



Ashwagandha (*Withania somnifera*) Bioactive Compounds Targeting Serotonin Receptors for Antidepressant Properties: Molecular Docking Analysis Prospects

Madhumithra M* ¹, Nandhini.S ², Gishmi.G ³, Sulochana.V ⁴, Umamageshwari G ⁵, Parthasarathi K V ⁶, Rathinavel G⁷, Rajeshwari.M.K⁸

K.S.Rangasamy College of Pharmacy, Namakkal, 637 215, Tamil Nadu, India.
The Tamilnadu Dr.M.G.R Medical University, Chennai, India.

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ABSTRACT

Introduction: The traditional herb ashwagandha (*Withania somnifera*) has been shown to have antidepressant properties, which has prompted research into how its bioactive molecules interact with serotonin receptors, which are essential for managing depression. **Aim and Objectives:** The goal of the study is to determine whether ashwagandha has antidepressant properties by analyzing how its components interact with serotonin receptors. By combining traditional use with contemporary pharmacology and providing insights into the benefits of ashwagandha for mental health, the goal is to clarify the molecular mechanisms behind its therapeutic actions on serotonin pathways. **Methodology:** The study evaluated the binding affinities of Ashwagandha's ligands (LIG01-LIG10) with serotonin receptors using molecular docking methodology. **Conclusions:** Ashwagandha's bioactive compounds, particularly LIG05, show promise as natural antidepressants by modulating serotonin pathways. The findings suggest Ashwagandha may contribute to holistic mental health management. Larger-scale studies are necessary to establish standardized dosing and confirm long-term efficacy and safety, warranting continued exploration for novel therapeutic approaches.

Keywords: LIG05, *Withania somnifera*, serotonin receptors, molecular docking, antidepressants, bioactive substances, and ashwagandha.

I. INTRODUCTION

Depression is a widespread mental illness marked by enduring melancholy, hopelessness, and a loss of enjoyment or interest in day-to-day activities ^[1]. It has a substantial impact on emotional, physical, and cognitive performance and goes beyond transient mood swings. Depression has many different causes, from psychological stresses including trauma, long-term stress, and negative thought patterns to biological variables like neurotransmitter imbalances and genetic predispositions ^[2]. Environmental elements like financial hardships, social isolation, and important life transitions also have a big impact. Fatigue, insomnia, trouble focusing, and recurrent thoughts of suicide or death are only a few of the symptoms of depression ^[3]. Its effects go beyond the individual; it strains relationships, lowers productivity, and adds to financial responsibilities. Although depression is a severe illness, it can be effectively treated with psychotherapy, medication, lifestyle modifications, and complementary therapies such as ashwagandha ^[4]. In order to assist people manage and recover from depression and promote a road to mental health and well-being, it is essential to increase awareness, cultivate compassion, and support prompt intervention.

The effects of serotonin, a neurotransmitter involved in mood regulation, sleep, hunger, and cognition, are mediated by serotonin receptors, also called 5-hydroxytryptamine (5-HT) receptors, which are essential parts of the central and peripheral nervous systems ^[5]. These receptors are divided into seven primary groups (5-HT1 to 5-HT7), each of which has subtypes that carry out different bodily activities. For example, 5-HT2A receptors are connected to perception and cognition, whereas 5-HT1A receptors are linked to anxiety and mood control ^[6]. Serotonin receptor dysregulation is a major target for therapeutic therapies like antidepressants and antipsychotics since it is intimately associated with mental health conditions like depression, anxiety, and schizophrenia ^[7].

Through its bioactive constituents, especially withanolides, ashwagandha (*Withania somnifera*), a beloved herb in Ayurvedic medicine, has demonstrated potential in regulating serotonin pathways ^[8]. These substances interact with serotonin receptors, such as 5-HT1A and 5-HT2A, exhibiting substantial binding affinities that may increase serotonin activity, according to molecular docking studies ^[9]. This method is consistent with the traditional usage of ashwagandha for mood enhancement and stress reduction. Furthermore, the adaptogenic qualities of ashwagandha enhance serotonin homeostasis and lower cortisol levels via regulating the

hypothalamic-pituitary-adrenal (HPA) axis [10]. By addressing oxidative stress and inflammation, which can impede serotonin receptor function, its antioxidant and anti-inflammatory properties further support neuroprotection [11].

Ashwagandha's potential as a natural antidepressant and anxiolytic is highlighted by its capacity to affect serotonin receptors. Although encouraging, more clinical research is required to confirm its effectiveness and set standard dosages. Ashwagandha's interaction with serotonin receptors, which are essential for mental health, provides a comprehensive strategy for treating mood disorders and improving general wellbeing.

CAUSES AND EPIDEMIOLOGY OF DEPRESSION

Overall, the comparison shows that although biological and psychological variables predominate, environmental and lifestyle factors can also have a substantial impact on the incidence of depression. This highlights the necessity of a thorough, multifaceted approach to preventative and therapeutic measures [12, 13].

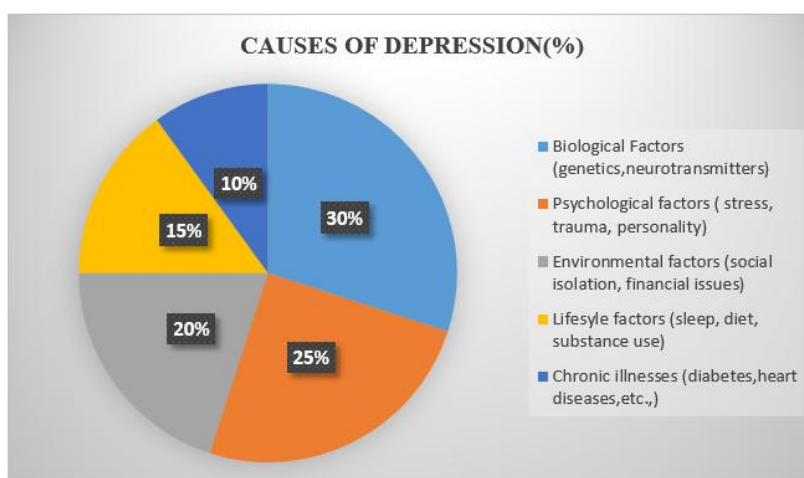


Figure 01: Statistical representation of the major causes of depression based on biological, psychological, environmental, lifestyle, and health-related factors.

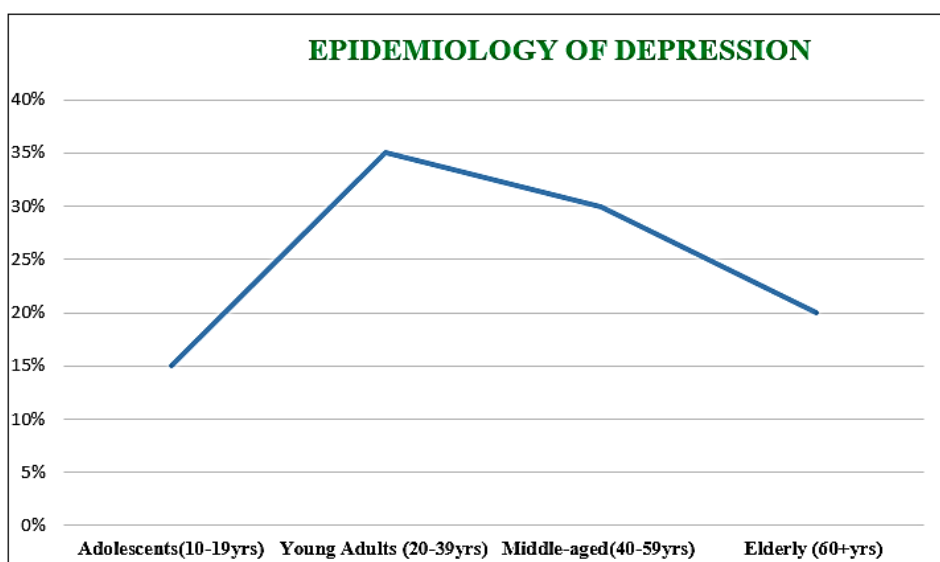


Figure02: Epidemiology of depression based on the age group

The frequency of depression varies greatly throughout age groups. It peaks in young adults (35%) but is comparatively lower in adolescents (15%), suggesting increased vulnerability at this period of life. The elderly population sees a further reduction to 20%,



while the middle-aged group shows a modest decline to 30%. Given that young and middle-aged persons are more likely to experience depression, these patterns emphasize the significance of focused mental health interventions ^[14, 15].

SYNONYMS

- ✓ *Physalis somnifera* Linn.
- ✓ *Withania kansuensis* Kuang and A. M. Lu
- ✓ *Withania microphysalis* Suess. ^[16].

VERNACULAR NAMES

- ✓ Bengali- Ashwagandha
- ✓ Eng.-Winter Cherry,
- ✓ Indian Ginseng
- ✓ Gujarati-Asundha, Ghodaasoda
- ✓ Hindi-Asgund, Panir
- ✓ Malayalam-Amukkiram, Pevetti
- ✓ Marathi-Asgund, Asvagandha
- ✓ Odia-Aswagandha
- ✓ Punjabi-Ak, Aksan, Asgund, Asgund Nagori, Isgand
- ✓ Tamil-Amukkasi, Ashuhan
- ✓ Telgu-Ashwagandha
- ✓ Urdu-Asgandhu, Gaori ^[16].

Chemical Constituents

Ashwagandha leaves and roots were extracted using methanol, hexane, and diethyl ether. The percentage of alkaloids in roots varies between 0.13 and 0.31%. *Withania somnifera*'s roots have sedative, narcotic, alterative, aphrodisiac, deobstruent, diuretic, and restorative properties.

Alkaloids and steroidal lactones are responsible for the root's pharmacological action. Although substantially higher yields (up to 4.3%) have been reported elsewhere, the total alkaloid content in the roots of Indian varieties has been reported to vary between 0.13 and 0.3. Choline, tropanol, pseudotropanol, cuscohygrine, 3-tigloyloxytropanol, isopelletierine, and various other steroidal lactones are among the several biochemical heterogeneous alkaloids. From the plant's roots, twelve alkaloids, thirty-five withanolides, and a number of saponins have been identified and examined.

Withanolide, a physiologically active component having a glucose molecule at carbon, is a saponin. Withaferin A and withanolide D are the two primary withanolides responsible for the pharmacological action of Indian ginseng. According to reports, leaves contain the medicinally active withanolide withaferin-A. Alkaloids are said to be present in the roots along with starch, reducing sugars, glycosides, dulcitol, withancil, an acid, and a neutral substance. Aspartic acid, glycine, tyrosine, alanine, glutamic acid, and cysteine are among the amino acids that have been identified from the roots. ^[17, 18].

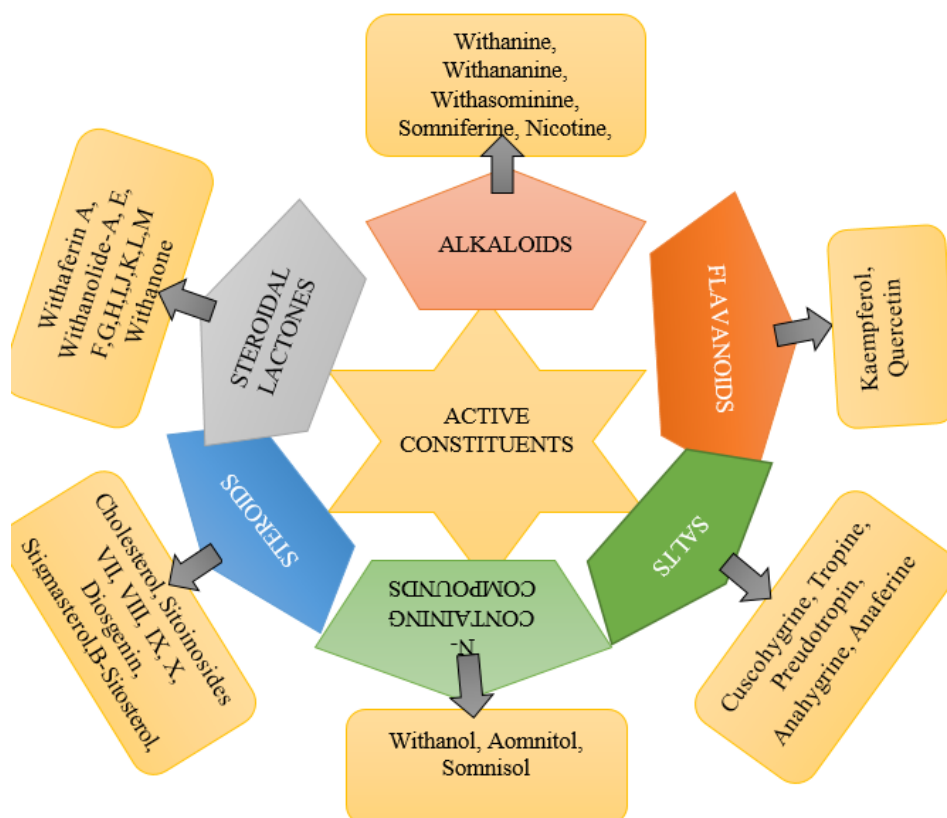


Figure 03: Represents the Active Constituents present in *Withania Somnifera*

Description

The ashwagandha plant is a small shrub that grows to a height of 35 to 75 cm. It has a central stem from which branches radiate outward in a star pattern (also called stellate) and are covered in a dense covering of tomentose hair. *Withania somnifera* has tiny, green blooms. The ripe fruit possesses milk-coagulating qualities and is orange-red in color. The roots are tuberous, long, and brown. [19, 20]

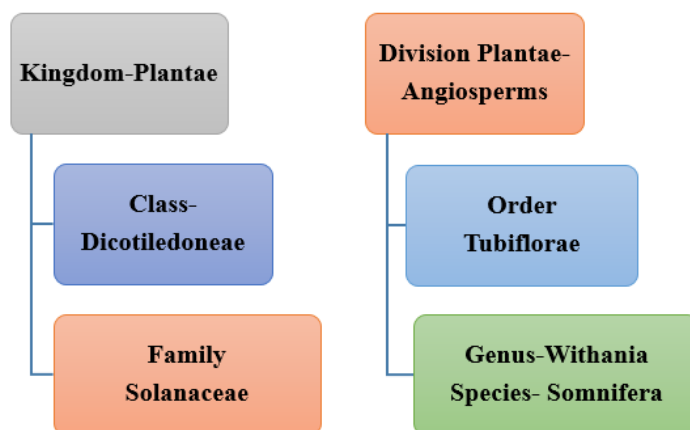


Figure 04: Represents the Taxonomic Position of *Withania somnifera*



Table 01: Vernacular Names of *Withania somnifera* [21].

Sanskrit	Ashwagandha, Ashvakandika, Gandhapatri, Palashaparni
Hindi	Asgandh, Punir
English	Winter cherry
Bengali	Ashwaganda, Asvagandha
Telugu	Asvagandhi, Penneru, Pennerugadda, Dommadolu
Gujrati	Asan, Asana, Asoda, Asundha, Ghodaasoda
Malayalam	Amukkiram, Pevetti
Tamil	Amukkira, Asubam, Asuvagandi
Marathi	Askandha, Kanchuki, Tilli
Urdu	Asgand, Asgand Nagori
Odiya	Asugandha
Persian	Kaknaj-e-Hindi, Asgand Nagaor
Arabic	Kaknaj-e-Hind

Table 02: Phytoconstituents of *Withania Somnifera* [21].

Leaves	Twelve withanolides, five unknown alkaloids, glycosides, chlorogenic acid, several free amino acids, glucose, condensed tannins, and flavonoids are reportedly present in the plant's leaves (Khare, 2007). The most important withanolide found in the extract of <i>Withania somnifera</i> leaves and dried roots is withaferin A, a steroidal lactone.
Fruit	Condensed tannins, flavonoids, amino acids, and proteolytic enzymes are all present in the green berries. Alanine, proline, glycine, tyrosine, hydroxyproline, valine, aspartic acid, glutamic acid, cystine, and cysteine are among the free amino acids that make up a significant portion of them. The elevated amino acid content may be caused by the presence of the proteolytic enzyme chamase in the berries.
Root	Amino acids, alkaloids, steroids, starch, reducing sugars, hentriacontane, dulcitol, glycosides, withaniol, an acid, and a neutral substance are claimed to be present in the roots. Pseudotropine, anahygrine, cuscohygrine, tropine, anaferine, withanane, isopelletierine, pseudo-withanine, withananine, somnine, somniferine, and somniferinine are examples of basic alkaloids. 3-tropyltigloate and an unnamed alkaloid are examples of neutral alkaloids. Visamine, withanine, and withasomnine are other alkaloids (Khare, 2007). Aspartic acid, glycine, tyrosine, alanine, proline, tryptophan, glutamic acid, and cystine are among the free amino acids found in the root.
Stem	Condensed tannins and flavonoids are found in the plant's stem.
Bark	Several free amino acids can be found in the bark.
Shoot	The delicate shoots are not fibrous and are high in calcium, phosphorus, and crude protein. According to reports, they contain scopoletin.

Medicinal uses in Ayurveda: [16]

The root is the most useful part of ashwagandha. Fruits, leaves, and seeds can also be utilized medicinally.

1. External Uses:

Oil massage is used for vata disorders and weakness, while ashwagandha leaves and root paste are applied to enlarge cervical glands or swelling of other glands to relieve edema and pain. Ashwagandha leaf juice is used as eardrops for ear discharge. Black root ashes are used to treat blisters. The powdered dried leaves are used to make a paste that is applied on women's faces as well as burns and wounds.

2. Internal uses:

✓ **Nervous system:** Because ashwagandha root is sedative, tranquilizing, and nervine tonic, it helps tonic nerves and is beneficial for fainting, giddiness, and insomnia (the Latin species name *somnifera* means "sleep-inducing") 6. Additionally, it is used as a general tonic, a "adaptogen" to assist the body deal with everyday stress, and to enhance cognitive function. Additionally, it helps



alleviate the symptoms of Parkinson's, Alzheimer's, and other neurodegenerative illnesses by enhancing the brain's memory processes including attention and focus. It helps the body store and maintain essential energy during the day and encourages restful, sound sleep at night. All muscular tissues, including the heart and lungs, are strengthened and toned with ashwagandha. It simultaneously reduces muscle inflammation and improves muscle tone. It is the perfect treatment for low body weight, stiffness, weakness, and aches and pains in the muscles.

✓ **Digestive system:** Ashwagandha bark powder is used to treat worms, constipation, and stomach pain since it is an appetizer, carminative, and anthelmintic.

✓ **Circulatory system:** Ashwagandha affects the heart, cleanses the blood, and lessens edema. Thus, it is utilized for edema, blood problems, and heart weakness. Rheumatoid arthritis is treated with the decoction.

✓ **Respiratory system:** Ashwagandha helps with coughing since it is an expectorant and has anti-asthmatic properties. Asthma can be effectively treated with ashwagandha ash, ghee, and honey. Thin phlegm is utilized as ash or as an alkaline extract. For asthma and cough, a small amount of bark decoction should be used. In the aforementioned circumstances, it is also utilized as a tonic.

✓ **Reproductive system:** Ashwagandha is regarded as sukrala, or semenagogue, which enhances the production of semen. It is used to treat semen problems and is well recognized for its aphrodisiac properties. 5 grams of ashwagandha powder, 10 grams of ghee and sugar, and 250 milliliters of milk make a healthy, aphrodisiac tonic. It totally eliminates endometritis-related leucorrhoea and puerperal pain.

✓ **Urinary system:** It is a diuretic used to treat anuria or oliguria.

✓ **Skin:** Wrinkles, early aging, and early hair graying are signs of Ashwagandhadi Churna. Vitiligo and other skin conditions are treated with it.

✓ **Satmilkaran:** It is an aphrodisiac, boosts immunity, and causes weight gain. Used to treat childhood marasmus and crippling illnesses.

Medicines in market: Dhatupoustika Churna, Phala Kalyan Ghrita, Rasaraj Rasa, Ashwagandhadi Churna, Balarista, Ashwagandha Rasayana, Ashwagandha Ghrit, Ashwagandharishta, etc.

Side effects and contraindications: Ashwagandha might cause various digestive issues when taken in excess, and it is not advised in cases of hyperthyroidism or pregnancy. Ashwagandha can have a hypnotic effect when taken in large quantities. Therefore, it is best to start with tiny doses and increase them gradually. Because ashwagandha might have sedative effects in large amounts, it is best taken in the evening.^[16]

Useful preparations of Ashwagandha

- When applied to a local inflammation, a paste made from ashwagandha leaves acts as an anti-inflammatory treatment.^[22, 23]
- Ashwagandha is used to make herbal massage oil, which helps with a variety of ailments include epilepsy, paralysis, and insomnia.
- Sperm count, motility, and semen quantity are all improved by a *Withania somnifera* mixture that is combined with honey, ghee, and sugar. It works well for erectile dysfunction, low libido, and early ejaculation.^[24, 25]
- Rheumatism, senile debility in all cases of general debility, nervous tiredness, spermatorrhoea, short memory, lack of physical vigor, and brain-fag can all be improved with regular usage of Ashwagandha churna. It increases the body's vitality and energy. It aids in correcting bodily systems that are out of equilibrium as a result of long-term illnesses like syphilis and rheumatism. Additionally, it fights early aging by replenishing the body's diminished energy from mental strain and overwork.
- Making a preparation of ashwagandha is a healthful way to lessen sweet cravings. One tablespoon of date sugar and one ounce of ashwagandha must be roasted in ghee for this preparation. For later usage, it must be stored in a screw-top glass jar in the refrigerator. This can be eaten 20 minutes before breakfast in the morning, in the middle of the afternoon if you have a sweet tooth, and before bed with a cup of hot milk if you have a sweet tooth.^[26, 27]



➤ Children who are thin can benefit greatly from regular use of ashwagandha. It enhances both body weight and vitality. ^[28, 29]

Effects of Ashwagandha in Alzheimer's disease and Parkinson's disease

Because it contains L-DOPA, the traditional Ayurvedic herb ashwagandha exhibits neuroprotective properties. ^[30] Through cholinergic pathways, it improves memory. In addition to improving learning capacity, it can improve mood. ^[31, 32]

Ashwagandha as a free radical scavenger and Antioxidant

It can boost the brain's three natural antioxidants. It can stimulate our immune system by causing macrophages to produce nitric oxide. ^[33, 34] It has a protective effect on DNA cleavage and scavenges free radicals. It works well for lead poisoning and iron overload. Extra pyramidal side effects were brought about by a slow-down neuroleptic. ^[35, 36]

Ashwagandha on anxiety and depression:

- Similar to Bacopa Monnieri, ashwagandha can help with anxiety and sadness. The anxiolytic effects of this plant resemble those of lorazepam. Like imipramine, it has an antidepressant effect. ^[37, 38]
- Up to 100 mg per kilogram of body weight, this herb has been shown to be harmless. It possesses antispasmodic and anticonvulsant properties. It has the capacity to stimulate endocrine glands. ^[39, 40]

II. METHODOLOGY

MOLECULAR DOCKING STUDIES

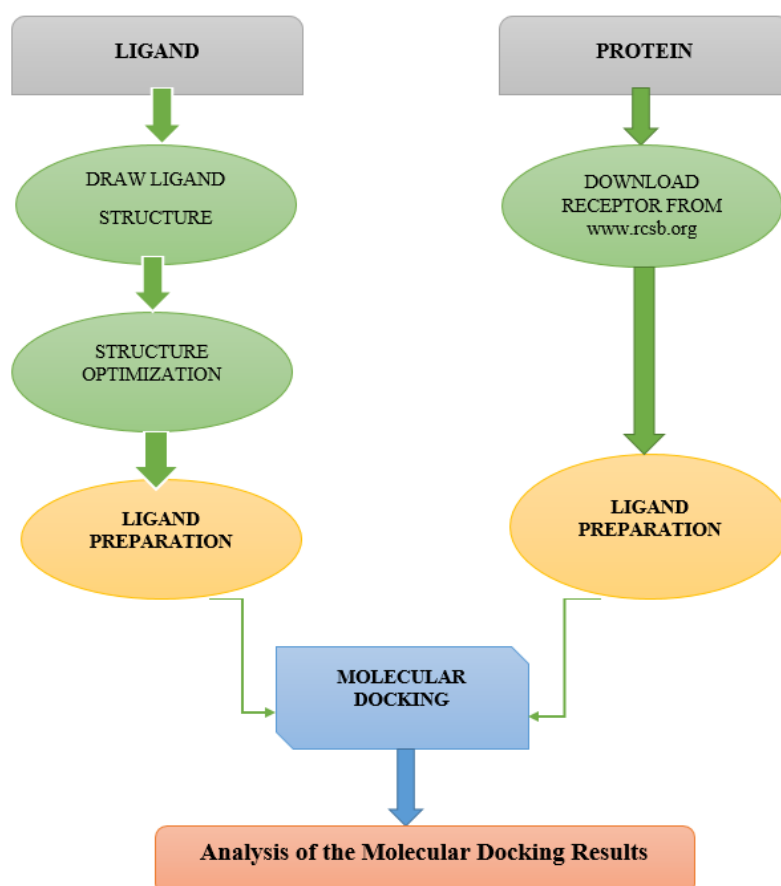


Figure 05: Various steps involved in performing the molecular docking simulations



1. Ligand Preparation

The structure of the suggested ligand is sketched and prepared for the docking simulations at this initial stage of the molecular docking process.

The following are the steps involved in ligand preparation:

- Sketching the ligand's structure.
- Improving the ligand's structure.
- Filling the ligand with any hydrogen that is lacking.
- The ligand's charges are added. ^[41, 42]

2. Protein Preparation

The creation of the protein structure that the suggested drug compounds will be docked against is the very next step. This stage consists of:

- Downloading the structure of the protein.
- Editing the structure of hydrogen.
- Adding the missing hydrogen.
- Addition of the charges on the protein.
- Identifying the active site of the protein. ^[43, 44]

3. Performing the Molecular Docking:

1. Auto dock carries out the molecular docking process in two ways: Look for the ligand conformations that work well with the protein. Here, the bioactive conformation of the suggested ligand is searched using the idea of global and local minima.
2. The protein-ligand complex binding is scored using the Gibbs free energy. Lower the Gibbs free energy better binding between the drug and protein receptor is considered.

4. Analysis of the results of the molecular docking:

This is the last stage of molecular docking, where several metrics are determined, including the dock score of the binding and various ligand-protein interactions.

The two crucial elements that are examined for molecular docking are as follows:

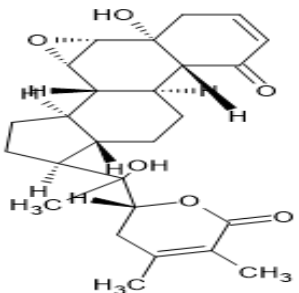
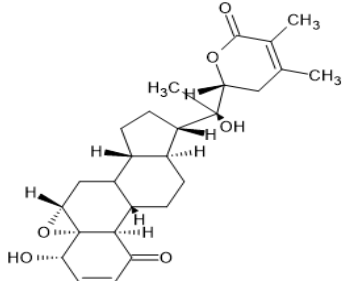
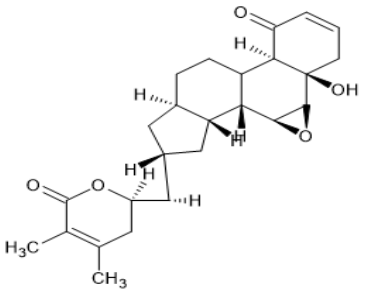
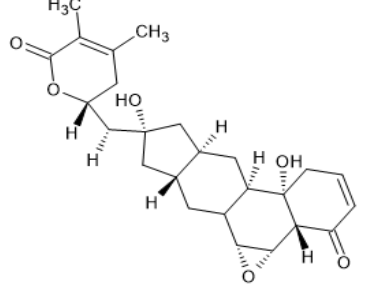
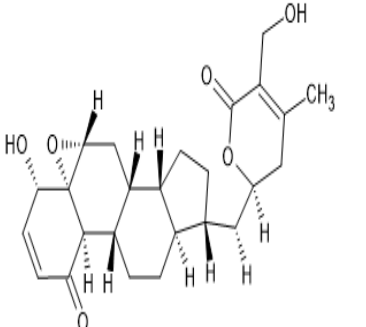
- Evaluation of each ligand's dock score with the target protein receptor
- Evaluation of different non-bonded interactions between the receptor and the ligand. Among all forms of non-bonded interactions, hydrogen bonding is regarded as the most important. ^[45]

III. RESULTS & CONCLUSION

LIG05 showed the highest binding score (-11.37) in the molecular docking investigation, suggesting a significant interaction with serotonin receptors. **LIG06 (-9.23)**, **LIG04 (-9.6)**, and **LIG02 (-9.19)** were other important ligands. Van der Waals forces, hydrogen bonding (particularly with residues like **LYS A: 345** and **SER A: 263**), and alkyl interactions were seen in these interactions, indicating that certain withanolides in ashwagandha have a high affinity for serotonin receptors.



Table 03: Structure of Compounds

LIGANDS ID	STRUCTURE
LIG01	
LIG02	
LIG03	
LIG04	
LIG05	

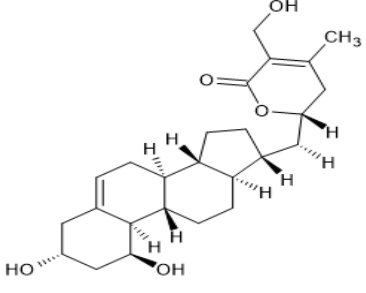
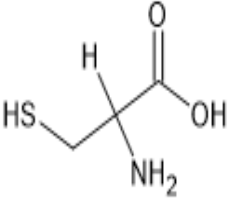
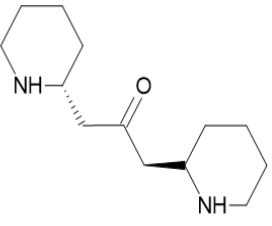
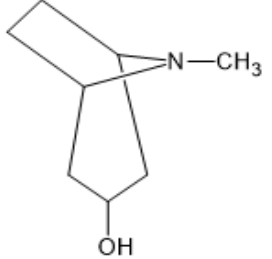
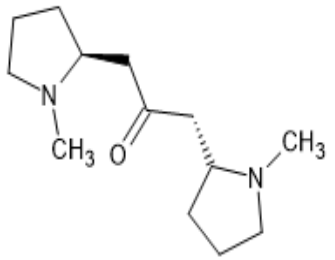
LIG06	
LIG07	
LIG08	
LIG09	
LIG10	

Table 04: Binding Score of Compounds

S.NO	LIGANDS ID	BINDING SCORE
1	LIG01	-8.58
2	LIG02	-9.19
3	LIG03	-8.65
4	LIG04	-9.6
5	LIG05	-11.37
6	LIG06	-9.23
7	LIG07	-5.29
8	LIG08	-5.72
9	LIG09	-5.56
10	LIG10	-6.83

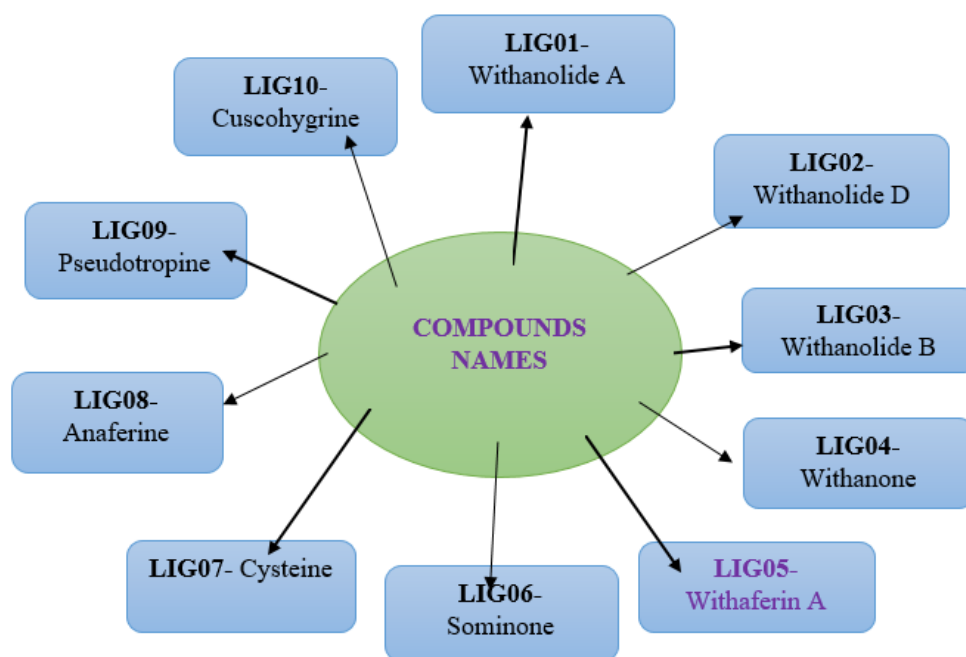
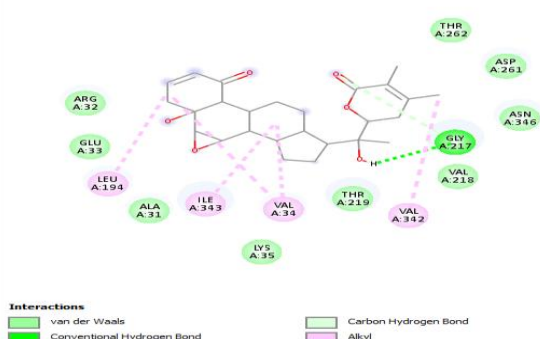
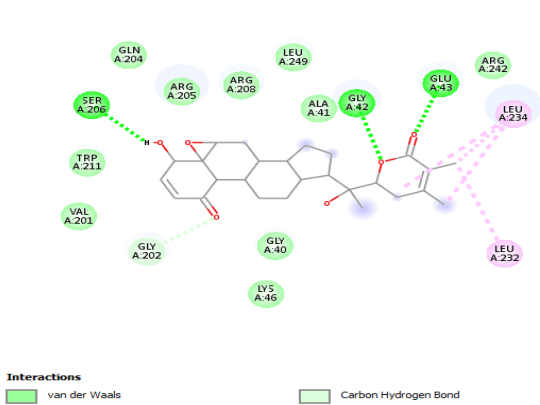


Figure 06: Names of the Compounds

Table 05: Represents the interactions of Compounds

S.NO	LIGANDS ID	INTERACTIONS
1	LIG01	 <p>Interactions</p> <ul style="list-style-type: none"> van der Waals Conventional Hydrogen Bond Carbon Hydrogen Bond Alkyl
2	LIG02	 <p>Interactions</p> <ul style="list-style-type: none"> van der Waals Conventional Hydrogen Bond Carbon Hydrogen Bond Alkyl



The results of this investigation highlight the potential of ashwagandha as a natural antidepressant. Strong binding affinities and a strong binding score of -11.37 were shown by bioactive substances such as LIG05 to serotonin receptors, especially when residues like **TYR A: 320, LYS A: 345, and SER A: 263** were involved. These interactions imply that ashwagandha's withanolides may successfully control serotonin pathways. Although the results are encouraging, more investigation is required to prove long-term efficacy, define safe dosages, and validate these findings. Ashwagandha provides a comprehensive approach to managing mental health by bridging the gap between ancient treatments and contemporary medicines.

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CONFLICTS OF INTEREST

The author declares there is no conflict of interest.

BIBLIOGRAPHY

1. Marchi L, Marra C, Esposito M, et al. The effects of ashwagandha on sleep and stress in patients with anxiety: a randomized controlled trial. *BJPsych Open*. 2025; 11(6):e260.
2. Mikulska M, Kuczynski P, Olpinska-Lischka M, et al. The effect of ashwagandha (*Withania somnifera*) on stress and mood: a systematic review. *Pharmaceutics*. 2023; 15(4):1057.
3. Singh N, Bhalla M, de Jager P, et al. An overview on ashwagandha: a Rasayana (rejuvenator) of Ayurveda. *Afr J Tradit Complement Altern Med*. 2011; 8(5 Suppl):208-213.
4. Kulkarni SK, Dhir A. *Withania somnifera*: an Indian ginseng. *Indian Drugs*. 1993; 30(7):305-311.
5. Nichols DE, Nichols CD. Serotonin receptors. *Chem Rev*. 2008; 108(5):1614-1641.
6. Hoyer D, Hannon JP, Martin GR. Molecular, pharmacological, and functional diversity of 5-HT receptors. *Pharmacol Biochem Behav*. 2002; 71(4):533-554.
7. Barnes NM, Sharp T. A review of central 5-HT receptors and their function. *Neuropharmacology*. 1999; 38(8):1083-1152.
8. Singh N, Bhalla M, de Jager P, et al. An overview on ashwagandha: a Rasayana (rejuvenator) of Ayurveda. *Afr J Tradit Complement Altern Med*. 2011; 8(5 Suppl):208-213.
9. Mikulska M, Kuczynski P, Olpinska-Lischka M, et al. The effect of ashwagandha (*Withania somnifera*) on stress and mood: a systematic review. *Pharmaceutics*. 2023; 15(4):1057.
10. Choudhary D, Bhattacharyya S, Bose S. Efficacy and safety of ashwagandha root extract in improving stress and sleep in adults. *J Ethnopharmacol*. 2022; 284:114744.
11. Kulkarni SK, Dhir A. *Withania somnifera*: an Indian ginseng. *Indian Drugs*. 1993; 30(7):305-311.
12. World Health Organization. Depression and other common mental disorders: global health estimates. Geneva: WHO; 2017.
13. Otte C, Gold SM, Penninx BW, et al. Major depressive disorder. *Nat Rev Dis Primers*. 2016; 2:16065.
14. Kessler RC, Bromet EJ. The epidemiology of depression across cultures. *Annu Rev Public Health*. 2013; 34:119-38.
15. Malhi GS, Mann JJ. Depression. *Lancet*. 2018; 392(10161):2299-312.
16. Dr. Sudhanshu Kumar Meher et al., Uses of *Withania somnifera* (Linn) Dunal (Ashwagandha) in Ayurveda and its Pharmacological Evidences 8(1): January -March, 2016.
17. Abraham A, Kirson I, Glotter E, Lavie D. A chemotaxonomic study of *Withania somnifera* (L) Dunal. *Phytochemistry*. 1968; 7(6):957-62.
18. Agarwal R, Diwanay S, Patki P, Patwardhan B. Studies on immunomodulatory activity of *Withania somnifera* (Ashwagandha) extracts in experimental immune inflammation. *J Ethno Pharmacol*. 1999; 67(1):27-35.
19. Bhakuni DS, Jain S. Chemistry of Cultivated Medicinal Plants- *Withania somnifera* Dunal Ashwagandha, Solanaceae. In: *Advances in Horticulture. 11- Medicinal and Aromatic Plants*. (Eds.K.L.Chadha, Rajendra Gupta) 1995, 115-19.
20. Bhattacharya SK. Adaptogenic activity of siotone, an herbal formulation against an unpredictable chronic stress induced physiological and behavioral perturbation in rats. National conference on recent trends in Spice and Medicinal Plant Research, Calcutta, 1998.
21. Nikhil Teli^{1*} et al., *Withania Somnifera* (Ashwagandha): A Source of Therapeutic Agents *Int.J.Curr.Res.Chem.Pharma.Sci*. 1 (7): 36-43 (2014).
22. Dar PA, Singh LR, Kamal MA, Dar TA. Unique medicinal properties of *Withania somnifera*: Phytochemical constituents and protein component. *Curr Pharm Des*. 2016; 22(5):535-540.
23. Khanna D, Sethi G, Ahn KS, Pandey MK, Kunnumakkara AB, Sung B, et al. Natural products as a gold mine for arthritis treatment. *Curr Opin Pharmacol*. 2007; 7(3):344-351.



24. Bhattacharya SK, Muruganandam AV. Adaptogenic activity of *Withania somnifera*: An experimental study using a rat model of chronic stress. *Pharmacol Biochem Behav.* 2003; 75(3):547-55.
25. Barua A, Bradaric MJ, Bitterman P, Abramowicz JS, Sharma S, Basu S, *et al.* *Am J Reprod Immunol.* 2013; 70(6):538-550.
26. Umadevi M, Rajeswari R, Sharmila C, Rahale Selvavenkadesh S, Pushpa R, Sampath Kumar KP, *et al.* Traditional And Medicinal Uses of *Withania somnifera*. ISSN: 2277-7695. 2012; 1(9):103.
27. Abraham A, Kirson I, Glotter E, Lavie D. A chemotaxonomic study of *Withania somnifera* (L) Dunal. *Phytochemistry.* 1968; 7(6):957-62.
28. Agarwal R, Diwanay S, Patki P, Patwardhan B. Studies on immunomodulatory activity of *Withania somnifera* (Ashwagandha) extracts in experimental immune inflammation. *J Ethno Pharmacol.* 1999; 67(1):27-35.
29. Bhakuni DS, Jain S. Chemistry of Cultivated Medicinal Plants- *Withania somnifera* Dunal Ashwagandha, Solanaceae. In: *Advances in Horticulture. 11- Medicinal and Aromatic Plants.* (Eds.K.L.Chadha, Rajendra Gupta) 1995, 115-19.
30. Ven Murthy MR, Ranjekar PK, Ramassamy C, Deshpande M. Scientific basis for the use of Indian ayurvedic medicinal plants in the treatment of neurodegenerative disorders: ashwagandha. *Cent NervSyst Agents Med Chem.* 2010; 10(3):238–246.
31. Zhao J, Nakamura N, Hattori M, Kuboyama T, Tohda C, Komatsu K..Withanolide derivatives from the roots of *Withania somnifera* and their neurite outgrowth activities. *Chem Pharm Bull (Tokyo).* 2002; 50:760-765.
32. Bhattacharya SK, Kumar A, Ghosal S. Effects of glycowithanolides from *Withania somnifera* on an animal model of Alzheimer's disease and perturbed central cholinergic markers of cognition in rats. *Phytotherapy Research.* 1995; 9(2):110-13.
33. Bhattacharya SK, Satyan KS, Ghosal S. Antioxidant activity of glycowithanolides from *Withania somnifera*. *Indian J Exp Biol.* 1997; 35(3):236–239.
34. Umadevi M, Rajeswari R, Sharmila C, Rahale Selvavenkadesh S, Pushpa R, Sampath Kumar KP, *et al.* Traditional And Medicinal Uses of *Withania somnifera*. ISSN: 2277-7695. 2012; 1(9):103.
35. Zhao J, Nakamura N, Hattori M, Kuboyama T, Tohda C, Komatsu K..Withanolide derivatives from the roots of *Withania somnifera* and their neurite outgrowth activities. *Chem Pharm Bull (Tokyo).* 2002; 50:760-765.
36. Guyton AC, Hall JE. *Adrenocortical Hormones Textbook of Medical Physiology.* 11th ed. Philadelphia: Saunders. 2006, 944-60.
37. Bhattacharya SK, Muruganandam AV. Adaptogenic activity of *Withania somnifera*: An experimental study using a rat model of chronic stress. *Pharmacol Biochem Behav.* 2003; 75(3):547-55.
38. Bhattacharya SK. Adaptogenic activity of siotone, an herbal formulation against an unpredictable chronic stress induced physiological and behavioral perturbation in rats. National conference on recent trends in Spice and Medicinal Plant Research, Calcutta, 1998.
39. Dar PA, Singh LR, Kamal MA, Dar TA. Unique medicinal properties of *Withania somnifera*: Phytochemical constituents and protein component. *Curr Pharm Des.* 2016; 22(5):535–540.
40. Archana, R., Namasivayam, A. Anti-stress effect of *Withania somnifera*. *J Ethnopharmacol* 1999. 64(1):91-3.
41. Morris GM, Huey R, Lindstrom W, Sanner MF, Belew RK, Goodsell DS, *et al.* AutoDock4 and AutoDockTools4: Automated docking with selective receptor flexibility. *J Comput Chem.* 2009; 30(16):2785–91.
42. Trott O, Olson AJ. AutoDock Vina: Improving the speed and accuracy of docking with a new scoring function, efficient optimization, and multithreading. *J Comput Chem.* 2010; 31(2):455–61.
43. Forli S, Huey R, Pique ME, Sanner MF, Goodsell DS, Olson AJ. Computational protein–ligand docking and virtual drug screening with the AutoDock suite. *Nat Protoc.* 2016; 11(5):905–19.
44. Kitchen DB, Decornez H, Furr JR, Bajorath J. Docking and scoring in virtual screening for drug discovery: Methods and applications. *Nat Rev Drug Discov.* 2004; 3(11):935–49.
45. Meng XY, Zhang HX, Mezei M, Cui M. Molecular docking: A powerful approach for structure-based drug discovery. *Curr Comput Aided Drug Des.* 2011; 7(2):146–57.

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