHA solution on erosive lesions. Their research demonstrated a noteworthy enhancement in enamel microhardness subsequent to the application of NHA solution, following a prior decrease induced by erosion. This improvement underscores the beneficial impact of NHA solution in potentially reversing the detrimental effects of erosive processes on enamel microstructure.⁵⁾

R., Haghgoo A et al in 2014 conducted a study comparing the effectiveness of nano-hydroxyapatite (NHA) and sodium fluoride (NaF) mouthwash in remineralizing incipient caries. Their research demonstrated that NHA was similarly effective to NaF mouthwash in remineralizing these early-stage carious lesions. This finding highlights the potential of NHA as a viable alternative to NaF mouthwash in dental care, particularly in the treatment and prevention of initial stages of tooth decay. The study underscores NHA's capacity to promote remineralization, thereby contributing to the maintenance of dental health and potentially offering a promising approach in dental therapy protocols aimed at managing early dental caries.⁶⁾

K. Najibfard et al in 2011 conducted an in-situ study to assess the effectiveness of NHA toothpaste in remineralizing carious lesions and preventing demineralization. Their findings indicated that NHA toothpaste demonstrated comparable efficacy to fluoride toothpaste in these applications. This study underscores the potential of NHA toothpaste as a viable alternative to fluoride-based products for promoting remineralization and protecting against demineralization of tooth enamel. The results suggest that NHA toothpaste could offer a promising option in dental care regimens aimed at addressing and preventing dental caries effectively.⁷⁾

Chicken egg shell powder (CESP) serves as a reservoir rich in calcium and functions exceptionally well as a remineralizing agent. It effectively deposits and releases mineral ions into the demineralized dentin structure and within the dentinal tubules, facilitating the restoration and strengthening of tooth enamel and dentin.⁸⁾

Kattimani et al. in 2014 unveiled findings indicating that hydroxyapatite derived from eggshells represents a versatile new material for regeneration, capable of serving as a substitute for bone grafts. This is due to its excellent biocompatibility, absence of disease transmission risks, ease of application, abundant supply, cost-effectiveness, and the ability to be prepared economically. These attributes highlight its potential as a highly beneficial alternative in medical procedures requiring bone regeneration.⁹⁾

Nano-hydroxyapatite shows promising potential in remineralizing early enamel caries lesions when subjected to dynamic pH-cycling conditions. Based on findings, a suspension containing 10% nano-hydroxyapatite emerged as the most effective concentration for promoting remineralization of initial enamel caries. Utilizing nano-hydroxyapatite at an appropriate concentration has the potential to offer significant benefits in facilitating remineralization through consistent daily application.¹⁰⁾

M. Mielnik-Błaszczak et al. in 2001 conducted a study wherein they concluded that a liquid suspension containing 4% (by weight) nano-hydroxyapatite showed significant potential in effectively promoting the remineralization of incipient caries lesions.¹¹⁾

Eggshell as Bone Forming Material

In recent years, numerous synthetic bone substitutes have been introduced to the market, boasting advanced technological innovation. However, their clinical outcomes frequently do not align with the sophisticated engineering involved and are often accompanied by high costs. As a result, there has been a resurgence of interest in natural

alternatives for bone substitutes, with a notable focus on exploring the potential of eggshells in this regard.¹²⁾

Hydroxyapatite (HA) is a naturally found mineral constituent of bone known for its osteoconductive properties. According to AK Gosain et al. in 2002 study, nanocrystalline HA exhibits osteo-inductive characteristics, effectively promoting cell stimulation for the regeneration of periodontal tissues. This versatile biomaterial, sourced from various origins such as bone, corals, and synthetics, is utilized extensively in bone defect grafting procedures to facilitate and accelerate bone healing processes.¹³⁾

The physical properties and biological responses exhibited by this material make it suitable for application in addressing minor bone defects, such as those found in post-extraction alveolar wounds or periodontal defects.¹⁴⁾

Eggshell demonstrates biocompatibility as a grafting material and possesses osteoconductive properties, facilitating the formation of new bone akin to Bio-Oss and demineralized freeze-dried bone matrix. Its potential in bone grafting procedures is further enhanced when combined with other materials, suggesting it could emerge as a promising biomaterial for such applications.¹⁵⁾

Eggshell as Antimicrobial Agent

The use of synthetic hydroxyapatite (HA) in biomedical fields is highly justified, given its proven excellent biocompatibility with human teeth and bones. Moreover, it has been established that HA possesses antibacterial properties.

Acc to Tin-Oo MM et al. in 2007 did research on locally produced hydroxyapatite, it was observed that HA inhibits the growth of *S. mutans* starting at concentrations of 50 mg/ml, with complete inhibition achieved at concentrations of 200 mg/ml. The antibacterial potential of HA can thus be effectively leveraged as a beneficial biomaterial in various applications related to dental and maxillofacial treatments.¹⁶⁾

Mangin et al. (2003) evaluated the efficacy of hydroxyapatite as a root-end filling material, assessing its sealing capabilities.¹⁷⁾ Meanwhile, Lucas et al. (2003) investigated the enhancement of mechanical strength in glass ionomer cement through the incorporation of hydroxyapatite. Their findings suggested that the addition of hydroxyapatite significantly enhances the fracture toughness of glass ionomer cement, improves its long-term bonding strength to dentin, and maintains its ability to release fluoride consistently over time, thereby positioning it as a durable and effective restorative material.¹⁸⁾

Li et al. (1998) discovered that hydroxyapatite sol is a secure biomaterial suitable for dental pulp treatment, as it promotes the early formation of dentine bridges and exhibits antibacterial properties to some extent. Leveraging the antibacterial potential of hydroxyapatite, it would be advantageous to utilize it as a foundation in the treatment of carious cavities, effectively targeting residual cariogenic bacteria.¹⁹⁾

Kouassi et al. in 2003 explored the antibacterial properties of hydraulic calcium phosphate intended for dental use, highlighting calcium bis-dihydrogenphosphate monohydrate CaO-based cement as capable of exerting antibacterial effects. They proposed its potential suitability for applications such as pulp capping and cavity lining. Given that locally produced hydroxyapatite belongs to the calcium phosphate family, further investigation is warranted to assess its antibacterial efficacy in similar dental applications.²⁰⁾

Owadally et al. (1994) conducted research focusing on the biological characteristics of IRM (Intermediate Restorative Material) enhanced by the incorporation of hydroxyapatite (HA) as a retrograde root filling substance. Their investigations revealed notable antibacterial effects against *Streptococcus anginosus* (milleri) and *Enterococcus faecalis* when assessed on blood agar plates utilizing standardized pellets of hydroxyapatite-modified formulations.²¹⁾

Ingram et al. in 1996 investigated the antibacterial properties of porous hydroxyapatite granules. They observed significant inhibition of growth in cultures of *Staphylococcus epidermidis* in every tested specimen containing hydroxyapatite granules. This finding underscores the potential of hydroxyapatite as an effective agent against bacterial growth in experimental settings.²²⁾

Hydroxyapatite ceramic, recognized as a specialized form of calcium phosphate product, serves diverse roles in several medical and dental applications. It functions as an adjunct in enhancing the efficacy of dental implants and cements, both in dental and orthopedic contexts. Additionally, it is employed in dentifrices for oral care, contributes to procedures in maxillofacial surgery, and serves as a crucial material in pulp-capping procedures. Furthermore, hydroxyapatite ceramic is utilized for repairing periodontal defects and addressing issues with failing implants, demonstrating its versatility and broad applicability across various dental and surgical disciplines.¹⁶⁰

Eggshell as Desensitizing Agent

Dentin hypersensitivity stands out as a widespread dental condition frequently encountered in clinical settings. Unlike periodontal diseases or dental caries, it represents a particularly painful dental issue that poses challenges in treatment and significantly impacts the quality of life for affected patients.²³¹ Given that eggshells have been demonstrated to be a promising material for repairing bone defects, and considering the similarities between bone and dentin, it is reasonable to explore the potential of eggshells as a desensitizing agent for dentin. Utilizing eggshell waste in this way could provide a cost-effective alternative to more expensive calcium sources, thereby reducing overall costs.²⁴¹ From the perspective of environmental sustainability and management, repurposing eggshell waste to address dentin hypersensitivity could offer a viable recycling solution. This approach not only promotes the reuse of natural waste materials but also enhances the economic advantages linked to their use, aligning with global efforts to advance a greener environment.²⁵¹

Avian eggshell slurry shows potential as a promising solution for treating dentin hypersensitivity. However, further in-vitro studies are needed to assess its long-term effectiveness as a desensitizing agent, particularly after mechanical challenges such as tooth brushing. Also, clinical studies analyzing the effect of eggshell slurry in treating dentin hypersensitivity are required.²⁶¹

Biorepair's active component, which plays a key role in occluding dentinal tubules and promoting dentin remineralization, is nanohydroxyapatite. The nanoscale size of hydroxyapatite facilitates its swift dissolution, leading to quicker occlusion of the dentinal tubules.²⁷¹ Furthermore, these nanocrystals are similar in morphology and structure to tooth apatite.²⁸¹ The released ions could act as a template for crystal growth and mineralization, and this could explain the increase in number of occluded dentinal tubules with time.²⁹¹

CONCLUSIONS

In conclusion, the utilization of eggshells in dentistry presents a range of promising applications, particularly in addressing issues related to dentin hypersensitivity and dental remineralization. The calcium carbonate present in eggshells is chemically similar to hydroxyapatite, the primary component of tooth enamel and dentin, which makes eggshells a viable and cost-effective alternative for dental treatments.

Moreover, the repurposing of eggshell waste aligns with global sustainability efforts by promoting recycling and reducing waste. This approach not only contributes to a greener environment but also leverages a readily available resource that would otherwise be discarded. Future research, including in-vitro and clinical studies, is essential to fully understand the efficacy and safety of eggshell-based materials in dental applications. As scientific and clinical evidence accumulates, eggshells could become an integral part of innovative dental treatments, further advancing the field while supporting sustainability goals.

REFERENCES

- Opris H, Baciut M, Bran S, Dinu C, Armencea G, Opris D, Mitre I, Manea A, Stoia S, Tamas T, Barbur I. Characterization of eggshell as a bio-regeneration material. *Medicine and Pharmacy Reports*. 2023 Jan;96(1):93.
- Neunzahn J, Szuwart T, Wiesmann HP. Eggshells as natural calcium carbonate source in combination with hyaluronan as beneficial additives for bone graft materials, an in vitro study. *Head & Face Medicine*. 2015 Dec; 11:1-0.
- Siva Rama Krishna D, Siddharthan A, Seshadri SK, Sampath Kumar TS. A novel route for synthesis of nanocrystalline hydroxyapatite from eggshell waste. *Journal of Materials Science: Materials in Medicine*. 2007 Sep; 18:1735-43.
- Haghighi R, Mehran M, Ahmadvand M, Ahmadvand MJ. Remineralization effect of eggshell versus nano-hydroxyapatite on caries-like lesions in permanent teeth (in vitro). *Journal of International Oral Health*. 2016 Apr 1;8(4):435-9.
- Haghighi R. Evaluation of the effect of nanohydroxyapatite on erosive lesions of the enamel of permanent teeth following exposure to soft beer in vitro. *Scientific Research and Essays*. 2011 Nov 16.
- Haghighi R, Rezvani MB, Zeinabadi MS. Comparison of nano-hydroxyapatite and sodium fluoride mouthrinse for remineralization of incipient carious lesions. *Journal of Dentistry (Tehran, Iran)*. 2014 Jul;11(4):406.

- Najibfard K, Ramalingam K, Chedjieu I, Amaechi BT. Remineralization of early caries by a nano-hydroxyapatite dentifrice. *Journal of Clinical Dentistry*. 2011 Jan 1;22(5):139.
- Esmael HM, Hashem SN, Mostafa MH. Assessment of The Power of The Chicken Eggshell Powder in Remineralization of Induced Caries Like Lesions in Primary Teeth; An In-Vitro Study. *Journal of Pharmaceutical Negative Results*. 2023 Feb 14;2192-201.
- Kattimani VS, Chakravarthi PS, Kanumuru NR, Subbarao VV, Sidharthan A, Kumar TS, et al. Eggshell derived hydroxyapatite as bone graft substitute in the healing of maxillary cystic bone defects: a preliminary report. *J Int Oral Health*. 2014; 6:15-9.
- Huang SB, Gao SS, Yu HY. Effect of nano-hydroxyapatite concentration on remineralization of initial enamel lesion in vitro. *Biomedical materials*. 2009 Jun 5;4(3):034104.
- Mielnik-Blaszczyk M, Krawczyk D, Pels E. The application of synthetic hydroxyapatite in children and adolescents in various clinical cases. In *Annales Universitatis Mariae Curie-Sklodowska. Sectio D: Medicina* 2001 Jan 1 (Vol. 56, pp. 95-98).
- Dupoirieux L. Ostrich eggshell as a bone substitute: a preliminary report of its biological behaviour in animals—a possibility in facial reconstructive surgery. *British Journal of Oral and Maxillofacial Surgery*. 1999 Dec 1;37(6):467-71.
- Kattimani VS, Chakravarthi PS, Kanumuru NR, Subbarao VV, Sidharthan A, Kumar TS, Prasad LK. Eggshell derived hydroxyapatite as bone graft substitute in the healing of maxillary cystic bone defects: a preliminary report. *Journal of international oral health: JIOH*. 2014 Jun;6(3):15.
- Dupoirieux L, Pourquier D, Souyris F. Powdered eggshell: a pilot study on a new bone substitute for use in maxillofacial surgery. *Journal of cranio-maxillofacial surgery*. 1995 Jun 1;23(3):187-94.
- Opris H, Dinu C, Baciut M, Baciut G, Mitre I, Crisan B, Armencea G, Prodan DA, Bran S. The influence of eggshell on bone regeneration in preclinical in vivo studies. *Biology*. 2020 Dec 18;9(12):476.
- MM TO, AR S, KA AS. Antibacterial property of locally produced hydroxyapatite. *Archives of Orofacial Sciences*. 2007;7:41-4.
- Mangin C, Yesilsoy C, Nissan R, Stevens R. The comparative sealing ability of hydroxyapatite cement, mineral trioxide aggregate, and super ethoxybenzoic acid as root-end filling materials. *Journal of Endodontics*. 2003 Apr 1;29(4):261-4.
- Lucas ME, Arita K, Nishino M. Toughness, bonding and fluoride-release properties of hydroxyapatite-added glass ionomer cement. *Biomaterials*. 2003 Sep 1;24(21):3787-94.
- Li TU, Akao M, Takagi M. Tissue reaction of hydroxyapatite sol to rat molar pulp. *Journal of Materials Science: Materials in Medicine*. 1998 Nov; 9:631-42.
- Kouassi M, Michalesco P, Lacoste-Armynot A, Boudeville P. Antibacterial effect of a hydraulic calcium phosphate cement for dental applications. *Journal of endodontics*. 2003 Feb 1;29(2):100-3.
- Owadally ID, Chong BS, Pitt Ford TR, Wilson RF. Biological properties of IRM® with the addition of hydroxyapatite as a retrograde root filling material. *Dental Traumatology*. 1994 Oct; 10(5):228-32.
- Ingram Jr AE, Robinson J, Rohrich RJ. The antibacterial effect of porous hydroxyapatite granules. *Plastic and reconstructive surgery*. 1996 Nov 1;98(6):1119.
- Davari AR, Ataei E, Assarzadeh H. Dentin hypersensitivity: etiology, diagnosis and treatment; a literature review. *Journal of Dentistry*. 2013 Sep;14(3):136.
- Kunam D, Manimaran S, Sampath V, Sekar M. Evaluation of dentinal tubule occlusion and depth of penetration of nano-hydroxyapatite derived from chicken eggshell powder with and without addition of sodium fluoride: An in vitro study. *Journal of Conservative Dentistry and Endodontics*. 2016 May 1;19(3):239-44.
- Onwubu SC, Mdluli PS, Singh S, Tlapana T. A novel application of nano eggshell/titanium dioxide composite on occluding dentine tubules: an in vitro study. *Brazilian Oral Research*. 2019 Mar 18;33:e016.
- El Tahlawy AA, Saba DA, Bakir NG. Avian eggshell slurry as a dentin desensitizing agent: an in vitro assessment using two techniques. *The Journal of Contemporary Dental Practice*. 2021 Jul 9;22(5):532-7.
- Bologa E, Stoleriu S, Iovan G, Ghiorghe C A, Nica I, Andrian S, Amza O E. Effects of dentifrices containing nanohydroxyapatite on dentinal tubule occlusion—a scanning electron microscopy and EDX study. *Appl Sci (Basel)* 2020; 10:6513.
- Scribante A, Dermenaki Farahani MR, Marino G, Matera C, Rodriguez y Baena R, Lanteri V, Butera A. Biomimetic Effect of Nano-Hydroxyapatite in Demineralized Enamel before Orthodontic Bonding of Brackets and Attachments: Visual, Adhesion Strength, and Hardness in In Vitro Tests. *BioMed Research International*. 2020;2020(1):6747498.
- Abou Neel EA, Bakhsh TA. An eggshell-based toothpaste as a cost-effective treatment of dentin hypersensitivity. *European journal of dentistry*. 2021 Oct;15(04):733-40.