Research Article

Green Synthesis and Characterization of Silver Nanoparticle Using *Mimosa pudica* Leaves for Anti-Diabetic Activity

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ABSTRACT

The present investigation was carried out for the synthesis of Silver Nanoparticles of *Mimosa pudica* leaf extract by standard Facile green synthesis for Anti diabetic activity. The Characteristics of Silver Nanoparticles of *Mimosa pudica* were studied using X-Ray Diffraction, Scanning Electron Microscope, Energy dispersive X-ray spectroscopy techniques. The crystalline nature of particles was confirmed by the peaks in the X-Ray Diffraction pattern. The size and shape of particles was calculated from Scanning Electron Microscope and the size measured between 20 and 32nm. Energy dispersive X-ray spectrum of nanoparticles was confirmed the presence of elemental silver. The In vitro Antidiabetic activity was carried out by α-amylase inhibition assay. The result showed that 800µg/ml concentration of drug was found to inhibit 50% of α-amylase which was the same as that of the standard Acarbose. Hence the drug has potent antidiabetic activity.

Keywords: Anti-diabetic activity, α-Amylase inhibition assay, *Mimosa pudica*, Silver Nano particles, Standard Acarbose.

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INTRODUCTION

Although some herbal medicines have promising potential and were widely used, many of them remain untested and not scientifically proved. Hence, the present study was to screen the phytochemical and analyze the antidiabetic activity of *Mimosa pudica* extract tagged with *silver nanoparticles*.

Mimosa pudica belongs to the family Mimosaceae is also known as Touch me not plant. It is a stout straggling prostate shrubby plant with the compound leaves sensitive to touch, spinous stipules and globose pinkish flower heads and grows as weed[1].

Figure 1: *Mimosa pudica* Plant

Thottalvadi Chooranam (*Mimosa pudica*) is a Siddha herbal preparation has been studied extensively in recent years for its anti-diabetic in animal models[2].

Mimosa pudica was used for its anti-hyperglycemic[3], anti-diarrheal[4], anti-convulsant[5] and cytotoxic properties [6]. Ethno pharmacologically, the root of this plant has been used for snakebite by traditional and tribal healers[7-11]; stems used against scorpion sting[12].

It also has anti-hepatotoxic, antioxidant and wound healing activities. It has been used in the treatment of urogenital disorders, sinus and wounds[13]. It is very useful in treating diarrhea, amoebic dysentery, bleeding piles and urinary infections[14].

Two well-known movements are observed in *Mimosa pudica*. one is the very rapid movement of the leaves when it is stimulated by touch, heat etc., and the other is the very slow, periodical movement of the leaves called nyctinastic movement which is controlled by a biological clock[15]. The movement is caused by a rapid loss of pressure in strategically situated cells that cause the leaves to droop right before one's eyes.

Roots of *Mimosa pudica* was reported to contain alkaloids, glycosides, flavonoids and tannins[16]. Seeds contains d-xylose and d-glucuronic acid. It contains Mimosine[17-18] which is a toxic alkaloid. The plant was reported to contain tubuline and a new class phytohormone turgorines is found to be active in the plant. The periodic leaf movement factors are the derivatives of 4-α-(b-D-glucopyranosyl-6-sulphate) gallic acid.

Phytochemical studies on *Mimosa pudica* have revealed the presence of alkaloids, fatty acids, non-protein amino acid[19,20], flavonoids, C-glycosides, sterols, terpenoids, and

tannins[21]. It has antiviral properties, aphrodisiac properties, antimicrobial properties, diuretic effect etc[22,23].

Hence, the present study was aimed with an effective approach of synthesizing silver nanoparticles using leaves of *Mimosa pudica* as a reducing agent and to study the characterization of silver nanoparticles of *Mimosa pudica* leaf extract and its inhibitory effect against α-amylase.

Nano, a scientific term used for determining the size of the particle[24]. Nanotechnology, a concept in the field of science and technology, in recent years, has also been likely to grow based on their demand, like other technologies. Nanoparticles are usually a cluster of atoms ranging between 1-100nm in size and they exhibit new properties based on their size, distribution and morphology [25]. Many materials are synthesized in Nano size for various applications including medicine, mechanical, biomedical electronics[26-27].

Metals are commonly used for synthesis of nanoparticles by chemical and biological methods. The chemical method usually involves use of chemicals for synthesis of nanoparticles which makes them certainly unsuitable against any application as it contains toxic compounds. Some chemical methods cannot avoid the use of chemicals, therefore use of noble metals like silver are into practice for synthesis of nanoparticles.

An alternative, eco-friendly and advantageous approach to chemical method is the biological method *Synthesis of nanoparticles by biological method is through microbes like Aspergillus flavus[28], Phoma exigua*[29], *Pseudomonas* spp[30] and plant sources such as *Chenopodium album*[31], *Acalypha indica*[32], *Diopyros kaki*[33], *Cynodon dactylon*[34], Glycyrrhiza glabra[35], *Nigella satia*, etc. By modifying the shape and reducing the size up to 100nm, it is possible to increase the properties of the source material against various applications[36].

In Ayurvedic and Unani medicine, *Mimosa pudica* root is used to treat bilious fevers, piles, jaundice, leprosy, dysentery, vaginal and uterine complaints, inflammations, burning sensation, fatigue, asthma, leucoderma and blood diseases. In Western medicine, Mimosa root is used for treating insomnia, irritability, premenstrual syndrome (PMS), menorrhagia, hemorrhoids, skin wounds, and diarrhea. It is also used to treat whooping cough and fevers in children, and there is some evidence to suggest that Mimosa is effective in relieving the symptoms of rheumatoid arthritis[37].

MATERIALS AND METHODS

Collection of plant materials

The leaves of the plant *Mimosa pudica* were collected from Siruseri (Sipcot), Navalur, Chennai on May, 2017.

The plant material was identified and authenticated by Professor Dr. J. Jayaraman, Ph.D. Director, Plant Anatomy Research Center, West Tambaram, Chennai. A voucher specimen was submitted at C. L. Baid Metha College of Pharmacy, Chennai-97.

Phytochemical screening studies

The chemical tests for various phyto constituents like alkaloids, flavonoids, saponins, phenols, terpenoids, anthraquinone, proteins and amino acids, carbohydrates and glycosides etc. were carried out and the results were recorded.

Biosynthesis of Silver Nanoparticles of *Mimosa pudica*:

10 grams of finely powdered leaves were mixed with 100 ml of deionized water and boiled for 30 minutes, cooled and filtered through Whatmann filter paper no.1. The extract was used freshly within an hour. 40 mL of *Mimosa pudica* leaf aqueous broth was added to 60 ml of 1 mM aqueous $AgNO_3$ solution and the solution was placed in an orbital shaker at room temperature, for reduction of Ag+ to SNPs. The bio-reduction of the silver ions in the solution was monitored periodically by measuring the UV–Vis spectroscopy of the solutions. The reaction is rapid if the brown color appears within 10 minutes and this reaction will confirm the formation of SNPs. The different concentration of $AgNO_3$ solution was used to get maximum SNPs. The SNPs obtained from the solution were purified by repeated centrifugation at 2000 rpm for 10 minutes followed by the dispersion of the pellet thrice in deionized water to remove the water-soluble biomolecules such as proteins and secondary metabolites. The water-suspended NPs were kept under vacuum for 24 hours to dry the NPs[38].

Characterization of Silver Nanoparticles of *Mimosa pudica*:

The UV absorbance of the synthesized NPs was measured in CYBERLAB UV-100 spectrophotometer operated at a resolution of 1 nm. The synthesized NPs were dried, powdered and used for X-ray diffraction (XRD) analysis. Scanning electron microscopy (SEM) images were acquired by ICON ANALYTICAL, QUANTA 200. X-ray diffraction analysis (SPECTRIS TECHNOLOGIESPANalytical, X' Pert PRO) was performed by preparing a thin film of powdered SNPs. To study the average particle size distribution and stability of nanoparticles, an ICON ANALYTICAL, Genesis XM4 instrument was used[39].

In vitro anti-diabetic activity

α- Amylase inhibition assay

α-amylase was dissolved in phosphate buffer saline (PBS, 0.02 mol/L, pH 6.8) at a concentration of 0.1 mg/mL. Various concentrations of sample solutions (0.25 mL) were mixed with α-amylase solution (0.25 mL) and incubated at 37°C for 5 minutes. Then the reaction was initiated by adding 0.5 mL 1.0% (w/v) starch substrate solution to the incubation medium. After incubation at 37°C for 3 minutes, the reaction was stopped by adding 0.5 mL DNS reagent (1% Dinitrosalicylic acid, 0.05% Na_2SO_3 and 1% NaOH solution) to the reaction mixture and boiling at 100°C for 5 minutes. After cooling to room temperature, the

absorbance (Abs) at 540 nm was recorded by a spectrophotometer. The inhibition percentage was calculated by the following equation:

$$\text{Inhibition (\%)} = [(Abs1 - Abs2)/Abs1] \times 100$$

Where,

Abs1=sample and Abs2 = control[40].

The SNPs were synthesized using *Mimosa pudica* leaf extract by the method described earlier. On mixing the leaf aqueous extract with silver nitrate solution, the color of the mixture was found to be changed into reddish brown from yellowish color. The color change indicated the reduction of silver nitrate into silver ions that was resulted in the formation of SNPs. The depicts the absorbance spectrum of reaction mixture containing aqueous silver solution (1Mm) and *Mimosa pudica* broth (prepared from 10 g plant powder). The absorption spectrum obtained from the synthesized SNPs within 10 minutes was to examine the Surface Plasmon resonance (SPR). The peak which obtained at the bio-reduction of silver ions was found to be 427nm. On adding the after mentioned plant broth to $AgNO_3$ solution, the solution changed from greenish yellow to brown color, the reason employed for the spectra under the wavelength of 200 to 800nm. The final color turns into deep brownish with passage of time. The intensity of the absorbance was found to increase as the reaction proceeded further. The strong and narrow diffraction peaks indicates that the product has well crystallized. The XRD peaks at 32.06°, 46.25°, 67.52° and 76.79° can be indexed to the (100), (200), (220), and (311) Bragg's reflections of cubic structure of silver respectively. The broadening of Bragg's peaks indicates the formation of nanoparticles. SNPs with controllable size and uniform shape can be easily obtained in the simple aqueous reduction method. The mean size of SNPs was calculated using the Debye–Scherrer's equation by determining the width of the (1 1 1) Bragg's reflection. The crystalline size was calculated from the width of the XRD peaks, assuming that they are free from non-uniform strains, using the Scherrer formula.

RESULTS AND DISCUSSION

Phytochemical screening studies

Table 1: Observations of Phytochemical screening studies.

S.NO	Phytochemicals	Water	Methanol	Ethanol	Acetone	Ethyl acetate	Chloroform	Petroleum ether
1	Alkaloids	-	-	-	-	-	-	-
2	Cardiac Glycosides	-	+	+	+	-	-	-
3	Carbohydrates	+	+	+	+	+	+	+
4	Flavonoids	-	+	+	+	-	-	-
5	Phenols	-	+	+	+	-	-	-
6	Phlobatannins	-	-	-	-	-	-	-
7	Proteins	-	-	-	-	-	-	-
8	Saponins	-	-	-	-	-	-	+
9	Sterols	-	-	-	-	-	-	-
10	Tannins	+	+	-	-	-	-	-
11	Terpenoids	-	+	+	+	+	+	-
12	Quinones	-	-	-	-	-	-	-
13	Oxalates	-	-	-	-	-	-	-

"+" ve indicates the presence of the constituent; "-" ve indicates the absence of the constituent

Characterization of silver nanoparticles

SEM Spectrum Analysis

The SEM micrograph of *Mimosa pudica* – AgNPs image clearly indicated the presence of spherical particles with size ranges between 20 and 32 nm.

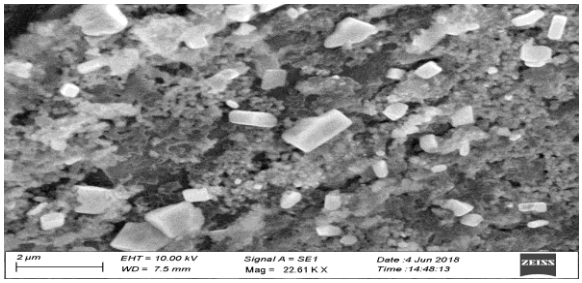


Figure 2: SEM images of *Mimosa pudica* – AgNPs

EDX Spectrum Analysis

The energy dispersive X-ray spectroscopy (EDX) analysis of *Mimosa pudica* AgNPs confirmed the presence of elemental silver as the major constituent.

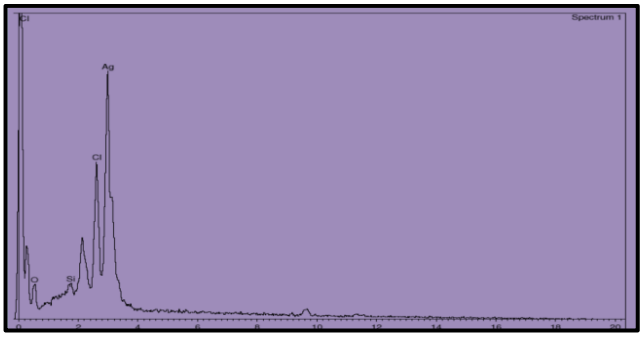


Figure 3: EDX spectrum of *Mimosa pudica* – AgNP

XRD Analysis

The X-Ray Diffraction studies of *Mimosa pudica* – AgNPs clearly interpreted the structure of the synthesized nanoparticles.

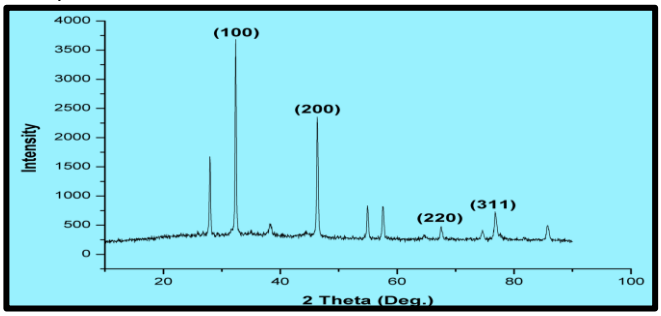


Figure 4: X-ray diffraction pattern of *Mimosa pudica* – AgNPs

***In vitro* antidiabetic activity**

Table 2: *In vitro* antidiabetic activity of *Mimosa pudica* by α – amylase inhibition assay

Concentration (in µg)	MPN (% Inhibition)	Acarbose (% Inhibition)
50	17.53	12.89
100	20.33	22.95
200	33.40	27.30
400	45.75	40.75
800	51.70	53.31
1600	58.60	64.84

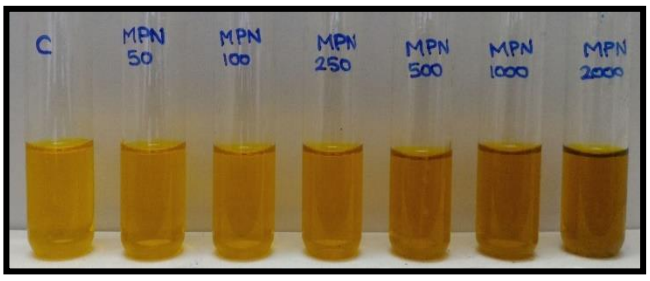
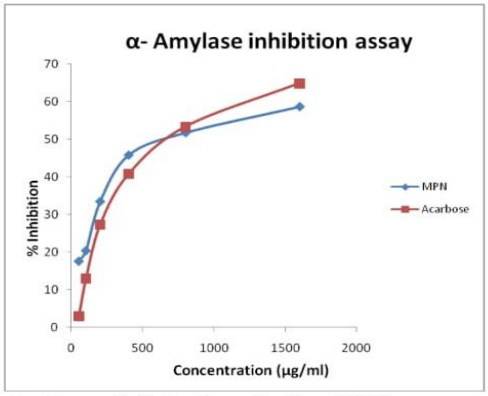


Figure 5: α – amylase assay of synthesized *silver nanoparticles* of *Mimosa pudica* extract.



Graph 1: *Invitro* antidiabetic activity of *Mimosa pudica* by α – amylase assay.

DISCUSSION

The *Mimosa pudica* leaf was collected, authenticated, pulverized and tested for phytochemical studies. Different solvents like Petroleum ether, Chloroform, Ethyl acetate, Acetone, Ethanol, Methanol and Water were macerated, Phytoconstituents like Cardiac glycosides, Carbohydrates, Flavonoids, Phenols, Tannins and Terpenoids were found in the leaves.

Silver nanoparticles were synthesized using *Mimosa pudica* leaf by standard method, further it was characterized by Scanning Electron Microscope (SEM), X-Ray Diffraction (XRD) and Energy Dispersive X-ray Spectroscopy (EDX). Silver nanoparticles tagged with *Mimosa pudica* was confirmed by above all techniques.

The In vitro antidiabetic activity was carried out for the synthesized silver nanoparticles of *Mimosa pudica* extract by α-amylase inhibition assay. The IC_{50} value of the given sample (MPN) was 689.6 µg/ml and the standard drug (Acarbose) was 725.96µg/ml. The result showed that 800µg/ml concentration of drug was found to inhibit 50% of

α-amylase which was the same as that of the standard Acarbose. This proves that the drug has potent antidiabetic activity.

CONCLUSION

In present days, herbal medicine plays major roles in health care system all over the world. This made us to explore the traditional medicinal plant *Mimosa pudica* leaf for antidiabetic activity by synthesizing with silver nanoparticles.

Review of literature showed the presence of many bioactive components such as flavonoids, glycosides, phenols, tannins, etc. and many pharmacological activities like antidepressant, antimicrobial, anti-hepatotoxic, antiulcer, etc. Thus, the present study was to investigate the phytochemicals, synthesize nanoparticles and characterize the nanoparticles and evaluate anti-diabetic activity.

The preliminary phytochemical screening of *Mimosa pudica* leaf extract showed the presence of bioactive components

terpenoids, flavonoids, glycosides, alkaloids, phenols and tannins.

Silver nanoparticles were synthesized using *Mimosa pudica* leaves by standard method and characterized by Scanning Electron Microscope (SEM), X-Ray Diffraction (XRD) and Energy Dispersive X-ray Spectroscopy (EDX). These studies confirmed the *Mimosa pudica* silver nanoparticles tagging.

By α-amylase activity, it was proven that Silver nanoparticles tagged with *Mimosa pudica* have potent antidiabetic activity.

Hence, this green synthesis will be further tested for different pharmacological activities and the dose will be standardized for human consumption.

REFERENCES

1. Hafsa Ahmad, Sakshi Sehgal, Anurag Mishra, Rajiv Gupta, Mimosa pudica L. (Laajvanti): An overview, Pharmacognosy Reviews, 6(12), 2012, 115–124. DOI: 10.4103/0973-7847.9994
2. Vaidyaratanm P.S., Indian medicinal plants database, 1st edn, Orient Longman, Arya Vidyashala, Kottakkal, II, 2001, 36-37.
3. Kamalakkannan N, Prince PS. Antihyperglycaemic and antioxidant effect of rutin, a polyphenolic flavonoid, in streptozotocin-induced diabetic wistar rats. Basic Clinical Pharmacology and Toxicology, 98(1), 2006, 97-103.

   DOi: 10.1111/j.1742-7843.2006.pto_241.x.PMID: 16433898
4. Md. Saifuddin Khalid, Shah Jinesh Kumar, Suresh D K , Rajnish Kumar Singh, Narasimha Reddy I V, Sunil Kumar, Evaluation of Anti-diarrhoeal potential of ethanolic extract of Mimosa pudica leaves, International Journal of Green Pharmacy, 5(1), 2011, 75-78.

   DOI: http://dx.doi.org/10.22377/ijgp.v5i1.179
5. Bum D, Dawack D L, Schmutz M, Rakotonirina A, Rakotonirina S V, Portet C, Jeker A, Roilpe H, Herrling P, Anticonvulsant activity of Mimosa pudica decoction, Fitoterapia 75(3–4), 2004, 309-314.

   DOI: https://doi.org/10.1016/j.fitote.2004.01.012
6. Sadia Afreen Chowdhury, Jannatul Islam, Md. MahfujurRahaman, Md. Mostafizur Rahman, Nowshin Nowaz Rumzhum, Rebeka Sultana, Nazma Parvin, Cytotoxicity, Antimicrobial and Antioxidant Studies of the Different Plant Parts of Mimosa Pudica, Stamford Journal of Pharmaceutical Sciences, 1(1), 2008, 80-84.

   DOI: https://doi.org/10.3329/sjps.v1i1.1813
7. Kirtikar K K, Basu B D, Indian Medicinal Plants, second ed. Lalit Mohan Publication, India, 1980; 2650.
8. Meenatchi sundaram, Subramani, Priyagrace, Selvin, Vijayaraghavan, Ramasamy, Velmurugan, Ambikapathi, Parameswari, Govindarajan, Michael, Antonysamy, Antitoxin activity of Mimosa pudica root extracts against Naja naja and Bangarus caerulus venoms, Bangladesh Journal of Pharmacology, 4 (2), 2009, 105-10. DOI: 10.3329/bjp.v4i2.2276
9. Sia F Y, Vejayan J, Jamuna A, Ambu S, Efficacy of tannins from Mimosa pudica and tannic acid in neutralizing cobra (Naja kaouthia) venom, Journal of Venomous Animals and Toxins including Tropical Diseases, 17 (1), 2011, 42-48.

   DOI: http://dx.doi.org/10.1590/S1678-91992011000100006
10. Vijaya Lakshmi, Lakshmi T, Anti venom activity of Traditional herbal drugs: An Update, International Research Journal of Pharmacy, 4(9), 2013, 1-3.

    DOI: http://dx.doi.org/10.7897/2230-8407.04901
11. Ghosh V Upasani, Vishal G Beldar, Anil U Tatiya, Upasani M S, Sanjay J Surana, Divyata S Patilb, Ethnomedicinal plants used for snakebite in India: a brief overview, Integrative Medicine Research, 6(2), 2017, 114-130.

    DOI: https://doi.org/10.1016/j.imr.2017.03.001
12. Patwari, B, A glossary of medicinal plants of Assam and Meghalaya, B. Patwari, 1992, 531.
13. Dnyaneshwar D Kokane, Rahul Y More, Mandar B Kale, Minakshi N Nehete, Prachi C Mehendale, Chhaya H Gadgoli , Evaluation of wound healing activity of root of Mimosa pudica, Journal of Ethnopharmacology, 124(2), 2009, 311–315.

    DOI: 10.1016/j.jep.2009.04.038
14. Bhagirath S Chauhan, David E Johnson, Germination, emergence, and dormancy of Mimosa pudica, Weed Biology and Management, 9(1), 2009, 38-45

    DOI: https://doi.org/10.1111/j.1445-6664.2008.00316.x
15. Minoru Ueda, Noboru Takada, Shosuke Yamamura, Molecular Approach to the Nyctinastic Movement of the Plant Controlled by a Biological Clock, International Journal of Molecular Sciences, 2(4), 2001, 156-164.

    DOI: https://doi.org/10.1016/S0040-4020(99)00619-5
16. Muhammad Gulzar, Hussain, Muhammad Ajaz, Jantan, Ibrahim, Bukhari, Syed Nasir Abba, Mimosa pudica L., a High-Value Medicinal Plant as a Source of Bioactives for Pharmaceuticals, Comprehensive Reviews in Food Science and Food Safety , 15(2), 2016, 303-315.

    DOI: https://doi.org/10.1111/1541-4337.12184
17. Jing Zhang, Ke Yuan, Wen-long Zhou, Jian Zhou, Ping Yang, Studies on the active components and antioxidant activities of the extracts of Mimosa pudica

Linn. from southern China, Pharmacognosy Magazine, 7(25), 2011, 35-39.

DOI: 10.4103/0973-1296.75899

18. Ahamefula Anselm Ahuchaogu, Okoronkwo Joseph Chukwu, Obike A I, Tochukwu ugonna oha, John Bull Onyekachi Echeme, Quantitative Determination of Secondary Metabolites and Antibacterial Activity of Mimosa Pudica, International Journal of Medicinal Plants and Natural Products, 3(2), 2017, 1-5.

DOI: http://dx.doi.org/10.20431/2454-7999.0302001

19. Baby Joseph, Jency George, Jeevitha Mohan, Pharmacology and Traditional Uses of Mimosa pudica, International Journal of Pharmaceutical Sciences and Drug Research, 5(2), 2013, 41-44.

DOI:
http://ijpsdr.com/index.php/ijpsdr/article/view/239

20. Abdullahi Hassan N, Karunakaran R, Abdulmumin S, A Review on the Pharmacological and Traditional Properties Of Mimosa Pudica, International Journal of Pharmacy and Pharmaceutical Sciences, 11(3), 2019, 12-16. DOI: 10.22159/ijpps.2019v11i3.30452.

21. Pratap Chandran R, Deepak V, Sai Krishna, Saniya Fathima, Ameena Thaha, Jeenitha Raj, Analysis of Phytochemical Constituents and Anthelmintic Activity of Leaf Extracts of Mimosa pudica L, Asian Journal of Biomedical and Pharmaceutical Sciences 8(65), 2018, 1-5. DOI: 10.4066/2249-622X.65.18-614

22. Gohil Kashmira J, Lawar Mayuri A, Shende Varsha M, A Comprehensive Review on 'Mimosa pudica': A Potential Herbal Panacea, Journal of Biologically Active Products from Nature, 1(5-6), 2011, 285-292.

DOI:
https://doi.org/10.1080/22311866.2011.10719096

23. Kshema Johnson, Gopinathan Narasimhan, Chitra Krishnan, Mimosa pudica Linn- A shyness Princess: A Review of its Plant movement, Active constituents, uses and Pharmacological activity, International Journal of Pharmaceutical Sciences and Research, 5(12), 2014, 5104-5118.

DOI: 10.13040/IJPSR.0975-8232.5(12).5104-18

24. Albrecht M A, Evans C W, Raston C L, Green chemistry and the health implications of nanoparticles, Green Chemistry 8(5), 2006, 417– 432.

DOI: 10.1039/b517131h

25. Satyavani K, Gurudeeban S, Ramanathan T, Balasubramanian T, Biomedical potential of silver nanoparticles synthesized from calli cells of Citrullus colocynthis (L.) Schrad leaves, Journal of Nanobiotechnology, 9(43), 2011, 1-8.

DOI: 10.1186/1477-3155-9-43.

26. Kalishwaralal Kalimuthu , Ramkumarpandian Suresh Babu, Deepak Venkataraman, Mohd Bilal, Sangiliyandi Gurunathan, Biosynthesis of silver nanocrystals by Bacillus licheniformis, Colloids and Surfaces B: Biointerfaces, 65(1), 2008, 150-153.

DOI: 10.1016/j.colsurfb.2008.02.018

27. Smitha S L, Nissamudeen K M, Daizy Philip, Gopchandran K G, Studies on surface plasmon resonance and photoluminescence of silver nanoparticles, Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 71(1), 2008, 186-190.

DOI: 10.1016/j.saa.2007.12.002

28. Vigneshwaran N, Ashtaputre N M, Varadarajan P V, NachaneK R P, Paralikar M, Balasubramanya R, Biological synthesis of silver nanoparticles using the fungus Aspergillus flavus, 61(6), 2007, 1413-1418

DOI: https://doi.org/10.1016/j.matlet.2006.07.042

29. Sourish Karmakar, Subir Kundu, Kanika Kundu, Bioconversion of Silver Salt into Silver Nanoparticles Using Different Microorganisms, Artificial Cells, Blood Substitutes, and Biotechnology, 38(5), 2010, 259-266.

DOI: https://doi.org/10.3109/10731199.2010.488633

30. Baker Syed, Nagendra Prasad M N, Dhananjaya B L, Mohan Kumar K, Yallappa S, Satish S, Synthesis of silver nanoparticles by endosymbiont Pseudomonas fluorescens CA 417 and their bactericidal activity, Enzyme and Microbial Technology, 95(2), 2016, 128-136.

DOI: https://doi.org/10.1016/j.enzmictec.2016.10.004

31. Amarendra Dhar Dwivedi, Krishna Gopal, Biosynthesis of silver and gold nanoparticles using Chenopodium album leaf extract, Colloids and Surfaces A Physicochemical and Engineering Aspects, 369(1), 2010, 27-33. DOI: 10.1016/j.colsurfa.2010.07.020

32. Krishnaraj C, Jagan E G, Rajasekar S, Selvakumar P, Kalaichelvan P T, Mohan N, Synthesis of silver nanoparticles using Acalypha indica leaf extracts and its antibacterial activity against water borne pathogens, Colloids and Surfaces B: Biointerfaces, 76(1), 2010, 50-56. DOI: 10.1016/j.colsurfb.2009.10.008

33. Jae Yong Song, Beom Soo Kim, Biological synthesis of bimetallic Au/Ag nanoparticles using Persimmon (Diopyros kaki) leaf extract, Korean J. Chem. Eng., 25(4), 2008, 808-811 .

DOI:10.1007/S11814-008-0133-Z

34. Sharma R K,Tahiliani S, Jain N, Priyadarshi R, Chhangani S, Purohit S D, Joshi, Prachi, Cynodon dactylon Leaf Extract Assisted Green Synthesis of Silver Nanoparticles and Their Anti-Microbial Activity, Source: Advanced Science, Engineering and Medicine, 5(80), 2013, 858-863

DOI: https://doi.org/10.1166/asem.2013.1352

35. Sree lakshmy V, Deepa M K, Mridula P, Green Synthesis of Silver Nanoparticles from Glycyrrhiza glabra Root Extract for the Treatment of Gastric Ulcer, Journal of Developing Drugs, 5(2), 2016, 1-5.

    DOI: 10.4172/2329-6631.1000152

36. Naheed Ahmad, Seema Sharma, Md. K Alama, Singh V N, Shamsid S F, Mehta B R, Anjum Fatma, Rapid synthesis of silver nanoparticles using dried medicinal plant of basil, Colloids and surfaces B: Biointerfaces, 81(1), 2010, 81-86.

    DOI: 10.1016/j.colsurfb.2010.06.029

37. Gohil Kashmira J, Lawar Mayuri A , Shende Varsha M, A Comprehensive Review on 'Mimosa pudica': A Potential Herbal Panacea, Journal of Biologically Active Products from Nature, 1(5-6), 2011, 285-292.

    DOI: https://doi.org/10.1080/22311866.2011.10719096

38. Chidambaram Jayaseelan, Abdul Rahuman, Govindasamy Rajakumar, Arivarasan Vishnu Kirthi, Thirunavukkarasu Santhoshkumar, Sampath Marimuthu, Asokan Bagavan, Chinnaperumal Kamaraj, Abdul Abduz Zahir, Gandhi Elango, Synthesis of pediculocidal and larvicidal silver nanoparticles by leaf extract from heartleaf moonseed plant, Tinospora cordifolia Miers, Parasitology Research, 109(1), 2011, 185-194. DOI: 10.1007/s00436-010-2242-y

39. Renu Sankar , Arunachalam Karthik, Annamalai Prabu, Selvaraju Karthik, Kanchi Subramanian, Shivashangari, Vilwanathan Ravikumar, Origanum vulgare mediated biosynthesis of silver nanoparticles for its antibacterial and anticancer activity, Colloids and Surfaces B: Biointerfaces, 108(1), 2013, 80-84.

    DOI: 10.1016/j.colsurfb.2013.02.033 PMID: 23537829

40. Qunqin Fei, Yuan Gao, Xin Zhang, Yi Sun, Bing Hu, Li Zhou, Saqib Jabbar, and Xiaoxiong Zeng, Effects of Oolong Tea Polyphenols, EGCG, and EGCG3 Me on Pancreatic α-Amylase Activity in Vitro, Journal of Agricultural and Food Chemistry, 62(39), 2014, 9507−9514.

    DOI: https://doi.org/10.1021/jf5032907

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