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The Role of Medicinal Plants in Bone Healing: A Scoping Review

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Abstract: Bone fractures are among the most common traumatic injuries worldwide with an estimated 178 million new cases in 2019, reflecting a 33.4% increase since 1990. Contributing factors include injuries, communicable and non-communicable diseases and nutritional deficiencies. Bone healing is vital for maintaining function. While modern treatments often require advanced facilities, medicinal plants have traditionally been used to aid bone repair. This review discusses selected medicinal plants with evidence-based support, focusing on their bioactive components and mechanisms of action. Comprehensive searches across four databases, from inception to May 2021 were performed following the PRISMA-ScR protocol. A total of 813 articles were identified, screened and narrowed to eligible studies. Plants such as *Piper sarmentosum, Tridax procumbens, Sambucus williamsii Hance, Lepidum sativum, Peperomis pellucida* and *Prunus dulcis* demonstrated beneficial effects on fracture healing. IN conclusion, certain medicinal plants show promise in promoting bone healing, offering valuable alternatives to advanced treatments.

Keywords: Medicinal plants, *Piper sarmentosum, Tridax procumbens, Sambucus williamsii Hance*, bone healing.

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INTRODUCTION

Bone fracture healing is a physiological process in which the body facilitates the repair of a bone fracture which consists of complex processes of cell and tissue proliferation and differentiation. The factors that are included in the bone healing process are growth factors, inflammatory cytokines, antioxidants, osteoclast, osteoblast cells, hormones, amino acids, and nutrients [1]. Medicinal plants are known to accelerate bone osteogenesis with no known side effects and are available at a reasonable price. In traditional medicine, the extract and poultice of plants aided with splint are usually practiced in the management of bone healing [1].

Drugs obtained from herbs represent the main form of treatment in most developing countries and it is consumed by about 75% of people worldwide [2]. Studies have demonstrated that some molecules extracted from natural compounds have high anti-inflammatory, antioxidant, and regenerative properties, which justifies the effectiveness of these products in different diseases [3]. Nevertheless, inflammation and bone healing mechanisms with the involvement of natural compounds are not completely transparent. The current known proof is fragmented and not comprehensively defined, hence leaving literature gaps in the description of the results in punctual research [4].

The main objective of this study is to analyze and record the role of different medicinal plants in bone healing. Specifically, we aim to study the role of Malaysian plants in bone healing.

MATERIAL AND METHODS

Study Design

A scoping review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) checklist to collect data on medicinal plants used in bone healing. The proposed

framework offers a systematic and standardized method for developing scoping studies that suit new or broad questions that are complex and heterogeneous. This method also uses relevant databases and creates a range of study types to ensure comprehensive and transparent literature reporting. The six-step process utilized to conduct the scoping review includes (a) formulating the research question, (b) sources of studies, (c) study selection, (d) recording data, (e) summarizing and analyzing the findings.

Formulating the Research Question

This scoping review was conducted based on a research question: "What is the role of medicinal plants in the process of bone healing?"

Source of Studies and Search Strategy

Articles published in English from 2012 until 2021 were searched in four databases which were Scopus, Pubmed/MEDLINE, Dimensions and Google Scholar. The search keywords are tabulated in Table I.

Table-I: The search string

Scopus	(TITLE-ABS-KEY ("medicinal plants") OR TITLE-ABS-KEY ("natural product") AND TITLE-ABS-KEY ("bone healing") AND NOT TITLE-ABS-KEY ("osteoporosis"))
PubMed	("Medicinal plant" OR "natural product" OR "herb") AND ("bone heal" OR "osteogenesis") -osteoporosis
Dimensions	("Medicinal plant" OR "natural product" OR "herb") AND ("bone heal" OR "osteogenesis") NOT osteoporosis
Google Scholar	("Medicinal plant" OR "natural product" OR "herb") AND ("bone heal" OR "osteogenesis") -osteoporosis

Study Selection

The relevant studies underwent initial screening by assessing the title and abstract. Specific keywords related to the study were scrutinized using the following entries: "bone healing", "fracture healing", "bone repair", "osteoblast", "osteoclast", "natural product", "medicinal plant", "plant medicine" and "herbal medicine". All included studies were reviewed in full text for validity based on inclusion and exclusion criteria. The reference lists of all related studies identified from the primary search were also screened.

Inclusion and Exclusion Criteria

Each study included in this paper satisfies the inclusion criteria which were (i) original studies on the effect of plant extracts on bone healing, (ii) published between 2012 and 2021. The criteria for exclusion were (i) studies related to the treatment of osteoporosis, (ii) articles written in a language other than English, (iii) opinion-based articles, conference abstracts, case reports, case series, and descriptive cross-sectional studies.

Data Extraction

A data extraction form was developed using Microsoft Excel. Extracted data included (i) author, (ii) publication year, (iii) study design, (iv) types of medicinal plants, (v) mechanism of action, and (vi) findings related to bone healing.

Summarizing and Analysing the Findings

The extracted data was collated and summarized using both quantitative and qualitative methods. The results were presented in a narrative format.

DEFINITION

Bone Repair

Bone repair is a specialized type of wound healing consisting of a sequence of inflammation, cell proliferation, repair, and remodelling. The impairment of the bone may be caused by exposure to either biological or physical trauma such as tooth extraction that would ignite the inflammatory cascade to the site in the first place. Mainly in the inflammatory phase, aside from the recruitment of inflammatory cascade to the site of injury, hematoma formation also can be suspected especially in the case of physical traumas [5]. It is evidenced that hematoma creates a healing microenvironment in the early stages to avoid any non-unions [6].

A few days after the bone injury, without the presence of stenting of the bone or rigid internal fixation, there would be fibro cartilaginous callus formation or soft callus where the granulation tissue will fill the gap in between and re-join the fracture [7]. In a few weeks, the soft callus would turn into a hard callus by calcification of the bone matrix resulting in a decrease of strain and movement. Finally, the bone remodelling would take place through the repeated and complementing activity of osteoblast and osteoclast in reshaping the bone deposited in the fracture site- termed 'coupled-remodelling' [7].

Bone Remodelling

Bone remodelling is defined as a continuous coordination process of mature bone destruction by osteoclasts and subsequent formation of bone by osteoblasts throughout life to maintain its strength [8]. This metabolic action is particularly used for the replacement of old and damaged bone and the reshaping of bone after fractures or micro-cracks due to heavy lifts [9]. Briefly, activation of osteoclast precursors happens by the presence of remodelling

signals to the bone initiated by either hormonal or mechanical action [10]. However, it is stated that the cell activities and origin of osteoprogenitor cells in this stage are still poorly understood, leading to gaps in understanding its physiology [11]. Bone formation generally occurs in three phases; production of proteinaceous osteoid matrix by collagen deposition, maturation of the matrix, followed by gradual matrix mineralization forming new bone when the collagen synthesis decreases [12].

This process is initiated by mesenchymal and hematopoietic cell types where it produces receptor activators of the nuclear factor of kB ligand (RANKL), which helps in the activation of osteoclasts to resorb bone [13].

Physiologically, the bone itself has a high capacity for remodelling to maintain its structure and function. However, there are clinical circumstances in which accelerated bone formation is desirable such as in the presence of non-union [14].

Regardless, primary healing is the preferable type of healing, and it is a type of bone repair that involves intramembranous ossification with the direct transition of the mesenchymal cells to osteoblast [15].

Natural Products

Natural products are compounds derived from microorganisms that have been developed into commercial products for use in human medicine [16]. It has been utilized since their earliest ancestors due to their great properties in treating certain diseases. The highest potential of natural products to the human body particularly in the bone healing process has not yet been known to the world. Thus, more research needs to be done to discover the potential of natural products to contribute to several cell healing processes [17].

RESULTS AND DISCUSSION

Medicinal Plants in Bone Healing

In patients with bone fractures or dislocations, medicinal plants are used to facilitate the healing of connective tissue and minimize inflammation. Studies have shown that molecules that are extracted from medicinal plants promote bone regeneration and suppress bone resorption by enhancing the generation and survival of osteoblast, inhibiting growth and activities of osteoclast, suppressing inflammation, enhancing the synthesis of bone collagen, and upregulating ESR1 depression to increase phytoestrogen effects [18].

Based on Table II, a review of the literature revealed that 6 medicinal plants were found to provide prospective benefits in pharmacological studies, particularly in bone healing. The studies on these plants are discussed in detail below.

Table-II: Plants for bone healing and its pharmacology.

Family	Scientific Name	Pharmacological Study
Piperaceae	*Piper sarmentosum*	Improve fracture healing by reducing plasma corticosterone levels and increasing 11-HSD1 dehydrogenase activity [20].
Asteraceae	*Tridax procumbens*	TPFs promote osteoblast differentiation by up-regulation of alkaline phosphatase, osteocalcin, osterix, Runx2 and bone morphogenetic proteins (BMPs)[22].
Caprifoliaceae	*Sambucus williamsii hance*	EE-rbSWH increases mineral deposition and improves callus formation by stimulation of osteoblastic cells BMP-2 signaling pathway [24].
Brassicaceae	*Lepidium sativum*	Have high calcium content in seed extract which contribute to bone mineralization, increased osteoblastic activity and cartilage forming cells in callus [25].
Piperaceae	*Peperomia pellucida*	Extract of *P. pellucida* increases dose dependency of mRNA level of the genes affecting col1, BMP-2 and osteocalcin. The extract also has calcium and phosphorus that are important for enhancing bone repair by osteoblastic process [27].
Rosaceae	*Prunus dulcis*	Minerals presented in *Prunus dulcis* extract; blood calcium, and phosphorus aid in bone osteoblastic activity [30].

a. Piper sarmentosum

P. sarmentosum is a plant in the Piperaceae family commonly found in Southeast Asia, particularly in Malaysia, Indonesia, China, and India [19,20] where it is locally known as “daun kaduk” in Malaysia and Indonesia. The leaves of *P. sarmentosum* are similar to betel leaves, but generally smaller in size and bear white flowers with a particular aroma and berries gathered in a columnar pattern [19]. Malaysian have traditionally eaten the leaves of *P. sarmentosum* raw and utilized them as a remedy for malaria and cough [19]. It is also believed that *P. sarmentosum* can be useful in the treatment of chest pain, rheumatoid pain, and kidney stones [20].

P. sarmentosum is believed to promote bone healing activity by promoting callus mineralization, speeding up cartilage ossification, and replacing soft calli with hard calli which will eventually prevent thrombosis formation thus improving fracture healing. Aside from that, the precise mechanism that promotes fracture healing must be identified further [19].

b. Tridax procumbens

Tridax procumbens flavonoids (TPFs) that were isolated from *T. procumbens* are well known for their medicinal properties among local natives. It originated in Central America but occurs throughout the tropics and subtropics countries such as Malaysia which locally known as "kanching baju" [21].

It was found that flavonoids can reduce calcium and phosphate excretion in the urine, affect the activity of osteoblast and osteoclast, and prevent loss of trabecular bone. TPFs are a safer alternative as a preventive measure against numerous diseases since it is from natural sources and lack adverse effects in comparison with conventional drug therapy [22].

TPFs can inhibit the differentiation of osteoclasts thus preventing bone resorption in primary osteoclastic cells, TPFs significantly inhibited RANKL-induced osteoclast development and pit formation [22]. TPFs also reduced the expression of osteoclast differentiation-related genes in primary osteoclastic cells, such as Trap, Cathepsin K, Mmp-9, and Mmp-13 [22]. Osteocalcin was found to be elevated after the introduction of TPFs at late-stage markers of osteoblast differentiation. These data suggest that TPFs stimulate osteoblast differentiation and bone production [22].

c. *Sambucus williamsii hance* (SWH)

SWH is a species of plant in the Caprifoliaceae family [23] with a long medicinal history used as an effective universal treatment for bruises caused by fractures, especially in China. A recent study demonstrated that SWH extract exerts osteoprotective effects in hyperglycemia-induced osteopenia by modulating oxidative stress through the cGMP/PKG2 signalling pathway. The extract enhanced osteogenesis and bone homeostasis by enhancing the expression of antioxidant genes and suppressing the expression of pro-oxidant genes, suggesting its potential as a therapeutic agent for diabetic osteoporosis [23].

Another recent study investigated the effects of the ethanol extract of root bark of *Sambucus williamsii* Hance (EE-rbSWH) on bone healing in a rat femur fracture model. The extract, administered orally at 340 and 680 mg/kg, significantly accelerated bone healing across 2, 4, and 8 weeks [24]. It enhanced bone mineral density, increased serum levels of alkaline phosphatase and osteocalcin, and promoted the formation of mineralized nodules in bone marrow stromal cells. Mechanistically, EE-rbSWH exerted its effects by upregulating mRNA and protein expression of BMP-2, BMPRIB, BMPRII, and Runx2 at the fracture site, indicating its role in recruiting osteoblasts and promoting bone regeneration via the BMP-2/Runx2 signaling pathway [24].

d. Lepidium sativum

L. sativum more commonly known as garden cress, halim, holan, chandrasura, or "hab arachad", etc belongs to the Brassicaceae family originally from the Middle East and Southwest Asia, where it is widely known for fracture healing [25]. It is traditionally used as an herbal healer and believed to act as an analgesic, galactagogue, hepatoprotective, antioxidant, antispasmodic, and more. All parts of plant roots, leaves, and seeds were completely utilized in oriental medicine [25].

There are a few compounds presented that would be found in the extract of its seeds that would contribute to its wide healing properties primarily in bone fracture healing ie; tannins, flavonoids, alkaloids, glycosides, mucilage, and other phenolic compounds that are the predominant element in callus formation in secondary bone healing [26].

e. Peperomia pellucida

On the other hand, *P. pellucida* is another succulent herb that is studied for its bone healing and other medicinal properties. It is a herbaceous plant of the Piperaceae family and is usually found in America, Africa, and Asia region while most of these plants contribute to Cameroonian traditional medicine [27]. It is traditionally used as a treatment of abdominal pain, acne, abscess, colic, fatigue, gout, and rheumatic joint pain where the seeds and the whole plant are used for the remedy [28].

P. pellucida also contains calcium that would aid in matrix deposition of bone besides flavonoids and other metabolites contributing to bone formation which will be highlighted further later. However, there is no systematic study confirming the acceleration of fracture healing effectiveness, and thus further studies are required for hypothesis demonstration.

The extract of *P. pellucida* can increase the dose dependency of mRNA level of the genes that affect type1 collagen (col1), bone morphogenetic protein-2 (BMP-2), and osteocalcin [29]. In detail, type 1 collagen configures about 90% of bone's organic mass and tendon and its mutation can cause osteogenesis imperfecta [29]. Whereas BMP-2 aids in mesenchymal stem cell differentiation into fibroblasts and chondroblasts and bone integrity maintenance [31].

A recent study demonstrated that the aqueous extract of *P. pellucida* accelerates bone healing in fractured rats, likely due to its rich mineral content, including calcium, phosphorus, magnesium, sodium, and potassium. The

extract significantly improved bone calcium levels at low doses and enhanced callus formation at the fracture site in a dose-dependent manner, as shown by radiological evidence of dense fibrocartilaginous callus development. Additionally, a reduction in serum alkaline phosphatase and phosphorus levels was observed, suggesting the extract's role in modulating bone metabolism and promoting effective fracture repair [30].

f. Prunus dulcis

P. dulcis more generally known as almonds originated from Iran and the Middle East [30]. Components derived from *P. dulcis* include antioxidants such as different classes of flavonoids and benzoic acid, apart from lipids, proteins, fiber, and other minerals [30]. It aids in protective effects and bone healing physiological mechanisms mentioning calcium, phosphorus, potassium, and magnesium [30]. Chemical and microstructural changes such as altering lipid composition and its antioxidant compounds are possible [30].

Based on an *in vivo* study, subjecting blood calcium measurement, serum calcium was measured to be reduced first and increased afterward. The former finding indicated the calcium intake in the bone [31]. Phosphorus serum level was also observed and was initially increased coincided with the calcium level changes [31]. Phosphorus is a bone component that is essential for proper bone mineralization aided by the phosphorus derived from *P. dulcis* extract, hydroxyapatite formation will be formed by the deposition of both calcium and phosphorus in the callus. Hence, resulting in faster bone healing [31].

CONCLUSION

The main goal of this scoping review is to investigate and record the different medicinal plants to aid in bone fracture healing. In the present review, we have discussed the beneficial effects of medicinal plant metabolites and their mechanism of action. The results of the effects of selected plant extract and poultice nonetheless manifest an increasing rate of bone healing, supported by scientific evidence extracted from the articles. In summary, *P. sarmentosum* can induce callus mineralization, accelerate cartilage ossification, and replace soft calli with hard calli thus inhibiting thrombosis. *T. procumbens* flavonoid content can stimulate osteoblast differentiation and bone production. *L. sativum* contains phenolic compounds that are the predominant element in callus formation in secondary bone healing. Lastly, *P. pellucida* and *P. dulcis* both have minerals present in their extract to aid in bone protective mechanisms and physiological healing. More studies need to be conducted on the action of medicinal plants in bone healing to open more possibilities for applying medicinal components in the medical field.

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REFERENCES

1. Singh V. Medicinal plants and bone healing [published correction appears in Natl J Maxillofac Surg. 2020;11(2):309]. Natl J Maxillofac Surg. 2017;8(1):4-11. doi:10.4103/0975-5950.208972
2. Beyene B, Beyene B, Deribe H. Review on application and management of medicinal plants for the livelihood of the local community. J Resour Dev Manag. 2016;22(1):33-9.
3. Arulselvan P, Fard MT, Tan WS, Gothai S, Fakurazi S, Norhaizan ME, et al. Role of antioxidants and natural products in inflammation. Oxid Med Cell Longev. 2016;2016:5276130. doi:10.1155/2016/5276130
4. Miranda LL, Guimarães-Lopes VP, Altoé LS, Fraga-Junior R, de Carvalho JM, Oliveira LF, et al. Plant extracts in the bone repair process: a systematic review. Mediators Inflamm. 2019;2019:1296153. doi:10.1155/2019/129615
5. Loi F, Córdova LA, Pajarinen J, Lin TH, Yao Z, Goodman SB. Inflammation, fracture and bone repair. Bone. 2016;86:119-30. doi:10.1016/j.bone.2016.02.020
6. Shiu HT, Leung PC, Ko CH. The roles of cellular and molecular components of a hematoma at early stage of bone healing. J Tissue Eng Regen Med. 2018;12(4):e1911-e25. doi:10.1002/term.2622
7. Sheen JR. Fracture healing overview [Internet]. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2021 [cited 2022 Feb 1]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK551678/
8. Katsimbri P. The biology of normal bone remodelling. Eur J Cancer Care (Engl). 2017;26(6):e12740. doi:10.1111/ecc.12740
9. Langdahl B, Ferrari S, Dempster DW. Bone modeling and remodelling: potential as therapeutic targets for the treatment of osteoporosis. Ther Adv Musculoskelet Dis. 2016;8(6):225-35. doi:10.1177/1759720X16670154
10. Rowe P. Physiology, bone remodelling [Internet]. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2021 [cited 2023 Dec 15]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK499863/
11. Mizoguchi T, Ono N. The diverse origin of bone-forming osteoblasts. J Bone Miner Res. 2021;36(8):1432-47. doi:10.1002/jbmr.4410
12. Moreira CA, Dempster DW, Baron R. Anatomy and ultrastructure of bone – histogenesis, growth and remodeling [Internet]. In: Feingold KR, Ahmed SF, Anawalt B, et al., editors. Endotext. South Dartmouth (MA): MDText.com, Inc.; 2000–

[updated 2019 Jun 5; cited 2025 Jun 20]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK279149/
13. Streicher C, Heyny A, Andrukhova O, Haigl B, Slavic S, Schüler C, et al. Estrogen regulates bone turnover by targeting RANKL expression in bone lining cells. Sci Rep. 2017;7(1):6460. doi:10.1038/s41598-017-06614-0
14. Lerner UH, Kindstedt E, Lundberg P. The critical interplay between bone resorbing and bone forming cells. J Clin Periodontol. 2019;46 Suppl 21:33-51. doi:10.1111/jcpe.13051
15. Bahney CS, Zondervan RL, Allison P, Theologis A, Ashley JW, Ahn J, et al. Cellular biology of fracture healing. J Orthop Res. 2019;37(1):35-50. doi:10.1002/jor.24170
16. Katz L, Baltz RH. Natural product discovery: past, present, and future. J Ind Microbiol Biotechnol. 2016;43(2-3):155-76. doi:10.1007/s10295-015-1723-5
17. Barbalho SM, Araújo AC, Penteado Detregiachi CR, Buchaim DV, Guiguer ÉL. The potential role of medicinal plants in bone regeneration. Altern Ther Health Med. 2019;25(4):32-9.
18. Shalan NA, Mustapha NM, Mohamed S. Noni leaf and black tea enhance bone regeneration in estrogen-deficient rats. Nutrition. 2017;33:42-51. doi:10.1016/j.nut.2016.08.006
19. Sun X, Chen W, Dai W, Xin H, Rahman K, Wang Y, et al. Piper sarmentosum Roxb.: a review on its botany, traditional uses, phytochemistry, and pharmacological activities. J Ethnopharmacol. 2020;263:112897. doi:10.1016/j.jep.2020.112897
20. Ugusman A, Md Fadze NF, Hamid AA, Asmawi Z, Aminuddin A. Piper sarmentosum attenuates dexamethasone-induced hypertension by stimulating endothelial nitric oxide synthase. J Res Pharm. 2020;24(1):1-9. doi:10.35333/jrp.2020.122
21. Al Mamun MA, Islam K, Alam MJ, Khatun A, Alam MM, Al-Bari MA, et al. Flavonoids isolated from Tridax procumbens (TPF) inhibit osteoclast differentiation and bone resorption. Biol Res. 2015;48(1):51. doi:10.1186/s40659-015-0056-1
22. Al Mamun MA, Hosen MJ, Islam K, Khatun A, Alam MM, Al-Bari MAA. Tridax procumbens flavonoids promote osteoblast differentiation and bone formation. Biol Res. 2015;48(1):56. doi:10.1186/s40659-015-0056-1
23. Yang B, Lin X, Tan J, She X, Liu Y, Kuang H. Root bark of Sambucus williamsii Hance promotes rat femoral fracture healing by the BMP-2/Runx2 signaling pathway. J Ethnopharmacol. 2016;191:107-14. doi:10.1016/j.jep.2016.05.017
24. Shen YW, Cheng YA, Li Y, Li Z, Yang BY, Li X. Sambucus williamsii Hance maintains bone homeostasis in hyperglycemia-induced osteopenia by reversing oxidative stress via cGMP/PKG signal transduction. Phytomedicine. 2023;110:154607. doi:10.1016/j.phymed.2022.154607
25. Giri K, Dixit JR, Kumar I, Palandurkar K, Giri R. Lepidium sativum: bone healer in traditional medicine, an experimental validation study in rats. J Family Med Prim Care. 2020;9(2):812-8. doi:10.4103/jfmpc.jfmpc_761_19
26. Hakeem KR, Alharbi FH, Baothman OA, Zamzami MA, Abou Gabal HH, Khoja SM, et al. Garden cress (Lepidium sativum L.) seeds enhancing osteogenesis post-induced bone fracture. Pharmacogn Mag. 2021;17(73):170-5. doi:10.4103/pm.pm_75_20
27. Sukri MAM, Nordin NA, Pauzi MR. A comprehensive review of Peperomia pellucida: chemical composition, traditional and pharmacological uses, and potential in dermatitis management. MyJAS [Internet]. 2025 Apr 30 [cited 2025 Jun 20];10(1):100-11. Available from: https://journal.unisza.edu.my/myjas/index.php/myjas/article/view/447
28. Henriksen K, Karsdal M. Type I collagen. In: Biochemistry of collagens, laminins and elastin. Cham: Springer; 2016. p.1-11.
29. Florence NT, Huguette STS, Hubert DJ, Josué W, Lambert N, Aimé G, et al. Aqueous extract of Peperomia pellucida (L.) HBK accelerates fracture healing in Wistar rats. BMC Complement Altern Med. 2017;17:188. doi:10.1186/s12906-017-1686-3
30. Anaraki N, Beyraghi AH, Raisi A, Davoodi F, Farjanikish G, Sadegh AB. The effect of aqueous extract of Prunus dulcis on tibial bone healing in the rabbit. J Orthop Surg Res. 2021;16(1):623. doi:10.1186/s13018-021-02498-z
31. Barreca D, Nabavi SM, Sureda A, Rasekhian M, Raciti R, Silva AS, et al. Almonds (Prunus dulcis Mill. DA Webb): a source of nutrients and health-promoting compounds. Nutrients. 2020;12(3):672. doi:10.3390/nu12030672