Oxidation Communications 47, No 1, 96–105 (*2024*)

Antibacterial, antioxidative, biological activity, etc.

ANTIHYPERTENSIVE EFFECT OF *Rauvolfia serpentina* FOR TREATING CARDIOVASCULAR DISEASE AND ANXIETY

H. M. MOYEENUDIN[a], S. IVO ROMAULD[b], ARUMUGAM SUMITHA[c], RAJENDRAN SUDHA[d], ASHWIN RAJ SURESH[e], S. PADMANABHAN[f], J. SENTHILKUMAR[g], B. SANTOSH KUMAR[h], M. SUNDEEP[i], JAISREE ANAND[a], PARTHIBAN BRINDHA DEVI[b]*

[a]*Department of Hotel Catering Management, Vels Institute of Science Technology and Advanced Studies, Chennai, Tamil Nadu, India*
[b]*Department of Bioengineering, Vels Institute of Science Technology and Advanced Studies, Chennai, Tamil Nadu, India*
E-mail: *pbrindhadevi@gmail.com*
[c]*Department of Pharmacology, ACS Medical College and Hospital, 600 077 Chennai, Tamil Nadu, India*
[d]*Department of Chemistry, Vels Institute of Science Technology and Advanced Studies, Chennai, Tamil Nadu, India*
[e]*Department of Biotechnology, Bannari Amman Institute of Technology, Sathyamangalam, Tamil Nadu, India*
[f]*School of Mechanical and Construction, Vel Tech Rangarajan Dr.Sagunthala R & D Institute of Science and Technology, Chennai, Tamil Nadu, India*
[g]*Department of Mechatronics Engineering, Sathyabama Institute of Science and Technology, Chennai, Tamil Nadu, India*
[h]*Department of Computer Science Engineering, New Horizon College of Engineering, Bangalore, India*
[i]*Department of Mechanical Engineering, MLR Institute of Technology, Hyderabad, Telangana, India*

ABSTRACT

The roots of *Rauwolfia serpentine* have some valuable properties like anti-hypertensive effect on consumption with its reserpine component as this root is the major source for reserpine alkaloid in evaluation with various herbs. In addition, the component ajmalicine is responsible in treating cardiovascular disease. The flowering plant *Rauwolfia serpentine* belongs to the family of Apocynaceae, found in Indian subcontinents or South Asia especially in India and mostly in places near to Himalayas. The studies

* For correspondence.

reveal that it is commonly used in Unani Medicine as this system raised since 1037 AD one of the oldest medicinal practice, further the root of *Rauwolfia serpentine* used as a medicine to treat cardio vascular diseases was recorded 1000 years before in the manuscripts. The specialty of *Rauwolfia serpentine* is the alkaloids which are present in this plant are reserpine and ajmalicine which helps in assisting in curing the cardiovascular disease; it is also comprised with ajmaline that helps in treating atrial fibrillation and acute intravenous treatments. The *in vitro* analysis of *Rauvolfia serpentine* has evidences since the alkaloid found through phytochemical analysis are assisting in curing the cardiovascular disease and anxiety.

Keywords: *Rauvolfia serpentine*, herbal medicine, Sarpagandha, hypertension, anxiety.

AIMS AND BACKGROUND

The main causes of hypertension are stress and bad eating habits, which are mediated by a stressful lifestyle and the consumption of foods that are heavy in sodium and fat content. Inadequate consumption of vegetables and fruits is another cause of hypertension. The alternative treatment for this illness will be developing healthy eating habits and exercise practices. Many herbs have the power to treat and reduce the symptoms of hypertension[1]. Hypertension is a major source of cardiovascular risk in poor nations. One main source is seen as food. It has been observed that diets high in sodium, fat, and calories are the main cause of hypertension. People now prefer to eat foods that are quick to prepare and serve, and most health issues are caused by poor eating habits and unfavorable lifestyle choices made in relation to food. This study was conducted to identify component that can help to lower blood pressure levels[2]. The *Rauwolfia serpentine* can be blended or added with any diet and it is suitable for controlling hypertension and bringing it back to normal. Hypertension, which also affects other body organs and causes stroke, kidney disease, and poor vision, is a prevalent cause of most coronary illnesses. Despite the fact that stress, melancholy, and work pressure can cause hypertension, eating habits remain a key concern in the modern world due to the expansion of fast food and the availability of junk food. There are many treatments used to treat this condition, but there is no permanent cure as it is tied to daily eating habits. Avoiding salt in meals can temporarily regulate the condition as it is also brought on by stress, depression, and work pressure[3]. Another option is daily exercise and low-calorie, low-fat eating with the daily food, this sickness might be cured because it tends to manage hypertension and return it to normal[4]. Patients visiting a range of healthcare facilities use alternative therapies, herbs, and supplements at a relatively high rate[5]. Clinicians should take into account the potential interactions or effects of such therapy on hypertension and other cardiovascular illnesses. In this succinct overview lead to focus on a number of often employed complementary therapies that could have a therapeutic effect on patients with hypertension[6]. We are not completely aware of these impacts, due to a number of issues. These issues include patients not disclosing to doctors their use of

herbal remedies or alternative therapies, the absence of standardised scientific criteria for the bioactivity of many herbal remedies or dietary supplements, and the variety of names that each bioactive material is marketed under. Therefore, specific inquiries about herbal remedies and complementary treatments are made at the hypertension clinic[7]. The description about the plant Rauvolfia serpentine is represented in Table 1.

Table 1. Description about the plant *Rauvolfia serpentine*

Botanical name	*Rauvolfia serpentina*
Genus	Rauvolfia
Family	Apocynaceae
Common Name	Indian snakeroot
Species	*R. serpentina*
Kingdom	Plantae
Habit	Herb
Traditional uses	Medicinal plant

EXPERIMENTAL

Rauvolfia serpentina is collected from a nursery at Maduravoyal, Chennai. The plant Rauvolfia serpentine roots were cut off and sterilised for using as an organ culture. The roots used for organ culture were carefully cleaned for 30 min with running tap water, and then soaked for 5 min in a 5% (v/v) solution of Labolene detergent. The roots of *Rauvolfia serpentina* explants were surface sterilised with a 0.1% in to the solution of mercuric chloride to make the surface clear from foreign material with the addition of sterile distilled water after being washed numerous times. The explants were thoroughly cleaned with sterile distilled water before being sliced into pieces measuring 0.620 cm and grown on sterile Murashige and Skoog (MS) media.

In order to determine the alkaloids present in the *R. serpentina* and the phytochemicals found from the extracts of the *R. serpentina* root the analytical grade chemicals, solvents and reagents are used for experiment along with HPTLC plates, the root of *R. serpentina* is processed for knowing foreign matter presence. In addition, the drying of root at 105°C is carried out Finally it is powdered for ash, to know the acid-insoluble ash, alcohol soluble ash from the extracts with the 10% aqueous solution using standard methods for the water-soluble ash for knowing pH level.

Rauvolfia serpentine root is subjected to a Liquid chromatographic analysis to identify the reserpine and rescinnamine components in *R. serpentine*. Furthermore the powdered form is passed with fluorescence detection, to a mutual learning about the composition. The process for pulling out the reserpine and rescinnamine is done through purification with a basic description of that utilised in the present authorised method for analysis of *R. serpentina*. The liquid chromatographic (LC) distributions are applied on a regular stage. The movable stage is with infusion of 1-pentanesul-

phonic acid sodium salt to methanol with a small quantity of an aqueous solution and it is supplemented to accomplish preferred removal distinctiveness.

RESULTS AND DISCUSSION

PHYTOCHEMICAL ANALYSIS OF *Rauwolfia serpentine* ROOT

The phytochemical analysis is carried out to know the phenols and alkaloids contents in *R. serpentina* by adding ethyl acetate to this root. The ethanol extract of *R. serpentina* roots was processed for the presence of carbohydrates, alkaloids, tannins, steroids, amino acids, and coumarins by standards methods[8] and has been analysed and tabulated in Table 2.

Phenols are secondary plant metabolites that are abundantly found in the plant kingdom, primarily in herbs, shrubs and vegetables as well as in roots. Phenols are thought to be hazardous for many infections and pests as they grow and develop. Significant antidiabetic and hypolipidemic effects are demonstrated by *R. serpentina*'s high total polyphenol content. It serves as an emulsifying and expectorant in medicine. The fact that phenolic chemicals are present suggests that this has potential as an anti-microbial agent. Gallic and diagallic acids, which are present in tannins, are responsible for its ability to suppress oxidation[9]. Tannins have astringent qualities as they speed up the recovery of cuts and inflamed mucous membranes. Consequently, describe how South Eastern Indian practitioners of traditional Unani medicine employ R. serpentina to treat a variety of ailments[10].

Table 2. Phytochemical analysis of extracts of *R. serpentina* root

Phytochemicals	Roots extracts		
	n-Hexane	Ethyl acetate	Ethanol
Amino acid	-	-	+
Steroids	-	+	+
Coumarins	-	-	+
Phenols	-	+	+
Tannins	-	+	+
Alkaloids	+	+	+
Carbohydrates	-	-	+

Flavonoids are strong free radical scavengers and water-soluble antioxidants that guard against oxidative cell damage and exhibit potent activity for treating disease. There are some flavonoids which help in reducing the risk of heart disease[11]. The flavonoids which serve as antioxidants have anti-inflammatory properties, and for that reason are utilised in herbal medicine to cure the disease[12]. In addition to saponins, glycosides, terpenes and sterols have been found in numerous plant families[13]. The ability to create foam in aqueous solutions, hemolytic activity, cholesterol-binding abilities, and bitterness are only a few of the traits of saponins[14]. The natural ability

of this compound is to cause red blood cells to coagulate. The use of *Rauvolfia serpentina* extracts to control the bleeding and cure wounds is supported by the plant's high saponin content. The plant's root is used as a sedative, sedative for insomnia, and as a treatment not only high blood pressure this root extract is regarded as the finest treatment for cardiovascular disease and has been adopted by the medical community in the majority of nations.

R. serpentina offers a wide range of beneficial therapeutic effects, with the ability to cure various diseases like psychotic conditions like schizophrenia, anxiety, epilepsy, sleeplessness, and insanity[15]. It is also used as a sedative and hypnotic[16]. According to reports, the plant has a huge amount of indole alkaloids that are therapeutically beneficial, and these alkaloids are primarily found in the roots. *R. serpentina* was mentioned in ancient herbal treatments for different circulatory diseases. Root extracts are prized as anathematics and for treating digestive ailments, particularly diarrhoea and dysentery[17].

They have been used in the combination with other plant extracts to treat fever. The root was advised for use in childbirth because it was thought to stimulate uterine contraction. The resulting alkaloids are frequently utilised in the creation of medicines and have a direct impact on hypertension and anxiety. In addition it cures other illnesses include pneumonia, asthma, AIDS, headaches, some skin conditions like fungal infections and spleen disorders which can also be treated with the reserpine and serpentine[18]. From both predictably increasing the numbers by produced plants with *in vitro* method, the roots and leaves were taken and cleaned under running water for 30 min. The shoot tip explants were cultivated and processed for analysis in vitro method and the received medium were supplemented with 5 mg/l 4,6-D were also employed for alkaloid extraction. A known quantity of roots 100 g were dried to a constant weight in an oven set at 50^{o}C. For the investigation, the dried root is ground into a fine powder in a mixer-grinder. Both the *in vitro* and conventionally produced plants dried plant powdered materials from the various portions were individually extracted with ethanol. Under low pressure, the solvent evaporated in a rotary evaporator at 60^{o}C to produce residues that range from brown to blackish. To get rid of pigments and fatty components, thus by every basic solution obtained by processing was poised in water and obtained solution is added with petroleum ether 100 ml. For each case of plant material, the natural solvents were mixed and vaporise under decreased heat to produce greenish masses. *R. serpentine* root was processed to have an aqueous layer which as divided with the chloroform once obtained, and the chemical that is vaporised under the reduced pressure is collected seperately. The results obtained from the root show a positive for reserpine[18].

ALKALOIDS PRESENT IN *R. serpentina*

Ajmalicine is an alkaloid that has a large variety of uses in healing of circulatory disorders, particularly in restoring normal cerebral blood flow[19]. It influences the smooth muscle functions which helps to stave off strokes, and reduce the blood pressure levels,

especially for the hypertension conditions. The roots of *Rauvolfia serpentina* contains ajmalicine which was taken by most of the pharmaceutical companies will be around 3500 kg is isolated from the roots of *Rauvolfia serpentina*, thus the ajmalicine taken each year from Rauvolfia or Catharanthus species to treat cardiovascular and circulatory disorders. The synthesis of loganin, which is then converted into secoloanin upon oxidation, begins with geraniol and proceeds through iridodial and irdotrial content. This facilitates the creation of the corynanthe type nucleus in the tryptamine, which leads to the production of ajmalicine. The tryptophan is transformed to tryptamine by secologanin, strictosidine, and cathenamine, from which ajmalicine is generated. Cathenamine's conversion to ajmalicine is facilitated by the enzymes tryptophan decarboxylase and NADPH (TDC). The primary enzyme responsible for the synthesis of ajmalicine in Rauvolfia may be decarboxylase. The chemical structure of alkaloids present in *R. serpentine* is represented in Fig. 1.

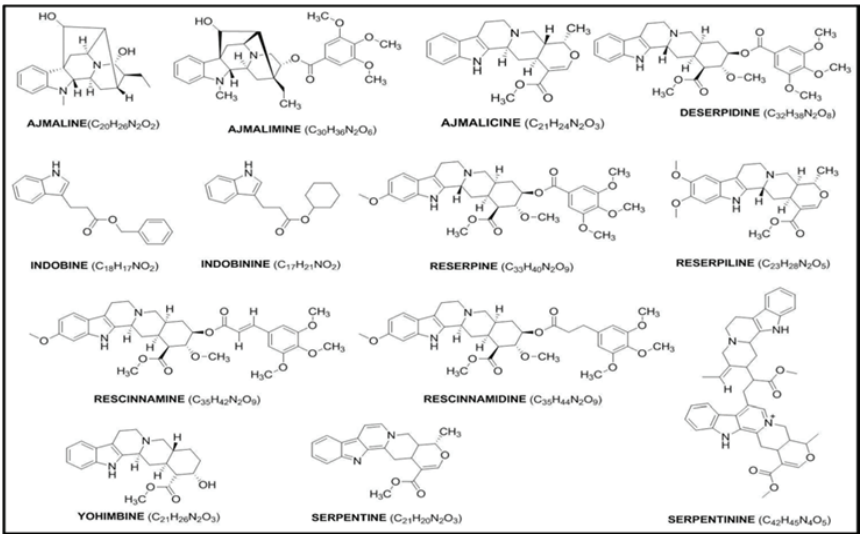

Fig. 1. *R. serpentina* alkaloid's chemical structures

Reserpine is a main compound in lowering blood pressure and the single, pure crystalline alkaloid that is extracted from Rauvolfia roots was first discovered before 70 years (Ref. 20). It is a comparatively little tertiary base that is found in the roots' oleoresin portion and is effective in treating hypertension, cardiovascular ailments, and neurological disorders. Reserpine, an indole derivative of the hydroxyohimbine type from *R. serpentine* root is added with 3,4,5-trimethyl benzoic acid ester of reserpic acid for knowing its effect, is thought to be responsible for the antihypertensive effects of Rauvolfia roots[21]. The most prevalent alkaloid is Reserpine in these roots, it is mostly utilised as a natural tranquilliser in body. Reserpine is now used in pharmacological investigations as well as physiologic studies of how the body works. Reserpine's depressive effects on the central nervous system (CNS) in order to assist

in the conditions like anxiety whereas the peripheral nervous system (PNS) are the cause which have antihypertensive effects to the nerve cell's catecholamine storage vesicles. This stops the serotonin and catecholamines from being normally stored in body and works as a stabiliser when there is a fall in catecholamine levels. By removing the transmitter material from the adrenergic neurons and may be by stimulating the central parasympathetic system, it disrupts the autonomic nervous system's ability to operate. These chemicals primarily regulate peripheral resistance at times not only that it aids in stabilising the cardiac contraction and heart rate. Additionally, it aids in sedation and blood pressure lowering, particularly when hypertension is aggravated by stress and sympathetic nervous system activity[22]. The predicted alkaloid values for the roots of *R. serpentina* are tabulated in Table 3.

Table 3. *Rauwolfia serpentina* alkaloids values

S. No	Alkaloids	ChemSpider value
1	Reserpine	5566
2	Serpentine	21560
3	Ajmaline	10145712
4	Ajmalicine	390541
5	Yohimbine	8622
6	Sarpagine	16736014

Ajmaline is initially extracted the substance from the roots of R. serpentine many decades before for medicinal purpose. It is named in honour of Hakim Ajmal Khan as "ajmaline", one of the most renowned Unani doctors of India. It is a class I antiarrhythmic drug derived from *R. serpentina* roots that is extremely helpful in identifying different Brugada Syndrome patient subgroups and in the diagnosis of this inherited heart condition with various reasons like stress and anxiety. Based on their primary modes of action, these drugs are largely divided into four groups: sodium channel blockers which will be more beneficial in treating the patients with cardiac arrhythmia through supra ventricular tachycardia which is received through irregular signals from heart, symptomatic ventricular premature beats, and prevention of ventricular fibrillation[23]. Thus the procainamide substance found in this compound can be used to treat atrial fibrillation. The beta adrenergic blockers also used for hypertesion, repolarisation prolongation, and the calcium channel blockers are used in conditions, like if calcium enters in cells of arteries and heart it will squeeze the arteries and the blood flow becomes faster by controlling the calcium to enters the arteries the arteries get relaxed and the blood flow becomes normal[24]. The *in vitro* analysis of the alkaloids is tabulated in Table 4.

Table 4. *in vitro* Analysis of *Rauwolfia serpentina* for alkaloids

Source	R. *serpentine* plant material	Reserpine*	Ajmalicine	Other alkaloids
In vitro	Root	+	+	+
	Stem	+	+	+
	Leaf	+	-	-
Raw plant Material				
	Root	+	+	+
	Leaf	+	-	-

*The *Rauwolfia serpentina* results for reserpine (0.96).

The rescinnamine, a pure ester alkaloid of alseroxylon fraction found in *Rauvolfia serpentina*, is pharmacologically and chemically linked to reserpine and has similar applications. Investigation on this was carried around 7 decades before to know the uses of antihypertensive medication to treat hypertension[25]. Clinically speaking, it is a less strong alkaloid than reserpine and does not reduce blood pressure as well[26]. But the rescinnamine present in *Rauvolfia serpentina* blocks the action of peptidyl dipeptidase, an enzyme that catalyses the conversion of angiotensin I into angiotensin II, a vasoconstrictor that increases the release of aldosterone from the adrenal cortex. Angiotensin I can not be converted to angiotensin II because the Angiotensin Converting Enzyme (ACE) is first inhibited. Angiotensin II levels in the plasma are reduced by ACE inhibition. Due to angiotensin II's role as a vasoconstrictor and a mediator of renin activity's negative response, its reduced concentration causes blood pressure drops, baroreceptor reflex mechanisms are activated, and as a result, vasopressor activity and aldosterone secretion decline[27].

CONCLUSIONS

The *in vitro* analysis of *Rauvolfia serpentine* has authenticated this study with the presence of phytochemical components that assist in treating the Cardiovascular Disease and Anxiety. Due to the broad variations in climate and environment, there are many chronic diseases that affect the great number of individuals worldwide[28]. The herbal treatment can be used to treat a variety of ailments with higher cultural acceptance; compatibility with the physical body without side effects, and fewer adverse effects is urgently needed to cure a huge amount of people. Reserpine and ajmalicine of *R. serpentina* play a major role in curing cardiovascular disease[29]. The *in vitro* analysis proves the presence of major chemical components of the roots from *R. serpentina* is a viable Unani herbal medicine used in pharmaceutical industry to meet this requirement. R. serpentine acts as an antioxidant and having antihypertensive effect on consumption. Reserpine proved to be beneficial in treating anxiety and hypertension, likewise ajmalicine as a vasodilator and alstonine has antipsychotic effect. Thus the alkaloids present in *R. serpentina* proved to be helpful in curing cardiovascular disease.

REFERENCES

1. H. M. MOYEENUDIN, S. VIJAYALAKSHMI: The Antihypertensive Effect from Aqueous Extract of *Oxalis corniculata* by *in vitro* Antihypertensive Activity Assay. Research Journal of Pharmacy and Technology (RJPT), **12** (6), 2981 (2019).
2. P. C. Van Den HOOGEN, E. J. FESKENS, et al: The Relation between Blood Pressure and Mortality Due to Coronary Heart Disease among Men in Different Parts of the World. N Engl J Med, **342** (1), 1 (2000).
3. C. CONVERSANO, G. ORRU, A. POZZA, M. MICCOLI, R. CIACCHINI, L. MARCHI, A. GEMIGNANI: Is Mindfulness-based Stress Reduction Effective for People with Hypertension: a Systematic Review and Meta-analysis of 30 Years of Evidence. International Journal of Environmental Research and Public Health (IJERPH), **18** (6), 2882 (2021).
4. THOMAS SEMLITSCH, et al.: Long-term Effects of Weight-reducing Diets in People with Hypertension. Cochrane Database of Systematic Reviews, 2 (2021).
5. DOI: 10.1002/14651858.CD008274.pub4.
6. R. K. SINDHU, A. GOYAL, E. ALGIN YAPAR, S. CAVALU: Bioactive Compounds and Nano Delivery Perspectives for Treatment of Cardiovascular Diseases. Appl Sci, **11** (22), 11031 (2021).
7. DHANPAT MISHRA, BASAVARAJ R. TUBAKI: Effect of *Brahmi vati* and *Sarpagandha Ghana vati* in Management of Essential Hypertension – a Randomized, Double Blind, Clinical Study. Journal of Ayurveda and Integrative Medicine (J-AIM), **10** (4), 269 (2019).
8. GRACY SOKIYA, ABHISHEK BHUSHAN SHARMA, GAURAV SHARMA: An Ayurvedic Exploratory Study of Vyana Vaishamya in Hypertension. World J Pharm Res, **10** (10), 72 (2021). DOI: 10.20959/wjpr202110-20927.
9. S. MONDAL et al.: In Quest of the Mysterious Holistic Vedic Herb *Bacopa monnieri* (L.) Pennell. Pharmacognosy Res, **15**, 3 (2023).
10. A. J. CHERUTH, S. A. Al BALOUSHI, K. KARTHISHWARAN, S. MAQSOOD, S. S. KURUP, S. SAKKIR: Medicinally Active Principles Analysis of *Tephrosia apollinea* (Delile) DC Growing in the United Arab Emirates. BMC Res Notes, **10** (1), 1 (2017).
11. N. P. GURAV, J. J. KADAM, S. M. PANDAV, V. S. MUNAGEKAR, G. H. JADHAV: *In vitro* Efficacy of Different Fungicides and Plant Extracts against *Colletotrichum gloeosporioidespenz* Causing Leaf Blight Disease of Sarpagandha. J Plant Dis Sci, **8** (2), 212 (2013).
12. A. R. BUNKAR: Therapeutic Uses of *Rauwolfia serpentina*. Int J Adv Sci Res, **2** (2), 23 (2017).
13. R. SONI, S. JAISWAL, J. K. BARA, P. SAKSENA: The Use of *Rauwolfia serpentina* in Hypertensive Patients. J Biotechnol Biochem, **2** (5), 28 (2016).
14. A. MALVIYA, R. SASON: The Phytochemical and Pharmacological Properties of Sarpagandha: *Rauwolfia Serpentina*. Ayushdhara, **3** (1), 473 (2016).
15. R. KUMARI, B. RATHI, A. RANI, S. BHATNAGAR: *Rauvolfia serpentina* L. Benth. ex Kurz.: Phytochemical, Pharmacological and Therapeutic Aspects. Int J Pharm Sci Rev Res, **23** (2), 348 (2013).
16. P. LOWINGER: *Rauwolfia se*rpentina in the Control of Anxiety. Psych Quar, **31**, 445 (1957). https://doi.org/10.1007/BF01568739.
17. NAMRATA SHANU GUPTA et al.: Involvement of Nitric Oxide Signal in *Alternaria alternata* Toxin Induced Defense Response in *Rauvolfia serpentina* Benth. ex Kurz calli. Plant Omics, **6** (3), 157 (2013).
18. D. ABHIJIT: Ethnobotanical Aspects of *Rauvolfia serpentina* (L). Benth. ex Kurz. in India, Nepal and Bangladesh. J Med Plants Res, **5** (2), 144 (2011).
19. OSAMU YAMAMOTO, YASUYUKI YAMADA: Production of Reserpine and Its Optimization in Cultured *Rauwolfia serpentina* Benth. Cells. Plant Cell Rep, **5** (1) 50 (1986).
20. MANISHA SINGH: Evaluating the Therapeutic Efficiency and Drug Targeting Ability of Alkaloids Present in *Rauwolfia serpentina*. International Journal of Green Pharmacy (IJGP), **11** (03), (2017).

21. S. BINDU, K. B. RAMESHKUMAR, B. KUMAR, A SINGH, C. ANILKUMAR: Distribution of Reserpine in Rauvolfia Species from India–HPTLC and LC–MS Studies. Ind Crops Prod, **62**, 430 (2014).
22. D. M. PEREIRA, F. FERRERES, J. M. OLIVEIRA, L. GASPAR, J. FARIA et al.: Pharmacological Effects of *Catharanthus roseus* Root Alkaloids in Acetylcholinesterase Inhibition and Cholinergic Neurotransmission. Phytomedicine, **17** (8–9), 646 (2010).
23. N. AFSHEEN, N. JAHAN, M. IJAZ, A. MANZOOR, K. M. KHAN, S. HINA: Cardioprotective and Metabolomic Profiling of Selected Medicinal Plants against Oxidative Stress. Oxid Med Cell Longev, **2018**, (2018).
24. P. CÁZARES-FLORES, D. LEVAC, V. De LUCA: *Rauvolfia serpentina* N-methyltransferases Involved in Ajmaline and Nβ-methylajmaline Biosynthesis Belong to a Gene Family Derived from γ-tocopherol C-methyltransferase. Plant J, **87** (4), 335 (2016).
25. A. RIZZO, C. De ASMUNDIS, P. BRUGADA, M. La MEIR, G. B. CHIERCHIA: Ablation for the Treatment of Brugada Syndrome: Current Status and Future Prospects. Expert Rev Med Devices, **17** (2), 123 (2020).
26. G. S. PANWAR, S. K. GURU: Stimulation of Reserpine Production in the Whole Plant Culture of *Rauwolfia serpentina* L. by Elicitors and Precursor Feeding. J Plant Biochem Biotechnol, **24** (1), 49 (2015).
27. SAIKAT GANTAIT, SUPRABUDDHA KUNDU: Does Synthetic Seed Storage at Higher Temperature Reduce Reserpine Content of *Rauvolfia serpentina* (L.) Benth. ex Kurz. Rendiconti Lincei, **28** (4), 679 (2017).
28. N. JAHAN, F. HUSSIAN, A. R. AYUB, M. ILYAS, M. A. KHAN, R. MANZOOR, W. A. KHAN: Isolation and Characterization of Flavonoids from Roots of *Rauvolfia serpentina* and Evaluation of Their Hypotensive Potential through Angiotensin-converting Enzyme (ACE) Inhibition Mode of Action. Chem Pap, **1**, (2022).
29. S. M. SHAH, S. A. NAQVI, N. MUNIR, S. ZAFAR, M. AKRAM, J. NISAR: Antihypertensive and Antihyperlipidemic Activity of Aqueous Methanolic Extract of *Rauwolfia serpentina* in Albino Rats. Dose-Response (DOS), **18** (3), 1559325820942077 (2020).
30. S. AGRAWAL: *Rauvolfia serpentina*: a Medicinal Plant of Exceptional Qualities. Alt Med Chiropr OA J, **2** (2), 180016 (2019).

Received 5 March 2024
Revised 21March 2024