International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2024: 7.101

A Systematic Review of Magnoflorine: Chemical Structure, Pharmacological Properties, Biological Activities, and Therapeutic Potential

Saurav Kumar Karwate[1], Rakesh Choure[2]

Research Scholar at Chhindwara University, M.P., India

Abstract: ***Magnoflorine is a plant-derived quaternary aporphine alkaloid found in several families of medicinal plants. Recent studies have shown that it possesses broad pharmacological potential, including anti-inflammatory, antimicrobial, antidiabetic, antihypertensive, and neuroprotective effects. It has also been linked to benefits in lifestyle-related disorders such as cancer, obesity, diabetes, dementia, and depression. Experimental studies highlighted its strong antioxidant activity, demonstrated through DPPH, ABTS, and DMPD radical-scavenging assays, as well as metal-ion reduction tests. Magnoflorine demonstrated effective DPPH radical scavenging with an IC_{50} of 10.58 µg/mL, comparable or superior to standard antioxidants like BHA, BHT, and α-tocopherol. Additionally, it inhibits key enzymes such as acetylcholinesterase, butyrylcholinesterase, and α-glycosidase at very low concentrations, suggesting potential roles in managing diabetes, Alzheimer's disease, and glaucoma. Overall, magnoflorine emerges as a promising natural compound for future therapeutic and drug development applications.***

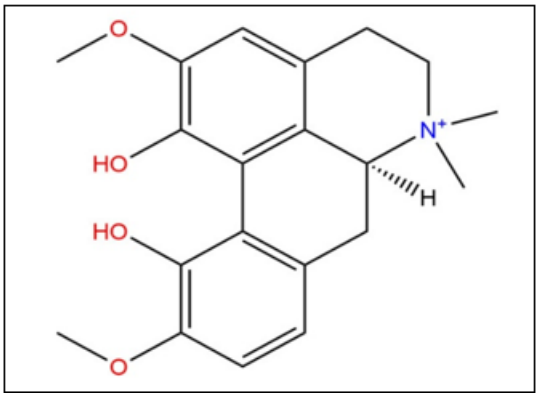
Keywords: Magnoflorine, Quaternary Aporphine Alkaloid, Antioxidant activity, Enzyme inhibition, Antidiabetic, In- Vitro studies.

1. Introduction

Alkaloids are important natural chemical compounds found in plants that have strong effects on the human body. Several classes of these compounds, which are derived from different amino acids present in their biosynthetic pathway [1]. Magnoflorine is a naturally occurring quaternary aporphine alkaloid, primarily found in Tinospora cordifolia (commonly known as Giloy). Magnoflorine is the most widely distributed and is found in numerous genera of flowering plant families, such as Ranunculaceae, Menispermaceae, and Magnoliaceae [2]. Structurally, Magnoflorine possesses a permanent positive charge on its nitrogen atom, which contributes to its water solubility and facilitates electrochemical redox behavior [3]. Pharmacological properties of magnoflorine and its derivatives have demonstrated bioactivities, including antioxidant, anti-inflammatory, anticancer, and antidiabetic. Promising therapeutic applications such as Neuroprotective and Neuropsychopharmacological, immunomodulatory and antifungal, cardiovascular (hypotensive) [4],[5]. Recent scientific investigations have provided experimental evidence for the use of magnoflorine – containing plants and revealed multiple mechanism of magnoflorine exerts its biological effects.

Chemical structure of Magnoflorine

Magnoflorine (MGN) is a widely distributed plant alkaloid found in species belonging to the Ranunculaceae, Menispermaceae, and Magnoliaceae families. It is chemically classified as a quaternary isoquinoline aporphine alkaloid. These alkaloids are biosynthesized from benzylisoquinoline precursors through an oxidative process that involves the loss of two hydrogen atoms, resulting in the formation of a 9,10-dihydrophenanthrene structure from two benzene rings. The molecular formula of Magnoflorine is C20H24NO4+. Structurally, MGN has two hydroxyl groups (-OH) at positions 1 and 11, and two methoxy (-CH3) groups at position 6 attached to the aporphine ring system. In plants, Magnoflorine generally occurs as a quaternary ammonium ion. It is characterized by high polarity and good solubility in water.[6]



Chemical Structure of Magnoflorine

Experimental Approach Used in Studies

According to the literature that is currently available, magnoflorine's biological characteristics have mostly been studied in vitro.[7]. Previous studies report that enzymes, substrates, and other reagents were sourced from accredited suppliers, and the majority of studies used highly purified magnoflorine from reputable commercial sources like Sigma-Aldrich.[8] While DMSO was commonly used in enzyme inhibition experiments to reduce potential solvent interference, ethanol was frequently used as a solvent in antioxidant evaluations.[9] Published reports indicate that experiments were carried out in controlled laboratory settings to guarantee consistency, dependability, and reproducibility of the results. DPPH, ABTS, and DMPD radical scavenging techniques, as well as ferric and cupric reducing capacity tests, were among the established assays used to measure antioxidant capacity. UV-visible spectrophotometric analysis was used to record absorbance readings at particular wavelengths, and these assays were usually carried out within

a concentration range of roughly 10–30 µg/mL.[10]. The overall evidence indicates that the antioxidant effect of magnoflorine increases in a concentration-dependent manner, and results were frequently expressed as IC_{50} values. The Ellman assay, which measured the inhibition of acetylcholinesterase and butyrylcholinesterase, was used in multiple studies to examine anticholinergic activity. Additionally,α-glucosidase inhibition assays were often used to assess antidiabetic activity.[11],[12]. Lineweaver–Burk graphical methods were frequently employed for kinetic evaluations, and IC_{50} and k_i values associated with enzyme inhibition were obtained from concentration-response curves.[13],[14]. Most studies reported performing experiments in triplicate, analyzing the data statistically, and determining statistical significance at $P < 0.005$ or comparable levels.

2. Result and Discussion

The antioxidant capacity of natural compounds is commonly evaluated using in vitro assays that measure their ability to reduce oxidative damage.[15]. According to the literature that is currently available, magnoflorine has a strong antioxidant potential and can help shield biological systems from oxidative stress. In the present analysis, metal ion reduction tests (Fe^{3+} and Cu^{2+}) and free radical scavenging tests (DPPH, ABTS, and DMPD) have been the main methods used to evaluate its antioxidant activity [15],[16]. Magnoflorine exhibited a concentration-dependent increase in reducing power in the ferric ion (Fe^{3+}) reduction assay, demonstrating its capacity to change Fe^{3+} into Fe^{2+}. Although it was not as active as powerful conventional antioxidants like Trolox and BHA. It was discovered to be similar to widely used antioxidants like BHT and α-tocopherol. These results suggest that magnoflorine can support antioxidant defense mechanisms in biological systems and function as an efficient electron donor.

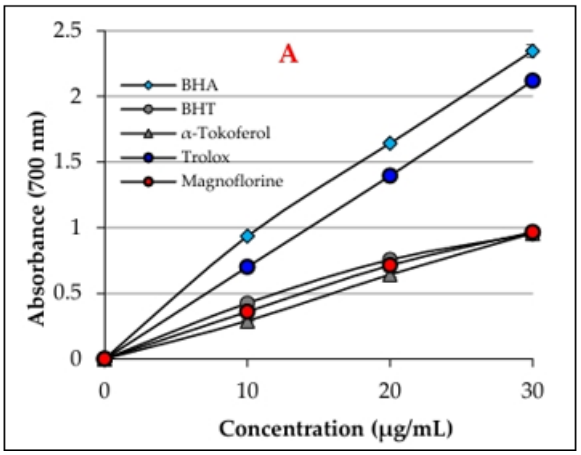


Figure 1: Reducing the power of Magnoflorine

Magnoflorine also showed concentration-dependent reducing activity in the cupric ion (Cu^{2+}) reduction assay, though it was not as effective as potent synthetic and natural antioxidants. However, these findings verify that magnoflorine can take part in redox reactions and contribute to the total. Magnoflorine's antioxidant capacity and metal ion reduction activity.[17],[18].

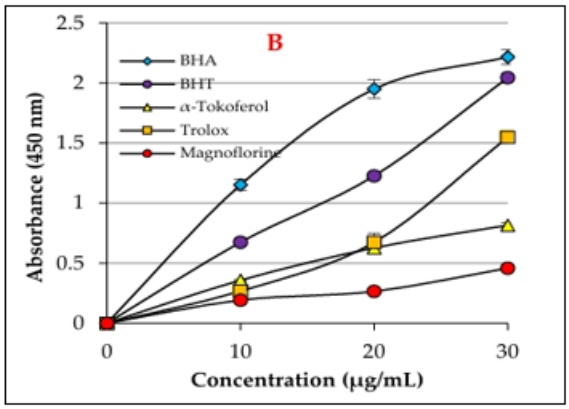


Figure 2: Metal ion reducing activity of Magnoflorine

The antioxidant potential of magnoflorine was clearly evident from free radical scavenging assays. Magnoflorine showed a strong scavenging activity in the DPPH assay, higher than BHA and comparable to α-tocopherol and BHT, indicating its capacity to donate both electrons and hydrogen atoms. Although its activity was less than that of extremely powerful synthetic antioxidants, magnoflorine also neutralized reactive radicals in the ABTS assay. In addition, notable, significant scavenging activity against DMPD radicals was documented, suggesting a moderate level of efficacy in comparison to conventional antioxidants. When combined, these results suggest that magnoflorine has antioxidant activity that is moderate but biologically significant, similar to that reported for several phenolic compounds. Its antioxidant behaviour seems to be influenced by a number of variables, such as concentration, temperature, and interactions with target molecules or oxidants. Its potential antioxidant effect may be dependent on many variables, such as concentration, temperature, and interactions with oxidants or target molecules. The bifunctional and multifunctional antioxidant nature of it was confirmed by its capacities to reduce Fe^{3+} and Cu^{2+} ions and to scavenge free radicals. Considering all these, magnoflorine may be a candidate for a natural antioxidant to be used in food conservation and against biological systems from oxidative injuries.

Table 1: Summary of In-Vitro Antioxidant Activity of Magnoflorine

Assay	Key Observation	Comparison
Fe^{3+} reduction	Conversion of Fe^{3+} to Fe^{2+} increased with concentration	Comparable to Alpha-tocopherol and BHT
Cu^{2+} reduction	Moderate reduction of Cu^{2+} observed	Slightly less active than strong antioxidants
DPPH scavenging	Free radicals were effectively neutralized	Comparable to Alpha-tocopherol and BHT
ABTS scavenging	Moderate radical scavenging activity observed	Less active than potent synthetic antioxidants
DMPD scavenging	Notable neutralization of free radicals	Moderate compared to standard antioxidants

3. Conclusion

Magnoflorine is a naturally occurring quaternary aporphine alkaloid that occurs in several medicinal plants, including Tinospora cordifolia. Its chemical structure has hydroxyl and methoxy groups plus a permanently charged N, which results in good water solubility and biological activity. Magnoflorine has been shown in recent years to have a wide range of pharmacological activity, thus raising the alertness level of researchers. It has been reported to have an antioxidant effect by scavenging free radicals and decreasing oxidative stress through experimental studies. It also has anti-inflammatory activity by regulating the inflammatory response pathways. In cancer models, magnoflorine has been reported to enhance the efficacy of conventional chemotherapeutic agents while showing limited toxicity toward normal cells. Significantly, its antidiabetic activity is closely related to competitive inhibition of intestinal α-glucosidase enzymes, which delays carbohydrate digestion and controls postprandial blood glucose levels**.** Collectively, magnoflorine is identified as a major bioactive compound with promising potential for future drug development.

Acknowledgement:
The author is grateful to the Department of Chemistry, PMCoE Government J.S.T. PG College, Balaghat, for support and thankful to Dr. Rakesh Choure for his advice and encouragement throughout the preparation of this manuscript.

References

[1] Baran, M., Miziak, P., & Bonio, K. (2020). Magnoflorine – a compound with anti-tumour activity. Journal of Preclinical and Clinical Research, 14(3): 98–101.
[2] Dwuma- badc, D. Ayim J.S.K. Withers S. F (1980). Constituents of West African medicinal plants. Journal of Natural Products 43:123-129.
[3] Zhou, X. (2017). Electrochemical behaviour and redox properties of magnoflorine: A potential electroactive alkaloid. Electrochimical Acta, 246:1059 –1067.
[4] Xu T.Kaung T.Du H. (2020). Magnoflorine: A Review of its pharmacology, pharmacokinetics, and toxicity. Pharmacol Res.2020.
[5] Okon. E., Kukula – Koch, W Jarzab, A. Halasa. M Stepulak, A.& Wawruszak , A. (2020). Advances in chemistry and bioactivity of magnoflorine and magnoflorine–containing Extracts.Molecules,25 (4):838.
[6] Okon E, Luszczki JJ, Kukula-Koch W, (2020). Synergistic or Additive Pharmacological Interactions between Magnoflorine and Cisplatin in Human Cancer Cells of Different Histological Origin. Int J Mol Sci. 21(8): 2848.
[7] Durmaz, L., Kiziltas, H., Guven, L., Karagecili, H., Alwasel, S., & Gulcin, I. (2022). Antioxidant, antidiabetic, anticholinergic, and antiglaucoma effects of magnofluorine. Molecules, 27(18): 5902.
[8] Gulcin, ˙I. (2003). Measurement of antioxidant ability of melatonin and serotonin by the DMPD and CUPRAC methods as Trolox equivalent. J. Enzyme Inhib.Med. Chem.23: 871–876.
[9] Topal, M.; Gocer, H.; Topal, F.; Kalin, P.; Polat Kose, P.; Gulcin, I.; Cetin Cakmak, K.; Kucuk, M.; Durmaz, L.; Goren, A.C.;(2003). Antioxidant, antiradical, and anticholinergic properties of cynarin purified from the Illyrian thistle (Onopordum illyricum L.). J.Enzym. Inhib. Med. Chem. 31:266–275.
[10] Takım, K.; Yigin, A.; Koyuncu, I.; Kaya, R.; Gulcin,I(2021). Anticancer, anticholinesterase, and antidiabetic activities of Tunceli garlic (Allium tuncelianum)-Determining its phytochemical content by LC-MS/MS analysis. J. Food Meas. Charact.15:3323–3335.
[11] Gulcin, I.; Tel, A.Z.; Kirecci, E.(2008). Antioxidant, antimicrobial, antifungal, and antiradical activities of Cyclotrichium niveum (Boiss.)Manden and Scheng. Int. J. Food Propert. 11: 450–471.
[12] Tao, Y.; Zhang, Y.; Cheng, Y.; Wang, Y. (2013). Rapid screening and identification of α-glucosidase inhibitors from mulberry leaves using enzyme-immobilized magnetic beads coupled with HPLC/MS and NMR. Biomed. Chromatogr. 27:148–155.
[13] Lineweaver, H.; Burk, D.(1934). The determination of enzyme dissociation constants. J. Am. Chem. Soc. 56: 658–666.
[14] Gulcin, I.; Alwasel, S.H.(2022). Metal ions, metal chelators, and metal chelating assay as an antioxidant method. Processes 10:132.
[15] Cetin Cakmak, K.; Gulcin, I.(2019) Anticholinergic and antioxidant activities of usnic acid: An activity-structure insight. Toxicol. Rep.6:1273–1280
[16] Gulcin, I.; Oktay, M.; Koksal, E.; Serbetci, H.; Beydemir, S.; Kufrevioglu, Ö.I.(2008) Antioxidant and radical scavenging activities of uric acid. Asian J. Chem. 20: 2079–2090.
[17] Gocer, H.; Gulcin, I.(2011). Caffeic acid phenethyl ester (CAPE): Correlation of structure and antioxidant properties. Int. J. Food Sci. Nutr. 62: 821–825.
[18] Topal, F.; Topal, M.; Gocer, H.; Kalın, P.; Kocyigit, U.M.; Gulcin, I.; Alwasel, S.H.(2016). Antioxidant activity of taxifolin: An activity-structure relationship. J. Enzym. Inhib. Med. Chem. 2016, 31, 674–68316.
[19] Patel, M.B.; Mishra, S.M.(2012) Magnoflorine from Tinospora cordifolia stem inhibitsα-glucosidase and is antiglycemic in rats. J. Funct. Foods 4:79–86.
[20] Gulcin,I.(2020). Antioxidants and antioxidant methods: An updated overview. Arch. Toxicol. 94: 651–715.
[21] Bae, J.H.; Park, Y.J.; Namiesnik, J.; Gulcin, I.; Kim, T.C.; Kim, H.C.; Heo, B.G.; Gorinstein, S.; Ku, Y.G. (2016) Effects of artificial lighting on bioactivity of sweet red pepper (Capsicum annuum L.). Int. J. Food Sci. Technol. 51: 1378–13853.
[22] Durmaz, L.; Ertürk, A.; Akyüz, M.; Polat Köse, L.; Uc, E.M.; Bingöl, Z.; Saglamtas, R.; Alwasel, S.; Gulcin, I., (2022). Screening of carbonic anhydrase, acetylcholinesterase, butyrylcholinesterase, and α-glycosidase enzymes inhibition effects and antioxidant activity ofcoumestrol. Molecules 27: 3091.
[23] Gulcin, I.; Beydemir, S.; Sat, I.G.; Küfrevio ˘glu, O.I (2005). Evaluation of antioxidant activity of cornelian cherry (Cornus mas L.). Acta Aliment. Hung. 34: 193–202.

[24] Serbetci Tohma, H.; Gulcin, I (2010). Antioxidant and radical scavenging activity of aerial parts and roots of Turkish liquorice (Glycyrrhiza glabra L.). Int. J. Food Prop.13: 657–671.
[25] Hao, D.-C.; Xiao, P.-G.; Ma, H.-Y.; Peng, Y.; He, C.-N. (2015). Mining chemodiversity from biodiversity: Pharmacophylogeny of medicinal plants of Ranunculaceae. Chin. J. Nat. Med. 201: 507–520.
[26] Hung, T.M.; Na, M.; Min, B.S.; Zhang, X.; Lee, I.; Ngoc, T.M.; Thuong, P.T.; Sok, D.E.; Bae, K, (2007). Protective effect of magnoflorine isolated from Coptidis rhizoma on Cu2+-induced oxidation of human low-density lipoprotein. Planta Med. 73:1281–1284
[27] Sharma U, Bala M, Kumar N, (2012). Immunomodulatory active compounds from Tinospora cordifolia. Journal of Ethnopharmacology. 141: 918-926.