WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 5.045
Volume 3, Issue 5, 138-158. Review Article ISSN 2277 – 7105

A REVIEW ON PHYTOCHEMISTRY AND PHARMACOLOGICAL ACTIVITY OF PARTS OF *MUCUNA PRURIENS* USED AS AN AYURVEDIC MEDICINE

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Article Received on
24 May 2014,

Revised on 15 June 2014,
Accepted on 10 July 2014

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ABSTRACT

Mucuna pruriens (L.) DC. belongs to the family Fabaceae is commonly known as Velvet bean, Cowitch, Cowhage in English and Kawaanch, Kavach in Hindi. It is mainly distributed in Asia, Africa, Pacific Islands and the United State. *M. pruriens* has been of keen interest in phytochemical and Ayurvedic research due to its excellent medicinal values. Traditionally it is used in treating diseases such as arthritis, anxiety, cancer, cough, diarrhoea, dysentery, diabetes, dysmenorrhea, delirium, gonorrhoea, gout, impotency and sexual debility, muscular pain, parasitic infections, Parkinson's disease, rheumatic disordersas an analgesic and antipyretic, to induce vomiting, to treat snakebite and scorpion stings, sterility ,tuberculosis etc. The plant exhibit wide array of phytoconstituents like alkaloids, flavonoids, tannins and phenolic compounds which are responsible for varied potent physiological and pharmacological activities. This review is in a narrative format and consists of publications relevant to *M. pruriens* available in public doman.

Keywords: *M. pruriens* (L.) DC, Phytochemistry, pharmacological activity, Ayurvedic uses.

INTRODUCTION

M. pruriens (Figure 1.) is a tropical twining herb commonly known as Velvet bean belongs to the family Fabaceae. The plant is famous for the extreme itchness it produces on contact, particularly with the young foliage and the seed pods due to the presence of 5-hydroxytryptamine (5-HT) [1-2]. The plant is an annual, climbing shrub with long vines that

can reach over 15 m in length [3].It is grown predominantly in Asia, Africa, and many parts of America [4]. The beans of the *M. pruriens* are known to produce the unusual non protein amino acid L-dopa, a potent neurotransmitter.[5] From the ancient times Cowhage has been used in Ayurvedic medicine for the treatment of Parkinson's disease associated with progressive degeneration of dopaminergic neurons in specific areas in the brain which is a common age-related neurodegenerative disorder. It affects more than four million people worldwide or for nervous system disorders as of the high concentration of L-dopa in the seeds. Dopamine does not cross the blood-brain barrier and therefore cannot be used directly as a treatment. But the researches discover that it is also used in many other diseases such as for treating arthritis, anxiety, cancer, cough, diarrhoea, dysentery, diabetes, dysmenorrhea, delirium, gonorrhoea, gout, impotence, muscular pain, parasitic infections, rheumatic disorders, as analgesic and antipyretic, to induce vomiting, to treat snakebite and scorpion stings, sexual debility, sterility ,tuberculosis and its direct application on skin can help to stimulate surface blood flow in conditions that involve paralysis [6-7]. In India, it is considered an aphrodisiac, diuretic, emmenagogue, nerve tonic and uterine stimulant. In Central America, it is known as Nescafe as the seeds are roasted and ground to make a coffee substitute for decades [7].

DISTRIBUTION

In India, it is one of the most popular medicinal plants [8].Cultivated in Uttar Pradesh, Madhya Pradesh and Andman and Nicobar Islands etc. It is widespread over most of the subcontinent and found in forms of bushes, hedges, in dry-deciduous low forests types throughout the plains of India. It grows naturally grown right from lower Himalayan range to entire tropical plains of India [8-9] and also cover the tropical regions, especially Africa, West Indies, tropical America, the Pacific Islands and the United State. [10-11].

Botanical classification [12]

Family: Fabaceae

Genus: Mucuna

Species: pruriens

Taxonomy and nomenclature [6]

Latin name: *Mucuna pruriens*

Synonyms: *Carpopogon pruriens, Dolichos pruriens, Mucuna aterrima, M. atropurpurea, M. cochinchinensis, M. cyanosperma, M. deeringiana, M. esquirolii, M. prurita, M. utilis,*

Stizolobium aterrimum, S. deeringianum, S. pruriens, S. pruritum, S. niveum, Negretia pruriens [12].

Common Names: Cowitch, Cowhage, Velvet Bean, Cow-itch, Buffalo bean [6] velvet bean, mucuna, nescafe, pode mico, fava-coceira, cabeca-de-frade, cowage, cowhage, cow-itch, bengal bean, mauritius bean, itchy bean, krame, picapica, chiporro, buffalo bean [12] .

Other names [13]

Bengali- Alkusa, Alkushi

English- Cowharge, Couritch plant

Gujarati- Kivanch

Hindi- Kawaanch, Kavach

Kannad- Nasugunni

Konkani- Khavalyavali, Majram

Malayalam- Nayikuruma, Shoriyanam

Marathi- Kuhili

Punjabi- Kawanchi, Gugli, Kavanch

Tamil- Punaikkali, Poonaikkate

Telgu- Dulagondi, Pilliadagu

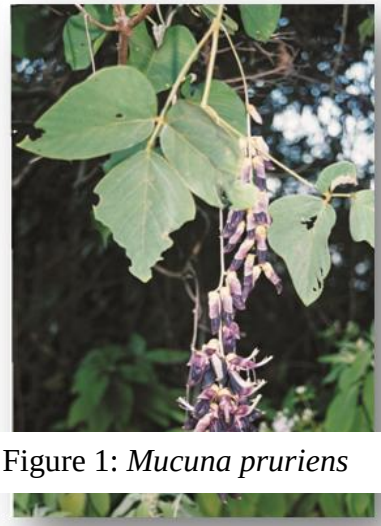

Figure 1: *Mucuna pruriens*

ECOLOGY

It is an annual twinning, climbing shrub with long vines that can reach over 15 m in length and 3-18 m in height. It can grow in well-drained soil, sandy soils and also in the soils with great acidity range but will not able to survive in very saturated soils. It usually prefers hot climates with rainfall ranging between 1,000-2,500 mm and also having capability to grow in as little as 400 mm of annual rainfall condition. It does have some tolerance to drought but for the proper growth the best temperature range needed is between 19-27°C with high light intensity [8]. Flowers are white to dark purple in colour and hang in long clusters. The pods produced in clusters which contain seeds known as mucuna beans. The seed pods are covered with reddish-orange hairs that are not easily detached and can cause intense irritation to the skin when come in contact to the body [12]. Young plant is almost completely covered with fuzzy hairs, but at the older age it loses them completely. The leaves are reversing ovate, tripinnate, rhombus-shaped, ovate, or sometimes widely ovate. The tips of the leaves are pointy and the sides are often heavily grooved. In young plants, both sides of the leaves have

hairs. The stems of the leaflets are 2-3 mm long. Additional adjacent leaves are present and are about 5 mm long [14].

CULTIVATION

In plains, it is a kharif season crop and the seeds are sown immediately after first shower (June- July). If sowing is delayed, it shows adverse effect on the yield [15]. It requires less nitrogen and phosphorous in the soil as it itself is a leguminous crop. It does not need any external irrigation as the soil moisture is sufficient during the rainy season. At the time of growth and development of the plant its vines need some external support to climb and creep. The complete development of the pods was takes place in the month of December and they are plucked after January. After drying in sun for 4-5 days pods are threshed for removal of seeds [9].

BOTANICAL DESCRIPTION

Roots: The outer surface is dark brown to black in colour and slightly rough due to the presence of many oblong slightly protruding prominent lenticels and a few rootlets and consist of many long, but softly woody, somewhat flexible roots, having a diameter of 7mm or more [15].

Leaf: leaves are fairly large, alternate, stipulate, pinnately and trifoliate. Stipules are deciduous about 1/5th inches in length. Stipels are three to five inch long and are minute and osculate, rachises leaflets are three to four inch long, by two to three inch wide, on short, thick, sparingly defexed hairy stalks, ovate-rhomboid acute or sub-acute, mucronate, membranous, glabrous or glabresent above and densely covered with fine lustures or silvery grey ad pressed hairs beneath. The shapes of terminal leaflets are rhomboid oval and smaller, while the lateral ones are vary unequal sided with their lower halves much broader [15].

Flower: The heads of the flower are in form of axially arrayed panicles. They are 15 to 32 cm long and have two or three, or many flowers. The leaves accompanying with them are about 12.5 mm long, the stand axes of the flower are from 2.5 to 5 mm. The bell is 7.5 to 9 mm long and silky. The length of sepals are either longer or of the same as that of shuttles. The colour of crown is purplish or white. The flag is 1.5 mm long. The wings are 2.5 to 3.8 cm long [14].

Pods: The pods are, 2 to 3 or 4 inch in length and half an inch broad. These are turgid explosively dehiscing pod, their shapes are like the letters blunt at either end, slightly covered at both ends and somewhat longitudinally ridged. The pod is compactly covered with numerous pointed hairs which are short, stiff or rigid, weak but not easily detached; initially they are of a pale yellowish brown or somewhat light rusty brown in colour but later changes into steel grey. The number of seeds present in the pods is 4 to 6 or sometimes more with septa or partitions between the seeds [15].

Seed: The seed are 15-20 mm long and 7-15 mm broad and 4 to 6.5 cm thick [14] reniform or ovoid in shape. The seed coat is hard, thick and glossy occasionally mottled. Seed Embryo fills up the seed and is made up of two large cotyledons [15].The hilum, the base of the funiculus (connection between placenta and plant seeds) is a surrounded by a significant arillus (fleshy seeds shell) [14].

TRADITIONAL USES OF DIFFERENT PARTS OF PLANT

Root: Used as a blood purifier, diuretic, emmenagogue, for asthma, cholera, dropsy, delirium, elephantiasis, fevers, gout, kidney stones rheumatism, to relieve dysmenorrhea, in catarrh and dropsy [7, 16-17].

Leaf: Used as an aphrodisiac, diuretic, nerve tonic, uterine stimulant, for scorpion stings and in dysentery [7].

Pods: Used in dropsy [17]

Seed: It cure night dreams and impotency and to promote fertility, for sexual debility, seminal weakness and spermatorrhea, as an aphrodisiac to increase seminal fluid and manly vigour, emmenagogue, antivenin, nervine, for abortion, diarrhea, diabetes, gonorrhea, muscular pain, persistent coughs, pulmonary tuberculosis, rheumatic disorders, scorpion stings and snakebite, worm infestation, sterility and general debility [7].

PHYTOCHEMISTRY

Major chemical constituents

Leaf: Bufotenine (Indole Alkaloid), Choline (Alkaloid-misc), Dopa, L (Proteid), Dopamine, Genistein, Genistein, hydroxy, Harman, 6-methoxy Tryptamine, 5-hydroxy Tryptamine, n-n-dimethyl, Tryptamine, n-n-dimethyl: 5-methoxy (Indole Alkaloid) [7, 18].

Pod: 5-Hydroxytryptamine, Bufotenine, Tryptamine 5-hydroxy Tryptamine, n-n-dimethyl, Tryptamine, n-n-dimethyl: methoxy, Tryptamine, n-n-dimethyl: n-oxide (Indole Alkaloid) [7, 18].

Seed: 1-Methyl-3-carboxy-6,7 -dihydroxy-1-,2, 3,-4Tetrahydroisoquinolone, 5-oxyindole-3-alkylamine, Alanine (Amino acid) , Alkylamine, 5-oxyindole-3 Alkylamine, indole-3 Amino acid analysis (Proteid) , Arachidic acid, Arginine (Amino acid), Aspartic acid, Behenic acid, Beta carboline, Calcium, Carbohydrates, Carboline, beta, Cis-12,13-epoxyoctadec-trans-9-cis-acid, Cis-12,13-epoxyoctadec-trans-9-enoic acid, Chymotrypsin Inhibitor, Cystine (Amino acid), DOPA- L (Proteid), Fat, Fatty acids, unsaturated, Flavone, 4'-5-6-trihydroxy-3'-7-8-trimethoxy4'-O-beta-d-xylopyranosyl(1-2)-O-alpha-1-rhamnopyranoside) (Flavone), Galactose, D (Carbohydrate), Gallic acid, Glycine, Glutamic acid, Glutathione, Histidine (Amino acid), Iron (Inorganic), Indole-3-alkylamine, Isoleucine, Lecithin (Carbohydrate), Leucine (Amino acid), Leucine, iso, Linoleic acid, Linolenic acid (Lipid), Lysine (Amino acid), Mannose, D (Carbohydrate), Methionine (Amino acid), Mucunadine, Mucunain, Mucunine, Mucuna polysaccharide (Carbohydrate), Mucuna pruriens alkaloid P, Mucuna pruriens alkaloid Q Mucuna pruriens alkaloid R Mucuna pruriens alkaloid S, Mucuna pruriens alkaloid X (Alkaloid-misc), Myristic acid, Niacin (Inorganic), N,N-Dimethyltryptamine, N,N-Dimethyltryptamine-n-oxide, Nicotine, Oleic acid, Palmitic acid, Palmitoleic acid (Lipid), Phenyalanine (Amino acid), Phosphorus (Inorganic), Polysaccharide (Carbohydrate), Proline (Amino acid), Protein (Protein), Prurienidine, Prurieninine (Alkaloid-misc), Quinoline, iso: 1-2-3-4-tetrahydro (Isoquinoline Alkaloid), Riboflavin (Inorganic), Saponins (Saponin), Serine (Amino acid), Serotonin, Sitosterol, (beta Sterol), Stearic acid, Stizolamine (Alkaloid), Thiamin (Inorganic), Threonine (Amino acid), Trypsin, Tryptamine, Tyrosine (Amino acid), Valine, Vernolic acid (Lipid) [7,18].

Physiochemical parameters of seed [13]

S. No	Parameters	ICMR	CCRAS (databaseVol.I, pp.201)	API Part I, Vol. III
1.	Foreign matter	NMT 2.0%	NMT 1%	-
2.	Ash content	NMT 4.0%	3.45%	NMT 5%
3.	Acid Insoluble ash	NMT 0.3%	0.33%	NMT 1%
4.	Alcohol soluble extractive	NMT 0.3%	9.2%	NMT 3%
5.	Water soluble extractive	NLT 21.0%	16.7%	NLT 23%
6.	*n*- Hexane soluble extractive	NLT 5.0%	-	-
7.	Loss on drying	NLT 8.0%	-	-
8.	Fixed oil	-	2.8%	NLT 3%

QUALITATIVE ANALYSIS

Profiling volatile compounds from Mucuna beans by solid phase micro extraction and gas chromatography-high resolution time of flight mass spectrometry [19]

By using a gas chromatograph coupled to a high resolution time of flight mass spectrometer system, the separation, detection and identification of the volatile compounds were evaluated in the four solid phase micro extraction (SPME) fibres, polydimethyl siloxane (PDMS), polydimethyl siloxane/ divinyl benzene (PDMS/DVB), polyacrylate (PA), and carboxen/polydimethyl siloxane (CAR/PDMS) in *M. pruriens* beans during the cooking of beans. The highest total 26 compounds, mostly alkyl benzenes and polycyclic compounds were identified in a CAR/PDMS fibre of black, white, black–white, and yellow green Mucuna beans.

QUANTITATIVE ANALYSIS

Quantitative determination of L-DOPA in dietary supplements containing *M. pruriens* by HPLC [20]

The simple and rapid HPLC method was developed to determine the L-DOPA content in 14 commercial dietary supplements (capsules and tablets) containing *M. pruriens* by using a mobile phase 10M mol/l *ammonium formate buffer (pH 3.5)/ acetonitrile (3:7, v/v)* the ultraviolet (UV) detector was set at 280 nm. Results showed that the L-DOPA content in the 14 commercial dietary supplements ranged from 0.71 to 9.13 mg/unit. The method was validated for precision (inter and intraday), repeatability and accuracy. The recovery was 100.8%, and relative standard deviation (RSD) values of the repeatability and intermediate precision were less than 8%. The correlation coefficient was 1.0000 and the limit of quantification of L-DOPA was 100 g/g**.**

Quantitative determination of L-DOPA in Seeds of *M. pruriens* germplasm by HPTLC [21]

The simple, rapid, cost-effective and easily adaptable densitometric high performance thin-layer chromatographic (HPTLC) method was developed for screening and quantitative determination of L-DOPA in Mucuna germ plasm collected from different geographical regions. The quantification of L-DOPA content was done in seeds extract by using a solvent system of *n-butanol: acetic acid: water (4:1:1, v/v/v)* as the mobile phase and the separation of L-DOPA was carried out on precoated silica gel 60 GF254 HPTLC plates, using 280 nm absorbance in reflectance mode. The method was validated for accuracy, precision and

repeatability. Linearity was found in the concentration range of 100 to 1000 ng/spot with the correlation coefficient value of 0.9980. Mean recovery was 100.89%. The LOD and LOQ for L-DOPA determination were found to be 3.41 ng/spot and 10.35 ng/spot respectively.

Estimation of L-DOPA from *M. pruriens* and formulations containing *M. pruriens* by HPTLC method [22]

The simple, precise, and accurate densitometric high-performance thin-layer chromatographic (HPTLC) method was developed for the analysis of L-dopa in *M. pruriens* seed extract and its formulations. The identification and quantitative was done by using *n-butanol: acetic acid: water (4.0: 1.0: 1.0 v/v/v)* as a mobile phase and UV detector was set at 280 nm. The relationship between the concentration of L-dopa and corresponding peak areas was found to be linear in the range of 100 to 1200ng/spot. The method was validated for precision (inter and intraday), repeatability, and accuracy. Mean recovery was 100.30%. The relative standard deviation (RSD) values of the precision were found to be in the range 0.64 to1.52%.

Estimation of L-dopa from *M. pruriens* Linn. and formulations containing *M. pruriens* by Spectro fluorimetric method [23]

The simple, precise, and accurate spectro fluorimetric method was developing for the analysis of L-dopa in *M. pruriens* seed extract and its formulations. The excitation and emission wavelength is found to be 282 and 630 nm respectively in 0.1N formic acid, and the relationship between the concentration (ng/ml) of L-dopa and corresponding fluorescence intensity (FI) was noted to be linear in the range of 30-800 ng/ml. The method was validated for precision (inter and intraday), repeatability, and accuracy. The Mean recovery was 99.94%. The relative standard deviation (RSD) values of the precision were found to be in the range 0.58-0.95%.

Quantification of β-Sitosterol from *M. pruriens* by TLC [24]

A sensitive, selective and precise densitometric thin-layer chromatographic method was developing for the analysis of b-sitosterol in *M. pruriens* roots. The separation and quantification is done by using mobile phase of *toluene: chloroform; methanol (4:4:1 v/v)* (RF 0.55) on silica gel 60 F254 aluminium plates and the plate is derivatized with anisaldehyde-sulphuric acid reagent and scan at 527 nm .The method was validated for precision, repeatability and accuracy. The calibration curve was linear in the concentration range of 100– 600 ng/ spot.

A HPTLC method for quantitative estimation of L-dopa from *M. pruriens* in polyherbal aphrodisiac formulation [25]

A selective, precise, and accurate densitometric high performance thin-layer chromatographic (HPTLC) analytical and fingerprinting method was develop for analysis of L-dopa in *M. pruriens* seed extract and in its polyherbal formulation. Quantification is done by using a mobile phase of *n butanol-water-glacial acetic acid (80:20:20, v/v/v)* on silica gel HPTLC 60 F254 plates scan at 520 nm. The relationship between the concentration of L-dopa and corresponding peak areas was found to be linear in the range of 600 to 1400 ng/spot. The method was validated for precision, repeatability and accuracy.

Quantification of antidiabetic oligocyclitols in seeds of *M. pruriens* by chromatographic and NMR techniques [26]

This study involved the combination of chromatographic and NMR techniques to demonstrate the presence and quantification of D-chiro-inositol and its two galacto-derivatives in *M. pruriens* seeds showing the anti-glycaemic effect. The results of the study revealed that the amount necessary to obtain a significant antidiabetic effect is about 7 mg pure D -chiro-inositol.

Electrochemical determination of L-Dopa in *M. pruriens* seeds, leaves and commercial siddha product using gold modified pencil graphite electrode [27]

A simple electrochemical method was developed for the determination of L-dopa present in the aqueous extracts of *M. pruriens* seeds (MPS), *M. pruriens* leaves (MPL) and Commercial Siddha Product (CSP).The gold modified pencil graphite electrode (GPGE) was used, that shows excellent electro catalytic activity towards the oxidation of both L-dopa and ascorbic acid (AA), with the separation of peak potential of 98mV. The differential pulse voltammetric (DPV) results indicated that the detection limit for L-dopa was 1.54mM (S/N=3).

PHYSIOLOGY

1. Antiparkinson's activity

An alternative medicine treatment for Parkinson's disease: results of a multicenter clinical trial. HP-200 in Parkinson's disease study group [28]

The efficacy and tolerability of HP-200, derived from *M. pruriens*, was examined in patients with Parkinson's disease. 60 patients (46 male and 14 female) with a mean (+/- SD) age of 59 +/- 9 years were treated in an open study for 12 weeks. Of these, 26 patients were taking

synthetic levodopa/carbidopa formulations before treatment with HP-200, and the remaining 34 were levodopa naive. HP-200, a powder (supplied as a 7.5 g sachet), was mixed with water and given orally. The Unified Parkinson's Disease Rating Scale (UPDRS) was used at baseline and periodically during the 12-week evaluation. Statistically significant reductions in Hoehn and Yahr stage and UPDRS scores were seen from baseline to the end of the 12-week treatment ($p < 0.0001$, t-test). The group mean (+/- SD) dose for optimal control of symptoms was 6 +/- 3 sachets. No significant adverse effects were seen in clinical laboratory reports, HP-200 developed from an alternative medicine source.

M. pruriens in Parkinson's disease: a double blind clinical and pharmacological study [29]

A randomised, controlled, double blind crossover trial was carried out on 8 Parkinson's disease patients with a short duration L-dopa response and on period dyskinesias completed. Patients were challenged with single doses of 200/50 mg LD/CD, and 15 and 30 g of mucuna preparation in randomised order at weekly intervals. On Compared with standard LD/CD, the 30 g mucuna preparation led to a considerably faster onset of effect (34.6 v 68.5 min; p=0.021), reflected in shorter latencies to peak L-dopa plasma concentrations. Mean on time was 21.9% (37 min) longer with 30 g mucuna than with LD/CD (p=0.021); peak L-dopa plasma concentrations were 110% higher and the area under the plasma concentration v time curve (area under curve) was 165.3% larger (p=0.012). No significant differences in dyskinesias or tolerability occurred. So, study proves that this natural source of L-dopa might possess advantages over conventional L-dopa preparations in the long term management of PD.

Neuroprotective effects of the antiparkinson drug _M. pruriens_ [30]

The present study evaluated the neuro restorative effect of *M. pruriens* cotyledon powder on the nigrostriatal tract of 6 hydroxydopamine 6-OHDA lesioned rats. *M. pruriens* cotyledon powder significantly increased the brain mitochondrial complex-I activity but did not affect the total monoamine oxidase activity (in vitro) as having Nicotine adenine dinucleotide (NADH) and coenzyme Q-10 in the cotyledon powder which are shown to have a therapeutic benefit in Parkinson's disease. Unlike synthetic levodopa treatment, *M. pruriens* cotyledon powder treatment significantly restored the endogenous levodopa, dopamine, norepinephrine and serotonin content in the substantia nigra.

Antiparkinson Drug – *M. pruriens* shows antioxidant and metal chelating activity [31]

The ability to scavenge DPPH radicals, ABTS radicals and reactive oxygen species demonstrated the antioxidant activity of *M. pruriens*. It significantly inhibited the oxidation of lipids and deoxyribose sugar and exhibited divalent iron chelating activity and did not show any genotoxic/mutagenic effect on the plasmid DNA. So, it revealed that neuroprotective and neurorestorative effect of *M. pruriens* which may be related to its antioxidant activity independent of the symptomatic effect. Along with this it is therapeutically safe in the treatment of patients with Parkinson's disease.

2. Aphrodisiac activity

A proton NMR study of the effect of *M. pruriens* on seminal plasma metabolites of infertile males [32]

For the study of impact of *M. pruriens* seeds on the metabolic profile of seminal plasma of infertile patients the proton nuclear magnetic resonance H^1NMR) spectroscopy was used. *M. pruriens* seed powder were administered to180 infertile patients for a period of three months and for the comparison, a total of age-matched healthy men control (n=50) group was studied. By H^1NMR spectroscopy, Lactate, citrate, glycerophosphocholine (GPC), choline, alanine, histidine, phenylalanine, tyrosine, uridine and glutamine were measured in seminal plasma and by using the standard laboratory methods and RIA, respectively, the degree of infertility and extent of hormonal imbalance induced by this milieu, separate sperm concentration, motility, lipid peroxide in seminal plasma and LH, FSH, T, and PRL hormone concentration in serum were examined and it was found that *M. pruriens* therapy rectifies the perturbed alanine, histidine, GPC, citrate and phenylalanine content in seminal plasma and improves the semen quality of post-treated infertile men with compared to pre-treated and along with this clinical variables in seminal plasma and blood serum were also improved over post therapy in infertile men. So it was concluded that *M. pruriens* seed powder rejuvenates the harmonic balance of male reproductive hormones in infertile men and reactivates the enzymatic activity of metabolic pathways and energy metabolism.

***M. pruriens* reduces stress and improves the quality of semen in infertile men** [33]

To study the effect of *M. pruriens* in infertile men who were under psychological stress, trial was performed on 60 males having psychological stress predicted on the basis of a questionnaire and elevated serum cortisol levels, compared with the 60 Age-matched healthy men with normal semen parameters and who had previously initiated at least one pregnancy

were included as controls. Their semen sample was collected before the treatment proceeds and then *M. pruriens* seed powder (5 g day−1) administered them orally. After 3 months of treatment again the semen sample was collected for carrying out morphological and biochemical analysis. Studies proves that on treatment with *M. pruriens* significantly improves psychological stress and seminal plasma lipid peroxide levels along with improved sperm count and motility and also restored the levels of SOD(Super Oxide dismutase), catalase, GSH(Glutathione) and ascorbic acid in seminal plasma of infertile men which was found to be low before the treatment.

Dose and time-dependent effects of ethanolic extract of *M. pruriens* Linn. seed on sexual behaviour of normal male rats [34]

This involves the study of effects of ethanolic extracts of the *M. pruriens* seed on general mating behaviour, libido and potency of normal male Wister albino rats. The results indicated that it produced a significant and sustained increase in the sexual activity of normal male rats at a particular dose (200 mg/kg) by enhancing the various sexual activity like mounting frequency, intromission frequency and ejaculation latency.

Effect of *M. pruriens* on semen profile and biochemical parameters in seminal plasma of infertile men [35]

The study involves the investigation of the effect of *M. pruriens* seeds on semen profiles and biochemical levels in seminal plasma of infertile men. 60 infertile males are compared with 60 normal healthy fertile men (controls). The results show that it significantly inhibited lipid peroxidation, elevated spermatogenesis, and improved sperm motility. Treatment also recovered the levels of total lipids, triglycerides, cholesterol, phospholipids, and vitamin A, C, and E and corrected fructose in seminal plasma of infertile men.

***M. pruriens* improves male fertility by its action on the hypothalamus–pituitary–gonadal axis** [36]

It involves the study of mechanism of action of *M. pruriens* in the treatment of male infertility. The clinical trial was performed on 75 normal healthy fertile men (controls) and 75 men undergoing infertility. Serum T (Testosterone), LH (luteinizing Hormone), FSH (Follicle Stimulating Hormone), PRL (Prolactin Hormone), dopamine, adrenaline, and noradrenaline in seminal and blood plasma were measured before and after treatment. After the treatment with *M. pruriens* significant improvement were observed in T, LH, dopamine, adrenaline, and nor-adrenaline levels in infertile men and reduced levels of FSH and PRL. Along with this

the sperm count and motility were also significantly recovered in infertile men after treatment.

***M. pruriens* and its Major Constituent L-DOPA Recover spermatogenic loss by combating ROS, loss of mitochondrial membrane potential and apoptosis** [37]

This involves the study of effect of *M. pruriens* and its major constituent L-DOPA (LD) on spermatogenic restorative efficacy. The experiment was carried out by generating a rat model with compromised spermatogenesis by administration of Ethinyl estradiol (EE) at a rate of 3 mg/kg body weight (BW)/day for a period of 14 days. MP and LD were administered in two separate groups of these animals starting 15th day for a period of 56 days, and the results were compared with an auto-recovery (AR) group. In all experimental groups, Sperm count and motility, testis histo-architecture, level of reactive oxygen species (ROS), mitochondrial membrane potential (MMP), apoptosis, peripheral hormone levels and testicular germ cell populations were analysed. The efficient and quick recovery of spermatogenesis in MP and LD groups was observed in comparison to the auto-recovery group. The treatment regulated ROS level, apoptosis, and mitochondrial membrane potential (MMP), recovered the hypothalamic-pituitary-gonadal axis and the number of testicular germ cells, ultimately leading to increased sperm count and motility.

3. Hypoglycemic activity

Evaluation of the anti-diabetic properties of *M. pruriens* seed extracts [38]

This involves the study of anti-diabetic properties of *M. pruriens* in wistar rats in which diabetes was induced by single intravenous injection of 120 mg/kg of alloxan monohydrate and different doses of the extract were administered to diabetic rats. Results were compared with normal and untreated diabetic rats. The administration of 5, 10, 20, 30, 40, 50, and 100 mg/kg of the crude ethanolic extract of *M. pruriens* seeds to alloxan-induced diabetic rats (plasma glucose > 450 mg/dL) resulted in 18.6%, 24.9%, 30.8%, 41.4%, 49.7%, 53.1% and 55.4% reduction, respectively in blood glucose level of the diabetic rats after 8h of treatment while the administration of glibenclamide (5 mg/kg/day) resulted in 59.7% reduction. Chronic administration of the extract resulted in a significant dose dependent reduction in the blood glucose level ($P<0.001$). It showed that the antidiabetic activity of *M. pruriens* seeds is present in the methanolic and ethanolic fractions of the extract.

Hypoglycemic effect of *M. pruriens* seed extract on normal and streptozotocin-diabetic rats [39]

This involves the study of hypoglycemic effect of aqueous extract of the seeds of *M. pruriens* investigated in normal, glucose load conditions and streptozotocin (STZ)-induced diabetic rats. In normal rats, the aqueous extract of the seeds of *M. pruriens* (100 and 200 mg/kg body weight) significantly (Pb 0.001) reduced the blood glucose levels after an oral glucose load from 127.5±3.2 to 75.6±4.8 mg% 2 h after oral administration of seed extract. It also significantly lowered the blood glucose in STZ diabetic rats from 240.5±7.2 to 90.6±5.6 mg% after 21 days of daily oral administration of the extract (Pb 0.001).Hence, it has an anti-hyperglycemic action.

Antihyperglycemic activity of *M. pruriens* on streptozotocin induced diabetes in rats and phytochemical evaluation by GC-MS [40]

This involves the study to identify the phytochemical constituents of *M. pruriens* extract by Gas Chromatography – Mass Spectrophotography (GC-MS) and to evaluate the hypoglycemic potential in streptozotocin induced diabetic rats. The rats were treated orally with the extract at 100 mg and 200 mg /kg b wt for 21 days. Biochemical parameters viz., fasting blood glucose (FBG), blood urea, serum creatinine and total cholesterol were analyzed. The analysis on GC-MS revealed the presence of phytochemicals like *n*-hexadecanoic acid (48.21 %), squalene (7.87%), oleic acid (7.62%) ascorbic acid (3.80%) and octadecanoic acid (6.21%) in the extract and the experimental study shows that *M. pruriens* reduced the blood sugar of diabetic rats from 242. 4 ± 9.2 mg/dl to 91.0 ± 5.2 mg/dl. Hence, it can be used as alternate medicine in the treatment of diabetes mellitus.

4. Antivenom activity

The protective effect of *M. pruriens* seeds against snake venom poisoning [41]

To study the protective effects of *M. pruriens* seed extract against the lethalities of various snake venoms or the effectiveness of anti-Mucuna pruriens (anti-MPE) antibody to neutralize the lethalities of snake venoms was investigated on the rats by in vitro neutralization, the rats were pre-treated with *M. pruriens* seed extract and challenged with various snake venoms. In vitro neutralization experiments proved that the anti–MPE antibodies effectively neutralized the lethalities of Asiatic cobra (Naja) venoms, but were not very effective against other venoms tested. On the basis of Indirect ELISA and immunoblotting, it was observed that there were extensive cross-reactions between anti-MPE IgG and venoms from many different

genera of poisonous snakes, suggesting the involvement of immunological neutralization in the protective effect of MPE pre-treatment against snake venom poisoning.

Blood chemistry of rats pretreated with *M. pruriens* seed aqueous extract MP101UJ after Echis carinatus venom challenge [42]

It involves the study of effect of a lethal Echis carinatus venom on serum enzyme levels and blood plasma coagulation parameters in rats that are pretreated with *M. pruriens* seed aqueous extract MP101UJ (21mg/kg body wt) 24h and 3wk before i.p. venom injection (0.50mg/kg rat) and other rats injected with venom alone (0.50mg/kg body wt).The enzyme levels and coagulation parameter levels were measured 4h after venom administration. The results showed that the increased enzymes lactate dehydrogenase (LDH), glutamic pyruvic transaminase (GPT), creatinine kinase (CK) and changed coagulation parameters D-Dimer and Quick levels due to the venom effect were inhibited by *M. pruriens* seed aqueous extract MP101UJ in pre-treated rats. Rats pre-treated with a single dose (21mg/kg and multiple doses 21mg/kg rat) of extract MP101UJ maintained the normal enzyme levels and showed an anticoagulant effect as evidenced by the high PTT level which was also observed in venom treated animals. D-Dimer and Quick values were normal. However, the extract MP101UJ appeared to significantly inhibit the lethal venom induced myotoxic, cytotoxic and coagulation activities in experimental animals.

5. Antioxidant activity

Studies on antioxidant activities of mucuna seed (*M. pruriens* var.) extract and various non-protein amino/imino acids through in vitro models [43]

This involves the study of antioxidant activities of a methanolic extract of Mucuna beans and several non-protein amino/imino acids, namely L-3,4-dihydroxyphenylalanine (L-dopa), L-3-carboxy-6,7-dihydroxy-1,2,3,4-tetrahydroisoquinoline,(−)-1-methyl-3-carboxy-6,7dihydroxy-1,2,3,4-tetrahydroisoquinoline and 5-hydroxytryptophan (5-HTP). All the tested compounds and the Mucuna seed extract showed excellent reducing power, by virtue of their hydrogen-donating ability and were to be more potent in free radical-scavenging activity in a dose dependent manner. All the tested compounds and the seed extract were shown free radical activity ($P < 0.05$) against α, α-di phenyl-β-picryl hydrazyl (DPPH) radicals. The tested compounds effectively scavenged the Hydroxyl radicals ($OH^{\bullet}$) and superoxide anion radicals ($O_2^{\bullet-}$). No such activity was found by 5-HTP up to a concentration of 2 mg ml/L, but it shows the highest peroxidation-inhibiting activity (95%).

6. Antimicrobial activity

Antibacterial activity of *M. pruriens* (L.) DC. var. pruriens – an ethnomedicinal plant [44]

This research involves the study of antibacterial activity of root and seed of *M. pruriens*. The hexane, petroleum ether, benzene, methanol and aqueous extracts of root and seed were tested against *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Bacillus subtilis*, *Pseudomonas aeruginosa*, *Salmonella typhi* and *Escherichia coli* using disc diffusion method. The results show that the extracts possess the various degrees of significant inhibitory effect against the tested organisms.

7. Anti-Depressant activity

Anti-depressant-like activity in rodent models of depression [45]

This involves the study of anti-depressant-like effects of *M. pruriens* in acute and chronic model of depression. Psycho-pharmacological investigation involved treatment (14 days) of mucuna in forced swim test (FST), tail suspension test (TST) in mice and olfactory bulbectomy in rats, respectively. The investigations results show the initial anti-depressant-like effect of Mucuna (10-20 mg/kg i.p.) or the mucuna (10 mg/kg) significantly enhanced the anti-depressant action of fluoxetine and bupropion in mice FST and TST respectively. Potentiation of 5-Hydroxytryptophan induced head twitches response (in mice) and reversal of reserpine induced hypothermia (rats) were observed at same dose level. Further, the behaviour anomalies exhibited by olfactory bulbectomised rats (OBX) were attenuated by chronic mucuna treatment as observed in open field.

8. Anti-Inflammatory activity

Effect of methanolic extract of *M. pruriens* seed on the immune response of mice [46]

This study involves evaluating the effect of the methanolic extract of *M. pruriens* seed in mice with respect to delayed hypersensitivity reaction (DTR), primary and secondary antibody response and in vivo inflammatory leucocyte mobilization. The extract caused elevation of secondary SRBCs-specific antibody titre with antibody response being significantly ($p<0.05$) increased at 250 and 500 mg/kg when compared with control. The results shows that the extract at 250 and 500 mg/kg produced significant ($p<0.05$) inhibition of DTR in mice by 33.33% and 28.89%, respectively and hence, can probably influenced immune response in mice.

Benefits of *M. pruriens* [47]

Improved sleep (promotes deep sleep) , reduced body fat & decreased cellulite , decreased wrinkles, improved skin texture & appearance , increased bone density and reversal of osteoporosis, increased lean muscle mass , improved mood and sense of well-being , enhanced libido & sexual performance, increased energy levels , improved cholesterol profile & regeneration of organs (heart, kidney, liver, lungs , dramatically strengthen immune system**.**

Side effects of *M. pruriens* [6, 48]

Increased serum levels of L-Dopa from consumption of Mucuna bean leads to high concentration of dopamine in peripheral tissues. It induces antiphysiological effects such as nausea, vomiting, anorexia, paranoid delusions, hallucinations, delirium and unmasking dementia**.** The most common side effects found in the body is a sensation of abdominal bloating and nausea. Other side effects observed during cowhage preparations include headache, pounding heartbeat, and symptoms of psychosis including confusion, agitation, hallucinations, and delusions. The hair of the cowhage bean pod is a strong irritant and can cause severe itching, burning, and swelling if it is taken by mouth or applied to the skin. Less common side effects include vomiting, abnormal body movements, and insomnia.

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