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Medical Applications of Dodonaea viscosa: A Biotechnological Perspective on a Medicinal Workhorse

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Abstract

Dodonaea viscosa is a commonly occurring medicinal plant that has been used in the treatment of inflammation, wounds and infectious diseases in various ethnomedicinal traditions. This review critically analyses the existing scientific evidences for its pharmacological activities, phytochemical composition and biotechnological potential especially with regard to its translational relevance. The plant has been reported to have a variety of bioactive metabolites, such as flavonoids, saponins, and clerodane diterpenoids, which have been linked to anti-inflammatory, antimicrobial, anti-biofilm, wound healing and cytotoxic properties. Of these, anti-inflammatory activity is the most important pharmacological activity. Wound healing applications from bioassays have advanced to formulation-based studies. *In vivo* studies in the context of antimicrobial and anti-biofilm properties have shown promising anti-virulence effects, such as inhibiting germ-tubes in *Candida albicans* and the development of biofilms; however, these effects are mainly confined to *in vitro* studies. Initial anticancer studies indicate cytotoxic and antiproliferative activity in colorectal cancer cell lines; mechanistic and selectivity information is lacking to make clinical conclusions. *In vitro* propagation systems as well as the ability to transform metabolites and enhance production of flavonoids by using nanoparticles have been successfully developed in biotechnology, but hairy root cultures have not been studied. Although there are also positive pharmacologic findings, there are still many limitations, such as phytochemical variability, poor standardization, and the lack of sufficient long-term toxicity assessments. In conclusion, *D. viscosa* is a potential medicinal plant that requires careful standardization, optimization of various formulation parameters, mechanistic studies, and translational research for effective development.

Keywords: *Dodonaea viscosa*; plant biotechnology; phytomedicine; anti-inflammatory activity; anti-biofilm activity; wound healing; secondary metabolites

Introduction

Dodonaea viscosa is a perennial medicinal shrub, and widely distributed in tropical and subtropical Africa, Asia, Australia and the Middle East. It has gained attention in the scientific world due to its widespread application in traditional medicine for treating inflammatory disorders, wounds, fever, gastrointestinal disorders,

skin infections and microbial diseases. Its wide ethnomedicinal uses in geographically isolated cultures could indicate the presence of biologically active phytochemicals with great therapeutic potential[1].

The use of medicinal plants continues to be a valuable source of bioactive compounds for contemporary pharmaceuticals production, especially for the search of alternative safer and eco-friendly drugs to those that are synthesized. The increasing awareness about antimicrobial resistance, chronic inflammatory diseases and side effects of conventional medicine have boosted research in the field of phytomedicine and plant biotechnology in recent years. In this regard, *D. viscosa* has been a promising medicinal plant because of the presence of various secondary metabolites such as flavonoids, diterpenoids, alkaloids, tannins and saponins, which are related to its pharmacological activities [2].

The anti-inflammatory, antimicrobial, anti-biofilm, anti-oxidant, wound-healing, hepatoprotective and cytotoxic properties of extracts and isolated compounds of *D. viscosa* have been demonstrated in earlier studies. Of these activities, anti-inflammatory activity is the most widely studied, especially the activity of the diterpenoids of the clerodane type, including hautriwaic acid. In addition, the use of *in vitro* propagation systems, metabolite biotransformation and using nanoparticles to increase secondary metabolite production has been highlighted as potential avenues for enhancing the medicinal value of the plant with recent advances in plant biotechnology [3].

Although the results are encouraging, there are also some drawbacks such as phytochemical variations among extracts, a lack of standardization, a lack of extensive toxicological studies, and limited clinical evidence. Hence, a thorough review of the literature would be required to fill the gap between preliminary pharmacological studies and therapeutic use. The purpose of this review is to present an overview of phytochemical profile, principal medical applications and biotechnology applications of *D. viscosa*, as well as the research gaps and future prospects for the pharmaceutical development of *D. viscosa*.

Phytochemical Profile: Basis of Bioactivity

One problem with the study of *D. viscosa* is that the composition of the phytochemicals extracted from the plants depends on the part of the plant (Table 1), the geographical location, the growth stage, and the extraction solvent used [4]. This is not something that can be easily overlooked. It implies that two studies in which the same term "*D. viscosa* leaf extract" appears may be employing two different preparations of the extract, and as a result, differences in the bioactivity reported from one study to the next may not reflect biological variation, but rather chemical variation in the extract used to make them. So, with this disclaimer in mind, the overall metabolite overview is sufficiently uniform to be described (Table 2). There are flavonoids, such as isorhamnetin and related compounds, which are reliably detected and which may be a likely contributor to the antioxidant and anti-inflammatory activities due to their ability to scavenge radicals and interfere with signals [5]. Best-studied members of this family are called clerodane diterpenoids, such as hautriwaic acid, which seem to possess anti-inflammatory and anti-virulence properties [6]. Antimicrobial activities at the membrane level are most likely mediated by saponins, which are present. The presence of saponins with a membrane-disrupting character suggests they are likely to be the most important compounds with an antimicrobial effect at the membrane level [7]. Although crude extracts have consistently shown to be more effective than isolated fractions in bioassays [8], no one has conducted a formal interaction study to see if these constituent classes work synergistically, additively, or independently against the same biological target. That is not an experiment that has been undone, and that is indeed a gap in the literature of mechanisms.

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Table 2. Extraction Methods and Pharmacological Outcomes of *Dodonaea viscosa*

Plant Part	Extraction Solvent/Method	Main Constituents Obtained	Reported Pharmacological Activity
Aerial parts	Aqueous extraction	Polyphenols	Anti-inflammatory activity
Leaves	Methanolic extraction	Flavonoids, diterpenoids	Anti-inflammatory and antimicrobial
Leaves	Ethanolic extraction	Phenolics and flavonoids	Antioxidant and wound healing
Leaves	Flavonoid-rich fractionation	Isorhamnetin-rich fraction	Enhanced wound healing
Leaves	Nanoparticle-assisted in vitro enhancement	Increased flavonoid content	Improved secondary metabolite production

Table 2. Major Bioactive Compounds Identified in *Dodonaea viscosa*

Compound/Class	Chemical Category	Reported Biological Activity	Proposed Mechanism
Hautriwaic acid	Clerodane diterpenoid	Anti-inflammatory, anti-virulence	Cyclooxygenase inhibition, suppression of inflammatory mediators
Isorhamnetin	Flavonoids	Antioxidant, wound healing	ROS scavenging, fibroblast stimulation
Quercetin derivatives	Flavonoids	Anti-inflammatory, antimicrobial	Cytokine modulation and membrane destabilization
Saponins	Glycosides	Antimicrobial activity	Membrane disruption of microbial cells
Tannins	Polyphenols	Antioxidant and antimicrobial	Protein precipitation and radical scavenging
Alkaloids	Nitrogen-containing metabolites	Cytotoxic and antimicrobial	Interference with cellular metabolism

Major Medical Applications

Anti-inflammatory and Analgesic Activity

The anti-inflammatory activity in *D. viscosa* is the only part of the pharmacological literature that has an isolated compound with experimental data. Cybulski et al tested the leaves for their activity in the carrageenan-induced paw oedema and the TPA-induced ear oedema model and found that the active compound was the clerodane diterpenoid hautriwaic acid, showing activity at doses comparable to reference compounds [8]. The amount of detail in the pharmacology literature for *D. viscosa* is rare at this level of specificity, which is referred to as compound, named model, dose data. The overall picture from the two papers indicates that the anti-

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inflammatory activity is not only real, but that it exists in isolated constituents and crude extracts and does not have an acute toxicity at the doses tested in rodents. The proposed mechanism is mediated through the cyclooxygenase inhibition, cytokine suppression and attenuation of reactive oxygen species [9] as illustrated in Figure 1 below. None of the papers provides an appropriate dose response curve of hautriwaic acid alone or a good comparison with ibuprofen or indomethacin at equivalent doses, which would allow one to make any meaningful statement about where this compound would land relative to other anti-inflammatory agents.

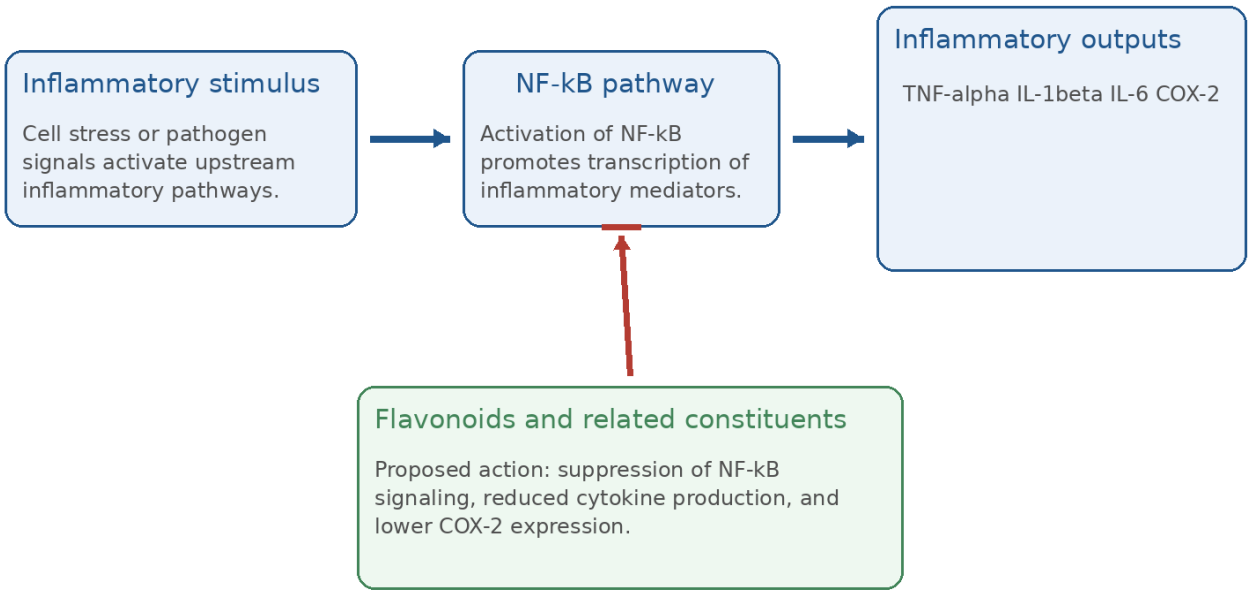

Figure 1. Anti-inflammatory activity of *Dodonaea viscosa*. Flavonoids and diterpenoids are suggested to inhibit inflammatory signaling and decrease mediators that lead to tissue inflammation. Developed from previous studies mentioned in the review.

Dodonaea viscosa has a multi-mechanistic anti-inflammatory activity, with no single molecular target known. Clerodane diterpenoids and flavonoids can inhibit the secretion of inflammatory cytokines (e.g., IL-6 and TNF-α), and block oxidative stress by scavenging ROS. Hautriwaic acid is suggested as one of the major anti-inflammatory diterpenoids because of its anti-inflammatory signaling effect by interfering with cyclooxygenase. Also, antioxidant flavonoids can help to reduce inflammatory tissue damage, by stabilizing cellular membranes and reducing lipid peroxidation. Although these exciting results were obtained, the exact molecular targets and signaling pathways remain only partially understood [10].

Antimicrobial and Anti-biofilm Activity

Antimicrobial activity in *D. viscosa* have been reported against various bacterial and fungal pathogens, for example, Kebede and Shibeshi reported antimicrobial activity from partially purified fractions against various infectious human pathogens [11]; and Bentarhlia et al. reported a new antimicrobial compound from leaf extracts [12]. The newer contributions differ in that they have moved beyond a reliance on the minimum inhibitory concentration (MIC) data to examine virulence endpoints, which is a more clinically relevant direction. However, (Nciki et al. reported that extracts of *D. viscosa*, when used at sub-inhibitory concentrations, inhibited *C. albicans* germ-tube formation and biofilm development [13]. Germ-tube suppression is important because germ-tube

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development is the morphological switch that allows *Candida* to invade tissue, so suppression without killing the organism is another type of anti-virulence strategy that could be beneficial. In that study, the constituents responsible have not been identified; however, diterpenoid rich fractions are most chemically plausible as they have been shown to be active against microbial virulence determinants in related plants. The anti-biofilm data have been summarized schematically in Figure 2. Clearly, all of this research is performed in a single fungal species *in vitro*; the antibacterial biofilm activity and *in vivo* anti-infective activity are still unexplored areas.

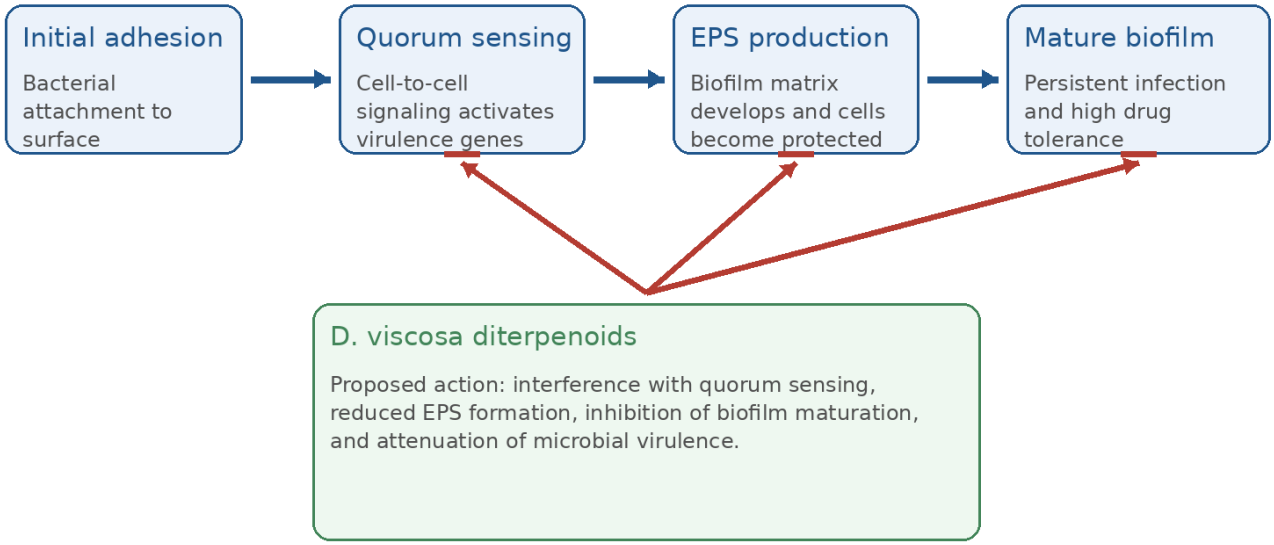

Figure 2. Proposed anti-biofilm activity of *Dodonaea viscosa*. Diterpenoid-rich constituents are proposed to interfere with quorum sensing, reduce extracellular polymeric substance formation, and limit biofilm maturation and microbial virulence.

Recent studies indicate that the antimicrobial activity of *D. viscosa* may be more than just its ability to kill microbes, but also to inhibit their virulence. Sub-inhibitory extracts resulted in the inhibition of germ-tube formation and biofilm maturation in *Candida albicans*, suggesting that they could interfere with quorum sensing and virulence-related signaling pathways. The fractions rich in diterpenoids are suggested to inhibit the formation of the EPS, which leads to decrease in microbial adhesion and biofilm stability. Most evidence available, however, is limited to in vitro fungal models, and antibacterial biofilm inhibition has not been well studied [14].

Wound Healing and Tissue Repair

D. viscosa has been most developed for pharmacological use for wound healing. The preparation of a flavonoid-rich fraction from the leaves, formulation of this extract, and testing in an excision wound model with wound contraction rate and epithelialization time as primary endpoints, were done by Subramanian et al. [15]. Much better results were obtained with the formulated fraction than with the untreated control in these parameters [16]. This study is more beneficial than the typical bioactivity paper because of two factors. The fraction is defined and enriched rather than a raw extract, and a step towards reproducibility, which is essential for therapeutic development. And the formulation was tested on its compatibility and stability – that is, the active material was verified to be compatible to be included in a delivery preparation. With regard to mechanism, the most plausible

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is one of two mechanisms: (1) flavonoids attenuate the early inflammatory stage of wound healing and (2) stimulate the activity of fibroblasts and the deposition of collagen in the tissue remodel stage [17]. It is not yet known whether isorhamnetin in particular, or flavonoids in general, or a mixture are responsible for this. This study is not a clinical outcome. The next step would be histopathologic analysis of the repair site, an armamentarium of comparison with a normal wound care agent, and likely further testing in another wound model before making a claim of clinical applicability with a straight face.

The therapeutic effects of *D. viscosa* on wound healing could be attributed to the combination effects of flavonoids, phenols, and anti-inflammatory metabolites. The action of flavonoids is considered to enhance cell proliferation, collagen formation, and re-epithelialization while decreasing inflammation in the early phases of wound healing. Other antioxidants can also protect the injured tissues from oxidative damage and cell regeneration. However, histopathological evaluation and comparisons with other wound healing drugs need to be conducted [18].

Cytotoxic and Anticancer Potential

Two papers make up most of what the *D. viscosa* cytotoxicity literature currently offers, and they are not really telling the same story. Herrera-Calderon et al. worked in HCT116 colorectal cancer cells and found cytotoxic and antiproliferative effects, with data pointing toward caspase 3 activation and p53 upregulation as part of the cell death pathway [19]. Tong et al. took a different route entirely: CCl4-intoxicated mice, hepatoprotective endpoints, restoration of ALP, AST, and ALT levels toward normal, with hematological parameters showing similar recovery [20]. These are not comparable experiments. The *in vivo* hepatoprotection data from Tong et al. describes a whole-organism response to a defined toxic insult—that is at least interpretable in a pharmacological context. The HCT116 data is harder to place. Caspase 3 and p53 involvement is interesting mechanistically, but these correlations were measured in a single cell line with no normal-cell selectivity data and no in vivo follow-up. A plant extract that kills cancer cells in a dish kills plenty of other things in a dish too; the selectivity question is what matters, and it was not asked. The honest summary of the anticancer evidence is that it exists, it has a mechanistic angle worth exploring, and it is nowhere near the stage at which clinical relevance can be discussed.

Cytotoxicity of *D. viscosa* extracts against colon cancer cell lines could be explained by apoptotic pathways involving activation of caspase-3 and elevation of p53 levels. These mechanisms imply induction of programmed cell death and suppression of tumor cell proliferation. However, ongoing studies on the matter remain deficient since there is no selective activity study conducted using normal human cells as well as in vivo tumors models for testing [19].

Biotechnology and Formulation Perspectives

The biotechnology literature for *D. viscosa* is best described as foundational rather than advanced, and there is little to be gained from overstating it. Here it has been shown that the plant can be propagated with high reliability via axillary bud multiplication and indirect organogenesis [21], the plant can be used for biotransformation of metabolites, such as the conversion of berberine to hepatoprotective metabolites [22] and that the *in vitro* application of $AgNO_3$ nanoparticles can lead to an increase in the specific flavonoid content [23]. These are three stand-alone proof-of-concept results, not a coordinated development programme. Hairy root culture, a microbial system that has been used to enhance secondary metabolite production in other medicinal plants and has a direct relevance to the useful secondary metabolites (diterpenoids and flavonoids) targeted in *D. viscosa* [24] has not been reported for this plant. That is something to mention as a gap as the production of hairy root systems is generally

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more stable than that of suspension cultures, and is more scalable. None of these upstream production methods offers immediate practicability, however. It is in the process of being formulated. The wound-healing study showed the possibility of stabilizing a *D. viscosa* fraction and its inclusion into a topical formulation that does not lose its biological activity [25]. This result, together with precision of the concentration of the active markers and the development of stability-tested formulations for antimicrobial and anti-inflammatory applications will be more achievable and more clinically relevant near-term goals than metabolic engineering.

Despite being in an early phase of development, biotechnological methods of *D. viscosa* exhibit significant promise in sustainable production of valuable bioactive metabolites. *In vitro* propagation of plant cultures, nanoparticle-mediated improvement of flavonoid synthesis, and experiments on biotransformation of metabolites have shown the possibility of obtaining pharmacologically important products under controlled conditions [3]. At the same time, there is still no research related to hairy root culture systems, commonly applied to medicinal plants in order to obtain secondary metabolites. Metabolic engineering of such systems could be one of the future directions in this area.

Toxicity and Quality Control

A common statement found in the *D. viscosa* literature is that the plant is of good safety. In one sense it must be, and in another sense it is untrue. Adekunle et al. did not mention any acute toxicity signs in mice at doses up to 5000 mg/kg and the leaf extract (80% methanol) in the rabbit primary irritation test gave a primary irritation index of 0.45 (slight to negligible irritation) with no sensitization response in the mouse ear swelling test [26]. Those numbers are good enough to proceed with the development of topical wound care. If they are talking about anything that involves long-term oral use, systemic absorption, or anything special like pregnant women, or people with a lot of medicines (polypharmacy) then they say nothing. There are no chronic toxicity studies available. No information is available on reproductive toxicity. Drug-interaction profiling has not been done. Several *D. viscosa* reviews, without qualification, say generally safe and mask this. Over top of this is the compositional variability problem [27] even if the plant name is the same on the label, the safety data from one extract preparation cannot be relied upon in another one whose phytochemical composition may vary. The only safe or defensible statement is that *D. viscosa* also looks like a pretty safe organism for topical preclinical development, and nothing more is justifiable [1].

Acute toxicity tests have revealed that *D. viscosa* extracts are not highly toxic substances [28]; however, a number of issues should be discussed concerning long-term use of this drug. Chronic toxicity tests, as well as reproductive toxicity tests and the study of pharmacokinetics of active substances, have not yet been performed in relation to this plant extract. Besides, phytochemically different extracts obtained from different geographic areas, using different extraction solvents, and harvested at different development stages can significantly vary in terms of their effect.

Conclusion

The phytochemical profile and the wide range of biological activities of *D. viscosa*, suggest a high medicinal and biotechnological potential. The current evidence shows that the plant has significant anti-inflammatory, wound healing, antimicrobial, anti-biofilm and potential anticancer properties, the most scientifically supported application being anti-inflammatory. Its isolation of bioactive compounds like hautriwaic

acid and the flavonoid rich fraction demonstrate the medicinal importance of its secondary metabolites, which are utilized in traditional medicine.

The ability of *D. viscosa* to be cultivated in vitro, to transform metabolites and to enhance the production of flavonoids by using nanoparticles also highlights the potential of *D. viscosa* for the sustainable production of pharmaceutically relevant compounds. Furthermore, studies using formulation-based wound healing suggest a step towards the therapeutic application and not only preliminary bioassays of wound healing.

Although these encouraging results have been found, several issues are still to be addressed. There is significant phytochemical variability among extracts, limited mechanistically studies, lack of standardized preparations and limited chronic toxicity evaluations which limit the translation of experimental findings into clinical applications. Moreover, most of the antimicrobial, anti-biofilm and anticancer studies are limited to in vitro models and require extensive in vivo and clinical studies.

In conclusion, *D. viscosa* is an important medicinal plant with potential application in the pharmaceutical and biotechnological fields. Standardization of extracts, characterization of metabolome, optimization of formulation, mechanism studies, and long-term safety studies should be a priority for future investigations to develop reliable plant-based therapeutics. Further investigation must focus on:

- Sample extraction procedure standardization,
- Metabolomic profiling of bioactive compounds,
- Further mechanistic elucidation by studying the molecular mechanism,
- Toxicological testing,
- Clinically useful drug formulation,
- And in vivo testing of potential pharmaceutical application for *Dodonaea viscosa*.

Author's Declaration

- We hereby confirm that all the Figures in the manuscript are original and have been created by us.
- We have obtained ethical clearance for our study from the local ethical committee at [Al-Nahrain University/College of Biotechnology]. This approval underscores our commitment to ethical research practices and the well-being of our participants.
- Ethical Clearance: The project was approved by the local ethical committee at [Al-Nahrain University/College of Biotechnology], ensuring adherence to ethical standards and the protection of participants' rights and welfare.

References

1. Murugesu, S., Perumal, V., Balan, T., Fatinanthan, S., Khatib, A., Arifin, N.J., Shukri, N.S.S.M., Saleh, M.S.M. & Hin, L.W. (2020). The investigation of antioxidant and antidiabetic activities of Christia vespertilionis leaves extracts, *South African Journal of Botany*, **133(**227-235. DOI: https://doi.org/10.1016/j.sajb.2020.07.015.
2. Khalil, A.H., Abdullah, Q.Y. & Ibrahim, H.M. (2026). Phytochemical Profiling and Bioactivity of Dodonaea viscosa L. Leaf Extract, *PSM Biological Research*, **11(1)**, 1-12.
3. Prasad, A., Sidhic, J., Sarbadhikary, P., Narayanankutty, A., George, S., George, B.P. & Abrahamse, H. (2024). Role of metal nanoparticles in organogenesis, secondary metabolite production and genetic transformation of plants under in vitro condition: a comprehensive review, *Plant Cell, Tissue and Organ Culture (PCTOC)*, **158(2)**, 33.

4. Mssillou, I., Agour, A., Slighoua, M., Tourabi, M., Nouioura, G., Lyoussi, B. & Derwich, E. (2022). Phytochemical characterization, antioxidant activity, and in vitro investigation of antimicrobial potential of Dittrichia viscosa L. leaf extracts against nosocomial infections, *Acta Ecologica Sinica*, **42(6)**, 661-669. DOI: https://doi.org/10.1016/j.chnaes.2021.09.021.
5. Al-Khayri, J.M., Sahana, G.R., Nagella, P., Joseph, B.V., Alessa, F.M. & Al-Mssallem, M.Q. (2022). Flavonoids as Potential Anti-Inflammatory Molecules: A Review, *Molecules*, **27(9)**, 2901.
6. Rali, S., Mshengu, B., Van De Venter, M. & Maharaj, V.J. (2025). In vitro nitric oxide inhibition of selected south African medicinal plants: A bio-guided purification of anti-inflammatory compounds from Conyza scabrida, *Fitoterapia*, **184(**106651. DOI: https://doi.org/10.1016/j.fitote.2025.106651.
7. Makiej, A., Smułek, W. & Kaczorek, E. (2025). The Perspectives of Combining Antibiotics with Saponins-Herbal Excipients, *Molecules*, **30(20)**, 2025/10/29. DOI: 10.3390/molecules30204102.
8. Cybulski, M., Michalak, O., Grzywaczyk, A., Krzeczyński, P., Zieliński, M. & Smułek, W. (2025). Exploration of Sapogenins as Promising Lead Compounds in the Development of Novel Antimicrobial Agents, *Chemistry & Biodiversity*, **22(12)**, e01569. DOI: https://doi.org/10.1002/cbdv.202501569.
9. Liu, J., Han, X., Zhang, T., Tian, K., Li, Z. & Luo, F. (2023). Reactive oxygen species (ROS) scavenging biomaterials for anti-inflammatory diseases: from mechanism to therapy, *Journal of Hematology & Oncology*, **16(1)**, 116. DOI: 10.1186/s13045-023-01512-7.
10. El-Feky, A.M., El-Rashedy, A.A. & Ibrahim, N.E. (2025). Computational and bioactivity investigations of flavonoid fraction from Dodonaea viscosa against oxidative stress and inflammation, *Sci Rep*, **15(1)**, 43652. 2025/12/12. DOI: 10.1038/s41598-025-29576-0.
11. Kebede, B. & Shibeshi, W. (2022). In vitro antibacterial and antifungal activities of extracts and fractions of leaves of Ricinus communis Linn against selected pathogens, *Veterinary Medicine and Science*, **8(4)**, 1802-1815. DOI: https://doi.org/10.1002/vms3.772.
12. Bentarhlia, N., Kartah, B.E., Fadil, M., El Harkaoui, S., Matthäus, B., Abboussi, O., Abdelmoumen, H., Bouhnik, O. & El Monfalouti, H. (2024). Exploring the wound-healing and antimicrobial potential of Dittrichia viscosa L lipidic extract: Chemical composition and in vivo evaluation, *Fitoterapia*, **172(**105707. DOI: https://doi.org/10.1016/j.fitote.2023.105707.
13. Nciki, S., Oderinlo, O.O., Gulube, Z., Osamudiamen, P.M., Idahosa, K.C. & Patel, M. (2020). Mezoneuron benthamianum inhibits cell adherence, hyphae formation, and phospholipase production in Candida albicans, *Archives of Microbiology*, **202(9)**, 2533-2542. DOI: 10.1007/s00203-020-01972-2.
14. Balasubramanian, N., Priya, V.T., Srivastava, S.K., Shanmugaiah, V. & Karunakaran, C. (2025). Dodonaea viscosa Jacq: Multi potential therapeutic agent for human health-A review, *Indian Journal of Natural Products and Resources (IJNPR)[Formerly Natural Product Radiance (NPR)]*, **16(2)**, 227-235.
15. Subramanian, S., Duraipandian, C., Alsayari, A., Ramachawolran, G., Wong, L.S., Sekar, M., Gan, S.H., Subramaniyan, V., Seethalakshmi, S., Jeyabalan, S., Dhanasekaran, S., Chinni, S.V., Mat Rani, N.N.I. & Wahab, S. (2023). Wound healing properties of a new formulated flavonoid-rich fraction from Dodonaea viscosa Jacq. leaves extract, *Frontiers in pharmacology*, **Volume 14 - 2023(**Original Research. DOI: 10.3389/fphar.2023.1096905.
16. Zulkefli, N., Che Zahari, C.N.M., Sayuti, N.H., Kamarudin, A.A., Saad, N., Hamezah, H.S., Bunawan, H., Baharum, S.N., Mediani, A., Ahmed, Q.U., Ismail, A.F.H. & Sarian, M.N. (2023). Flavonoids as Potential Wound-Healing Molecules: Emphasis on Pathways Perspective, *International journal of molecular sciences*, **24(5)**, 4607.
17. Zhang, M., Chen, X., Zhang, Y., Zhao, X., Zhao, J. & Wang, X. (2022). The potential of functionalized dressing releasing flavonoids facilitates scar-free healing, *Frontiers in Medicine*, **Volume 9 - 2022(**Review. DOI: 10.3389/fmed.2022.978120.
18. El-Feky, A.M., El-Rashedy, A.A. & Ibrahim, N.E. (2025). Computational and bioactivity investigations of flavonoid fraction from Dodonaea viscosa against oxidative stress and inflammation, *Scientific reports*, **15(1)**, 43652. DOI: 10.1038/s41598-025-29576-0.

19. Herrera-Calderon, O., Herrera-Ramírez, A., Cardona-G, W., Melgar-Merino, E.J., Chávez, H., Pari-Olarte, J.B., Loyola-Gonzales, E., Kong-Chirinos, J.F., Almeida-Galindo, J.S., Peña-Rojas, G. & Andía-Ayme, V. (2023). Dodonaea viscosa Jacq. induces cytotoxicity, antiproliferative activity, and cell death in colorectal cancer cells via regulation of caspase 3 and p53, *Frontiers in pharmacology*, **Volume 14 - 2023(**Original Research. DOI: 10.3389/fphar.2023.1197569.
20. Tong, Z.-W., Gul, H., Awais, M., Saddick, S., Khan, F.S., Gulfraz, M., Afzal, U., Nazir, K., Malik, M.Y., Khan, S.U. & Khan, M.I. (2021). Determination of in vivo biological activities of Dodonaea viscosa flowers against CCL4 toxicity in albino mice with bioactive compound detection, *Scientific reports*, **11(1)**, 13336. DOI: 10.1038/s41598-021-92638-6.
21. Benniamin, A., Jothi, G. & Sundari, M. (2015). Rapid in vitro Propagation of Dodonaea viscosa (Sapindaceae) Through Axillary Bud Multiplication and Indirect Organogenesis, *Journal of Non-Timber Forest Products*, **22(1)**, 33-36.
22. Abd El-Salam, M., Mekky, H., El-Naggar, E., Ghareeb, D., El-Demellawy, M. & El-Fiky, F. (2015). Hepatoprotective properties and biotransformation of berberine and berberrubine by cell suspension cultures of Dodonaea viscosa and Ocimum basilicum, *South African Journal of Botany*, **97(**191-195.
23. Al-Aubaidi, H.K. (2016). Increasing of some medical Flavonoid compounds of Dodonaea viscosa L. using AgNO3 Nanoparticles in Vitro, *Iraqi Journal of Science*, 343-338.
24. Morey, K.J. & Peebles, C.A. (2022). Hairy roots: An untapped potential for production of plant products, *Frontiers in Plant Science*, **13(**937095.
25. Mssillou, I., Agour, A., Slighoua, M., Chebaibi, M., Amrati, F.E.-Z., Alshawwa, S.Z., kamaly, O.A., El Moussaoui, A., Lyoussi, B. & Derwich, E. (2022). Ointment-based combination of Dittrichia viscosa L. and Marrubium vulgare L. accelerate burn wound healing, *Pharmaceuticals*, **15(3)**, 289.
26. Adekunle, Y.A., Samuel, B.B., Ezeuduji, J.U., Adedokun, O.A., Oluyemi, W.M., Nahar, L., Fatokun, A.A. & Sarker, S.D. (2023). Acute and sub-acute oral toxicity assessment of the methanol root extract of Olax subscorpioidea Oliv.(Olacaceae) in mice and rats, *South African Journal of Botany*, **163(**157-164.
27. Hoffman, M., Marx, J., Kaigongi, M.M., Masondo, N.A., Lukhoba, C.W., Yenesew, A. & Makunga, N.P. (2026). Reflecting on the interesting phytopharmacology of the cosmopolitan Dodonaea genus: past, present and future, *Phytochemistry Reviews*, **25(1)**, 461-488. DOI: 10.1007/s11101-025-10135-4.
28. Alanazi, A.Z., Al-Rejaie, S.S., Ahmed, M.M., Alhazzani, K., Alhosaini, K., As Sobeai, H.M., Alsanea, S., Alam, P., Almarfadi, O.M., Alqahtani, A.S., Alhamed, A.S., Alqinyah, M., Alhamami, H.N., Almutery, M.F. & Mohany, M. (2023). Protective role of Dodonaea viscosa extract against streptozotocin-induced hepatotoxicity and nephrotoxicity in rats, *Saudi Pharmaceutical Journal*, **31(8)**, 101669. DOI: https://doi.org/10.1016/j.jsps.2023.06.002.