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Review Article

Universal Aspects of the Genus *Mucuna* and the Properties Describe of *Mucuna urens* and *Mucuna pruriens*

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ABSTRACT
The plant genus *Mucuna* comes from the family Fabaceae, subfamily Papilionaceae. At present, about 100 species of climbing shrubs of the genus *Mucuna* have been found, among which *Mucuna pruriens* and *Mucuna urens* stand out, due to the large number of pharmacological properties they possess. We sought to exemplify some of the most important uses, as well as pharmacological and nutritional properties that have been found over the years in *Mucuna urens* and *Mucuna pruriens*. Plants of the genus *Mucuna* have been used in various areas worldwide because they possess a large number of phytoconstituents that give them multiple properties. These plants have stood out for their nutritional value, their antioxidant activity, and their properties to treat various pathologies.
Keywords: Antioxidants, *Mucuna*, *Mucuna pruriens, Mucuna urens*, Nutritive value, Pharmacological properties.

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INTRODUCTION

Phytochemicals are plant chemicals non-nutritive that have protective or preventive properties for different pathologies. They are non-essential nutrients, which means that the human body does not need them to perform their vital functions. It is well known that plants produce these chemicals to protect themselves, but recent research shows that they can also protect humans against disease, pathogenic microorganisms, or antioxidants. Some foods, such as whole grains, vegetables, beans, fruits, and herbs, contain many phytochemicals.[1]

The plant genus *Mucuna* comes from the family Fabaceae, subfamily Papilionaceae.[2] At present, about 100 species of climbing shrubs of the genus *Mucuna* have been found. This genus is found worldwide in tropical forests, especially in the Caribbean, India, and Africa.[3] The seeds of this genus contain a high amount of fiber, carbohydrates, and proteins; minerals and essential amino acids, and low levels of lipids, making them of great interest in the area of research.[4]

Mucuna pruriens (Fabaceae) is a legume widely used in Mesoamerica. This plant has long, slender branches, lanceolate leaves, and white flowers with a bluish color. The pods or legumes are hairy, thick, and leathery, averaging 4 inches long. They contain four to six seeds. They are dark brown and densely covered with stiff hairs.[5,6]

M. pruriens has traditionally been used as a food source for certain ethnic groups in several countries. It is cultivated in Asia, America, Africa, and the Pacific Islands, where its pods are used as vegetables for human consumption, and its young leaves are used as animal fodder. It is widespread in tropical and subtropical regions of the world.[5]

In addition, it contains a large number of phytoconstituents such as tannins, flavonoids, alkaloids, and phenolic compounds that attribute various pharmacological properties to it.[7] This plant has been widely studied for its therapeutic effects against Parkinson's disease, against the effects of snake bites, male sexual disorders, among others.[5]

On the other hand, the *Mucuna urens* plant is commonly known as ox-eye or pica-pica and is characterized by being a vine of extensive growth.[8,9] The fruits of this plant have legume pods with four or three seeds and when ripe, they are divided by dorsal sutures. Its seeds are black when dry and lack endosperm.[10]

M. urens has a very wide distribution throughout the planet, as it usually grows in tropical rainforests.[8,9] in places such as Asia and America, including Costa Rica. In the latter, it can be found in forests and undergrowth in the central valley, as well as in the hot lands of the Pacific, in the Monteverde cloud forest, in mangroves, hills, secondary growths, and even on the coasts.[8]

However, the search for contraceptive methods in men has encouraged the study of this plant, since cases have been reported in which semen consistency

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and sperm motility are affected in people living near places where the plant is widely cultivated and consumed.[11] In addition, *M. urens* is a very easily accessible plant with great nutritional value.[12-14]

Based on all of the above, this research aimed to exemplify some of the most important uses, as well as pharmacological and nutritional properties that have been found over the years in *M. urens* and *M. pruriens*.

DISCUSSION

Mucuna urens

Antispermatogenic activity

In recent years, several *in vivo* assays have been carried out to study the male contraceptive activity of *M. urens* seeds. Thus, in one of them, the effect of an orally administered crude extract of *M. urens* on the gonads and sexual accessory glands of adult male guinea pigs was investigated. In this assay, it was found that there was no pregnancy in the females mated to the treated males without showing loss of libido in these groups. In addition, in the experimental groups of this trial, degeneration of spermatozoa in the lumen, arrest of spermatogenesis in the sperm stage, and a reduction in the secretion of the prostate glands and seminal vesicle were observed. It is noteworthy that with increasing doses of *M. urens* extract the anti-sperm effects were intensified.[11]

In addition, in a similar study performed with albino rats, they demonstrated the anti-spermatogenic effects of an ethanol extract of *M. urens*, in which it was observed that in all treatment groups there was a significant dose-dependent reduction in sperm count and motility, as well as alterations in sperm morphology, including unusual head with large acrosome, looped cord, distal drop midpiece, pinhead, pyriform head and long hook.[15]

On the other hand, a group of scientists performed a histomorphological evaluation of the testes of mice exposed to an ethanolic extract of *M. urens* seed for 7 days. The structures analyzed were blood vessels, seminiferous tubules, and connective tissues. In the different groups of mice in this experiment, it was observed that the severity of the lesions of the testicular structures increased with the dose and duration of the treatment, since, in the group with the highest dose, all these structures were highly degenerated and eroded compared to the group with the lowest dose. For this reason, the scientists concluded that the ethanolic extract of *M. urens* seeds may cause impaired fertility by altering the ultrastructure of the testes.[16]

It has also been shown that administering different doses of methanolic extracts of *M. urens* influences sexual behavior and sperm parameters. In an investigation with male albino rats, some parameters of sexual behavior were significantly altered, such as an increase in the mounting latency and a decrease in the intrusion latency compared to the negative control and positive control group, and it was found that the frequency of mounting and intrusion were dependent on the dose administered. In addition, no effect on erection frequency or latency was shown. When the effect of the extract on spermatozoa mortality was analyzed, it was found that the lowest dose achieved a higher percentage of active spermatozoa concerning the high and intermediate doses. Finally, there was a distortion in the morphology of the spermatozoa, where they had curved and bent necks and others with a thin body.[17]

On the other hand, a dominant lethal mutation assay was performed in rats treated with an ethanolic extract of *M. urens* seeds for 14 days. It was observed that the females exposed to the control group and the group that received the lowest dose had implants in the uterine horn; the other treatment groups had no implants, obtaining 100% lethal mutations. These results are attributed to the induction of dominant lethal mutations in early spermatocytes and spermatids in male albino rats.[18]

Although the potential effect of *M. urens* plant seed extract as a male contraceptive has been demonstrated in animals, which can be used for profit, a group of scientists investigated whether processed *M. urens* still possesses this effect, since this seed is used in the food industry and can generate undesirable effects in the male population. For this purpose, its effect on testicular and epididymal weight, conception rate, sperm count, sperm viability, and sperm head abnormality was investigated.[19]

It is concluded that rats treated with processed *M. urens* seeds showed no significant effect on testis and epididymal weights, yet epididymal sperm counts and epididymal viability were dependently reduced compared with the control. In addition, conception rates were significantly reduced in a dose-dependent manner. Thus seeds, even when processed, can have a toxic effect on reproductive endpoints. Therefore, its indiscriminate use in the food industry could result in reduced spermatogenic activities or infertility, reproductive toxicity, and dysfunction in men.[19]

Nutritional Value

Several investigations have shown that *M. urens* have a high content of essential amino acids compared to those reported for *M. pruriens*.[13,20] The cysteine, tyrosine, and methionine contents are exceptions to the above-mentioned.[12,13] Cystine values ranged from 411 mg /100 g in the cooked sample to 782 mg/100 g in the raw sample. Tyrosine ranged from 722 mg/100 g in the germinated sample to 1.23 g/100 g in the autoclaved sample, and methionine values were the lowest (1.02 g /100 g) in the germinated sample, but the highest (1.73 g/100 g) in the raw sample. Methionine content is within the range (1.16-1.32 g/100 g) reported for *Mucuna*. Lysine, methionine, and cystine are the most susceptible to loss of bioavailability during processing as a result of oxidation or reactions with other food components.[12]

One investigation compared the amounts of amino acids present in *M. urens* with soybeans. This information is compiled in the following Table 1.[14]

Crude protein values are comparable to those reported for some *Mucuna* species.[20] The results are expressed with dry matter composition. Crude protein ranged from 24.3 g/100 g crude sample to 27.1 g/100 g autoclaved sample. Crude protein values for raw and cooked samples were 24.3 g/100 g and 25.1 g/100 g, respectively. The results for roasted (26.5 g/100 g), sprouted (26.5 g/100 g), and autoclaved (27.1 g/100 g) are higher than those reported previously. However, the results are within the crude protein range of 23 to 35 g/100 g reported for *Mucuna* beans. The higher crude protein levels observed in the cooked, roasted, and autoclaved samples could be attributed to the treatment effect, as previous reports indicate that cooking and roasting improve the nutritional values of food legumes.[12]

Fermentation was shown to significantly increase the crude protein content of *M. urens* flour samples from 13.42 to 18.63%. This could be attributed to the increase in microbial mass during fermentation, which leads to extensive hydrolysis of protein molecules to amino acids. It is because of the above that fermented *M. urens* flour could be used as a source of protein in the diet, as well as a protein supplement in the processing of some foods. In addition, *M. urens* contains a high water absorption capacity which indicates that its flour can be used as a thickening agent in the preparation of soups and baked products.[21]

M. urens reported a total carbohydrate content that ranged between 72.39 g and 75.49 g/100 g. This suggested that this plant corresponds to a good source of carbohydrates.[20] However, the fermentation process decreases the carbohydrate values significantly in contrast to the unfermented *M. urens* flour samples. This could be due to the bioconversion of the substrate that is usually accompanied by the release of heat.[21]

Table 1: Amino acid and crude protein composition of *M. urens* seeds compared with soybeans.[14]

Amino Acids	Mucuna (g/100g protein)	Soybean (g/100 g protein)
Lysine	6.57±0.3	6.14
Histidine	2.20±0.1	2.68
Arginine	0.65±0.2	9.09
Aspartic acid	10.82±0.3	12.74
Threonine	4.46±0.2	4.26
Serine	5.75±0.2	6.09
Glutamic acid	13.41±0.4	10.71
Proline	4.28±0.2	5.63
Glycine	2.56±0.2	4.34
Alanine	4.14±0.1	4.40
Cystine	4.01±0.2	1.14
Valine	4.55±0.2	5.17
Methionine	1.70±0.1	1.20
Isoleucine	3.30±0.2	5.48
Leucine	8.26±0.3	8.66
Tyrosine	5.08±0.2	3.50
Phenylalanine	6.70±0.2	6.10

Three morphotypes of *M. urens* were tested. For calcium content, morphotypes 1 and 3 were 0.33 g and 0.31 g in 100 g total, respectively, while that of morphotype 2 was 0.07 g in 100 g total, indicating that morphotypes 1 and 3 had five times more calcium than morphotype 2. Also, iron was found to be absent in morphotype 1, while morphotypes 2 and 3 had iron contents of 2.20 mg and 13.80 mg in 100 g total, respectively. Potassium content ranged from 3.00 to 8.74 g in 100 g total.[20]

The ascorbic acid content of morphotype 1 (17.10 g) and morphotype 3 (14.05 g) in 100 g of product was significantly higher than that of morphotype 2 (11.24 g). In addition, *M. urens* showed an oxalate content that ranged between 2.14-2.25 mg in 100 g, which corresponds to low values, considering that the limit for this is 10 mg oxalate/ration. It should be noted that oxalate has a detrimental effect on nutrient absorption by the body. It is one of the known anti-nutritional factors in plants. Depending on its form, it can bind calcium or magnesium to foods undergoing digestion and, therefore, can make these unavailable to the body.[20]

Also, processed *M. urens* beans have higher zinc values than unprocessed raw samples. Sprouted and roasted beans contain more manganese than cooked, autoclaved, and raw beans. However, sprouted, roasted, and cooked *Mucuna* bean samples contain more sodium than raw and autoclaved beans. Overall, while processing may improve the concentrations of potassium, sodium, manganese, copper, and zinc in *M. urens* beans, the same cannot be said for phosphorus, calcium, magnesium, and iron.[12]

Regarding the variation in the number of minerals present in *M. urens* after the fermentation process, Table 2 shows the result of the mineral composition of unfermented and fermented *M. urens* samples. The iron content was significantly higher in fermented flour compared to unfermented flour (UMUA). It ranged from 6.15 mg in 100 g UMUA to 8.75 mg in 100 g in the 72-hr fermented sample (FMUD). The magnesium content in the flour samples decreased from 83.66 mg in UMUA to 70.33 mg / 100 g in FMUD. All samples were significantly different. The most abundant mineral in *M. urens* flour was potassium. An observable difference was noted where there was a significant decrease from 500.00 mg / 100 g in UMUA to 85.00 mg / 100 g in FMUD. Phosphorus had an increase from 185 mg / 100 g UMUA to 340.00 mg / 100 g FMUD. Sodium content decreased from 10.30 mg to 2.30 mg / 100 g in UMUA and FMUD, respectively.[21]

Table 2: Effect of fermentation on mineral composition (mg/100 g) in different samples of *M. urens*.[21]

Code	Iron	Magnesium	Potassium	Phosphorus	Sodium
UMUA	6.15±0.07	83.66±0.57	500.00±10.00	185.00±1.00	10.30±0.36
FMUB	6.50±0.39	80.00±1.00	350.00±10.00	236.06±2.00	7.56±0.51
FMUC	7.85±0.39	74.00±1.00	250.00±10.00	256.6±1.00	4.27±0.25
FMUD	8.75±0.83	70.33±1.52	85.00±5.00	340.00±2.00	2.30±0.48

Values are means ± SD of determination in triplicate.
Means in the same column with different superscripts are significantly different at (p<0.05). UMUA = unfermented *Mucuna urens* flour (Control), FMUB = fermented *Mucuna urens* flour (24 hr), FMUC = fermented *Mucuna urens* flour (48 hr), FMUD = fermented *Mucuna urens* flour (72 hr).

Feed value in broiler diets

Another property of *M. urens* seed that has been studied is its nutritional value in the diet of broiler chickens to partially substituting soybean meal to reduce production costs in this industry. Several studies have been carried out in which soybean meal is replaced by *M. urens* meal in different percentages, where the results showed that the increase in the percentage of *M. urens* meal in the diet does not significantly influence final body weight, average weekly weight gain, average weekly feed intake and feed conversion rate.[22,23]

Likewise, it was observed that birds fed a meal diet with more than 15% *M. urens* had a significantly higher production increase per day. In addition, the average egg weight increased significantly, so feed efficiency and egg quality were not significantly influenced by the treatments.[24]

On the other hand, scientists indicate that processed *M. urens* meal could replace soybean meal by up to 60% in the diet to obtain higher economic returns, since the cost/kg of feed, the cost of feed consumed and the cost/kg of weight gain were significantly reduced when replacing soybean meal.[22,23] This had no detrimental effect on laying performance and egg quality.[24]

Cytoprotective activity

The hydroalcoholic extract of *M. urens* at different concentrations has been shown to have a cytoprotective and proliferative effect on an *in vitro* culture of PC-12 cells treated with increasing doses of 6-OHDA. PC-12 cells are a cell line derived from rat adrenal medulla pheochromocytoma (Rattus norvegicus). These cells are widely used as a model of Parkinson's disease because they are catecholaminergic cells and secrete the catecholaminergic neurotransmitters, dopamine, and norepinephrine.[25]

Among the main findings obtained was a considerable proliferation of cells incubated at concentrations of 0.05 and 1 mg/mL of the extract. In addition, a cytoprotective effect, presumably of antioxidant character, was observed in cells preincubated with 0.25 mg/mL of extract at concentrations of 0.20 and 0.30 mmol/L of neurotoxin. This study was able to prove the proliferative and cytoprotective capacity *in vitro* of the hydroalcoholic extract of *M. urens*.[25]

Treatment of Parkinson's disease

Currently there is no drug that can stop or slow the progression of Parkinson's disease, which is why in recent years, medicinal plants have been studied as an alternative solution to this problem. The powder from the seeds of *M. urens* contains a high concentration of L-Dopa, which is why it has been used over the years in traditional Indian medicine for the treatment of Parkinson's disease.[25]

The Neuroscience Research Program of the University of Costa Rica has conducted several *in vivo* trials using crude extracts of *M. urens*. The most relevant results obtained were that the combination of *M. urens* with carbidopa is more effective than the administration of L-Dopa with carbidopa.[25]

Mucuna Pruriens

Antimicrobial Activity

The antimicrobial activity of the alcoholic extract of *M. pruriens* leaves has been studied by qualitative and quantitative methods, such as disk diffusion (widely used to investigate the antimicrobial activity of natural substances and plant extracts) and cup-plate methods against various microorganisms, using different concentrations.[26]

A preliminary phytochemical study performed on methanol extracts of *M. pruriens* root and seed revealed the presence of alkaloids, anthraquinones, flavonoids, phenols, tannins, terpenoids, and xanthoprotein. These extracts were tested against *Staphylococcus aureus, Klebsiella pneumoniae, Bacillus subtilis, Pseudomonas aeruginosa, Salmonella typhi* using the disk diffusion method. In them, it was observed that hexane, petroleum ether, benzene, methanol, and aqueous extracts of root and seed of *M. pruriens* were shown to possess various degrees of significant inhibitory effect against the organisms tested.[1]

Another study was conducted comparing the antimicrobial activity of *M. pruriens* extracts against the standard drug streptomycin. As shown in Table 3, *M. pruriens* showed maximum activity at 240 mg/ml against all bacterial strains and competes with streptomycin at a concentration of 1 mg/ml. The antimicrobial activity of *M. pruriens* may be due to the presence of tannins, flavonoids, alkaloids,[26] which were also found, as mentioned above.

Antioxidant activity

Antioxidants can provide resistance against oxidative stress by scavenging free radicals and thereby prevent disease. The antioxidant principles in *M. pruriens* leaf extract compete with oxygen to react with nitric oxide by inhibiting nitrite generation. The antioxidant activity exhibited by the extract may be due to the presence of tannins, flavonoids, alkaloids, and amino acids from its leaves.[26]

One trial evaluated the antioxidant activity of *M. pruriens* and compared it with that of L-Dopa. The phenolic concentration of plant seeds was quantified using Folin-Denis reagent and antioxidant activity. The results showed that *M. pruriens* has a high antioxidant capacity, although it is not superior to the antioxidant capacity of isolated L-Dopa.[1]

Table 3: Antibacterial activity of the alcoholic extract of *M. pruriens*.[26]

Inhibition zones (mm)							
	Mucuna pruriens (mg/mL)						Streptomycin (1 mg/mL)
Microorganism	240	160	80	40	20	5	
Staphylococcus aureus	45	15	12	0	0	0	21
Escherichia coli	28	13	0	0	0	0	24
Bacillus subtilis	38	14	12	11	0	0	26
Pseudomonas aeruginosa	34	18	17	14	0	0	22

Another *in vitro* and *in vivo* study was performed using an alcoholic extract of *M. pruriens* seeds to study its antioxidant activity, as well as its effect on the oxidation of GSH content, iron-induced lipid peroxidation, and its interaction with superoxide and hydroxyl radicals. In this study, it was possible to demonstrate that *M. pruriens* seeds affect lipid peroxidation through the elimination of hydroxyl radicals and superoxides.[27]

Moreover, *M. pruriens* extract exhibited a marked free radical scavenging effect and the antioxidant activity of the extract was further confirmed by evaluating nitric oxide scavenging with an IC_{50} value of 97 ug/ml and reducing power activity with an IC_{50} value of 205 ug/ml, as seen in Table 4. The *M. pruriens* extract effectively scavenged the free radical in nitric oxide (NO) and reduced the power in a dose-related manner.[26]

The lipid peroxidation assay shows the CI50 value of 140 µg/ml, this activity may be related to the H^+ ion donating ability of the extract, which scavenges the peroxyl radical to inhibit the peroxidation chain.[26]

Nutritional Value

As a source of nutrients, *M. pruriens* is an exceptional plant. It is a good food source as it is rich in crude protein, essential fatty acids, starch content, and certain essential amino acids.[1] *M. pruriens* seeds contain an average of 314.4 g of crude protein per kilogram. Due to the presence of relatively high levels of crude fat and protein, the seeds appear to be a rich source of energy. In addition, boiling generates a 3.59% increase in the crude protein content of the seed, and roasting causes a 6.26% increase.[28]

The presence of detergent fiber in *M. pruriens* is 213.0 g and 96.0 g per kilogram for neutral detergent fiber and acid detergent fiber, respectively. This reveals that the seeds can be used as a source of fiber, in addition to the fact that fiber helps to maintain the health of the gastrointestinal tract.[28]

M. pruriens seeds exhibit globulins and albumins as the main proteins, as well as lipids that are rich in unsaturated fatty acids such as oleic acid and linoleic acid, in addition to monounsaturated and polyunsaturated fatty acids, which together account for 70.85% of these. Although the seeds contain high levels of protein, their digestibility and utilization are poor due to the presence of certain anti-nutritional compounds.[28]

However, processing caused a reduction in the levels of all anti-nutritional factors according to an investigation carried out. Table 5 shows that boiling causes a 39.68% reduction in tannin level, while roasting causes a 30.16% reduction in tannin level concerning the raw sample. Boiling

Table 4: Antioxidant activity of the alcoholic extract of *M. pruriens* leaves in various methods.[26]

S. No.	Concentration (µg/ml)	% inhibition			
		DPPH	NO	Lipid peroxidation	Reducing power
1	3	7.2	6.40	7.9	8.1
2	6	13	10.40	12.2	10.5
3	12	18.2	16.14	20.1	17.5
4	25	27.1	27.33	29.2	22.7
5	50	35.2	34.10	39.3	29.7
6	100	42	52.40	56	33.5
7	200	53	63	68	48.6
8	400	79	66	78	65.9
9	800	80	69	85	86.4
10	CI50	187.5	97	140	205

Values are the average of 3 repetitions.

Table 5: Percentage change in the levels of anti-nutritional factors due to processing.[28]

Treatment	Tannins (mg /100 g)	Phytic acid (mg /100 g)
Raw seed	-	-
Boiled seed	39.68 (-)	59.30 (-)
Roasted seed	30.16 (-)	24.37 (-)

(+) = increased %, (-) = decreased %.

was more effective in reducing phytic acid causing a 59.30% loss while roasting caused a 24.37% reduction. This reduction in phytic acid levels increases the availability of minerals in the digestive tract of the animals as the chelating capacity of phytic acid is reduced.[28]

Treatment for Parkinson's disease

Parkinson's disease is a degenerative neurological disease that affects approximately 1.5% of the world's population over the age of 50. In this disease, there is a deficiency of dopamine, due to a gradual loss of dopaminergic neurons in the substantia nigra pars compacta, which causes motor symptoms such as bradykinesia, resting tremor, and muscle rigidity.[29] Also, poor movement, difficulty with balance and walking, depression, and dementia may occur due to this dopamine insufficiency. Due to the cause of this disease, L-dopa is the most effective treatment for this disease.[30,31]

Since 1937 it was discovered that *M. Pruriens* seeds are rich in L-dopa, but until 1960 it was related to be a treatment for Parkinson's disease.[32] The activity of *M. Pruriens* against this disease has been highly studied due to its high content of L-dopa and its neuroprotective effects, which regenerate dopamine in the brain and thus counteract the motor effects, although it cannot cure the disease since it is a neurodegenerative disease and therefore, treatment must be taken for life. Its therapeutic and adverse effects result from its decarboxylation into dopamine by the enzyme decarboxylase. L-Dopa is administered instead of dopamine because dopamine cannot cross the blood-brain barrier.[2,33-37]

In a 2004 study, its antiparkinson activity is significantly higher compared to synthetic L-Dopa in the 6-hydroxydopamine (6-OHDA)-injured rat models of Parkinson's disease. The study evaluated the neurorestorative effect of *M. pruriens* cotyledon powder on the nigrostriatal tract of 6-OHDA-injured rats. *M. Pruriens* cotyledon powder significantly increased brain mitochondrial complex activity, but did not affect total monoamine oxidase activity (*in vitro*), unlike treatment with synthetic L-Dopa.[38]

Treatment with *M. pruriens* cotyledon powder significantly restored endogenous L-Dopa, dopamine, norepinephrine, and serotonin content in the substantia nigra. Nicotine adenine dinucleotide (NADH) and coenzyme Q-10 were shown to have therapeutic benefits in Parkinson's disease and were present in *M. pruriens.* Although previous studies showed that treatment with *M. Pruriens* controls the symptoms of Parkinson's disease, this essay demonstrates an additional finding of a neurorestorative benefit in degenerative dopaminergic neurons in the substantia nigra, which may be due to increased complex I activity and presence of NADH and coenzyme Q-10.[38]

Protection against snakebite

Snakebite mortality is a serious public health problem and available therapies are known to induce a debilitating effect. Traditional medicine suggests that *M. pruriens* seeds may provide protection against the effects of such a bite. A 2015 study sought to identify which protein neutralized snake venom and to unveil its mechanism of action, and MP-4 was determined to be the one sought.[39]

However, after several structural biochemical tools, it became evident that MP-4 did not offer direct protection against snake venom, since it is an inhibitor of serine proteases, but the antibodies generated against MP-4 cross-react with all the venom and provide protection to mice against it. Therefore, from this study it can be concluded that MP-4 can be added as an effective adjuvant in prophylactic preparations for protection against snake envenomation.[39]

Likewise, a trial was conducted to investigate the neutralizing effects of *M. pruriens* seeds and *Mimosa pudica* extracts on the venom of *Bitis arietans* and *Naja nigricollis.* For this purpose, the LD_{50} of the extracts of these plants was analyzed at a concentration of 50 mg/ mL in mice. It was found that these plants neutralize the fibrinolytic activity of *Naja nigricollis*, however, to neutralize the activity of *Bitis arietans* they need a higher concentration. In addition, it was shown that *M. pruriens* can suppress hemolysis caused by *Naja nigricollis* venom by 70%. It was concluded that *M. pruriens* and *M. pudica* have properties that allow them to be promising antivenoms.[40]

Effect on sexual behavior in rats

Sexual dysfunction is a common problem with increasing prevalence and etiological factors, including degenerative diseases, increased injuries and stress associated with industrialized lifestyles. Sexual dysfunction can be treated by medical and surgical treatment modalities; however, herbal and plant-derived remedies continue to be a popular alternative for improving one's sex life despite the availability of conventional medical treatments. In many countries, different varieties of plants have been used as sexual stimulants in traditional medicine.[41]

According to Indian medicine, since ancient times *M. Pruriens* has been used to treat male sexual disorders, therefore, several studies have been conducted where the effects of ethanolic extracts of *M. Pruriens* seed on general mating behavior, libido and potency of albino rats have been observed, as well as its efficacy on male sexual behavior and sperm parameters in long-term hyperglycemic male rats. In a study, it was demonstrated this effect of the ethanolic extract of *M. Pruriens*, so they used albino rats and compared the result with a drug evaluated as a reference standard (sildenafil citrate). The experimental groups were divided according to the dose to be extracted and were fed orally with saline solution or extract or standard drug once a day for 45 days. To analyze mating behavior, female rats in the estrus phase were used.[41]

The administered extract significantly increased mounting frequency, ejaculation latency, and decreased mounting latency. The potency test significantly increased erections, fast lunges, long lunges, and total reflexes. Therefore, the results indicated that ethanolic extracts of *M. pruriens* seed produced a significant and sustained increase in sexual activity of the normal male at a particular dose (200 mg/kg). Compared with the control, all drug-treated groups have shown drug-induced effects for some parameters.[41]

On the other hand, as for hyperglycemic rats, the conducted study reveals the potential efficacy of ethanolic seed extract of *M. pruriens* in improving sexual behavior with androgenic and antidiabetic effects in streptozotocin induced diabetic males rats. Furthermore, it supports the use of *M. pruriens* in the Indian system of medicine as a sexual invigorant in diabetic conditions.[42]

These studies are related to others along the same lines evaluating the use of *M. pruriens* in male sexual disorders, making use of rats. In another study conducted in 2011, it was determined that lipid-based extraction with the method for *M. pruriens* is fast and provides better extraction capacity concerning L-DOPA, in addition, it has improved the therapeutic effects of *M. pruriens* and male sexual behavior in animals.[43]

Treatment for infertility

Infertility can be defined as the lack of pregnancy after 1 year of unprotected sexual intercourse and is the manifestation of one or more pathological conditions of male or female origin. According to studies, *M. pruriens* seed powder helps to combat stress-mediated, poor semen quality and acts as a restorative and invigorating tonic or aphrodisiac in infertile subjects.[44]

A 2009 study investigated the possible effects of *M. Pruriens* on seminal plasma and blood, dopamine levels, sex hormones, and semen quality using 75 normal healthy men and 75 infertile men. In addition, the research was conducted using a high-performance liquid chromatography assay for the quantification of dopa, adrenaline, and noradrenaline in seminal plasma and blood. Infertile men were prescribed *M. pruriens* seed powder, (5g/d), orally, in a single dose with milk for 3 months. Semen and blood samples were collected before administration of the drug and after 3 months of treatment.[44]

As a measure of biochemical factors correlated with male and infertility, dopamine, noradrenaline, and adrenaline levels were observed to decrease in seminal plasma as well as serum of infertile men. The decreased dopamine levels were associated with a decrease in serum T and Luteinizing hormone (LH) levels in all three infertile groups (normozoospermic, oligozoospermic, and asthenozoospermic) and with a significant increase in prolactin (PRL) and follicle-stimulating hormone (FSH) in the oligozoospermic infertile men. However, after treatment with *M. pruriens* there was a significant improvement in dopamine, noradrenaline, and adrenaline levels, as well as in T and LH levels. In addition, PRL and FSH levels decreased in infertile men after treatment; therefore, this study provides evidence that *M. pruriens* treatment regulates steroidogenesis and improves semen quality in infertile men.[44]

Hypoglycemic effect

A trial was carried out to study the hypoglycemic effect of the aqueous extract of *M. pruriens* seeds in normal rats and streptozotocin-induced diabetic rats. In this study, it was obtained that when using the seed extract of this plant, blood glucose levels were significantly decreased after an oral glucose load. In addition, it significantly reduced blood glucose levels in diabetic rats after consuming the extract daily for 21 days. Due to the above, it was concluded that *M. pruriens* has anti-hyperglycemic action.[45]

Another trial was conducted to study the antidiabetic properties of *M. pruriens*. For this purpose, diabetes was induced by injection of alloxan monohydrate in Wistar rats. It was observed that when 5, 10, 20, 30, 30, 40, 50, and 100 mg/kg of the crude ethanolic extract of *M. pruriens* seeds were administered to diabetic rats, a reduction in blood glucose levels of 18.6%, 24.9%, 30.8%, 41.4%, 49.7%, 53.1%, and 55.4% was obtained after the administration of this extract. On the other hand, it was compared with a group of diabetic rats which were administered 5 mg/kg/day of glibenclamide, and a reduction in blood glucose of 59.7% was obtained. It was concluded that chronic administration of *M. pruriens* demonstrated a significant dose-dependent reduction in blood glucose levels and resulted in weight loss in the rats.[46]

Another study aimed to evaluate the reparative effect of the alcoholic extract of *M. pruriens* seeds on the liver and pancreas of streptozotocin-induced diabetic Wistar rats. For this purpose, 6 rats were used as controls and 18 rats were induced with diabetes and then divided into two groups, where one group was treated with glibenclamide and the other with *M. pruriens* for 28 days. At the end of this period, it was found that the extract of this plant successfully controlled blood levels in diabetic rats. In addition, an improvement in serum insulin and cholesterol levels, an increase in beta-cell mass and a partial restoration of liver function were found. Thus, it was concluded that the ethanolic extract of *M. pruriens* can induce positive structural changes in the liver and pancreas due to its antidiabetic and antioxidant properties.[47]

Toxicity

Plants have been used as medicine for the treatment of diseases for thousands of years. These herbal remedies, although natural, can cause some serious harmful effects on vital organs. For this reason it is of utmost importance to investigate to what extent a plant such as *M. Pruriens* can be toxic, as it can be used in a wrong way.[48]

Now, the seeds of *M. pruriens* produce the non-protein amino acid 3-(3,4-dihydroxyphenyl)-l-alanine (L-Dopa), a substance to which the toxicity of its seeds could be attributed.[49] The amount of this component per 100 g of the seeds of this plant is between 1.25 g and 9.16 g.[50]

In a 2011 study, the acute systemic toxicity and topical toxicity of the methanolic extract of *M. pruriens* (seeds) were evaluated in albino mice and rabbits, respectively. The mice showed normal activity for up to 72 hr. The intracutaneous test is designed to evaluate local responses to extracts of materials under test after intracutaneous injection in rabbits. Acute systemic toxicity shows that the methanolic extract of *M. pruriens* could be considered safe in experimental mice for systemic action. While the same extract did not produce any signs of topical toxicity, except slight edema, when administered intracutaneously, however, more detailed toxicological studies are required.[48]

Another study was conducted with Wistar rats to evaluate the oral toxicity at repeated doses over 28 days of *M. pruriens* seeds included in the diet as a meal at 10 %, 20 % and 50 %, equivalent to an intake of *M. pruriens* of 2 g/day, 4 g/day and 10 g/day respectively. It was shown that this plant has a potential hepatotoxic effect that can be reduced by cooking the seeds.[50]

CONCLUSION

Based on the above, plants of the *Mucuna* genus have been used in various areas worldwide because they possess a large number of phytoconstituents that give them multiple properties. These plants have stood out for their nutritional value, for their antioxidant activity and for their properties to treat various pathologies such as Parkinson's disease, infertility, bacterial infections, and diabetes, among others. Therefore, it is evident that the plants of the *Mucuna* genus have a great therapeutic potential, however, it is necessary to carry out more research on these plants, since their information is limited and outdated.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

M. pruriens: *Mucuna pruriens*; **M. urens:** *Mucuna urens***;** **UMUA:** Unfermented *Mucuna urens* flour; **FMUB:** Fermented *Mucuna urens* flour (24 hr); **FMUC:** Fermented *Mucuna urens* flour (48 hr); **FMUD:** Fermented *Mucuna urens* flour (72 hr); **NO:** Nitric oxide; **6-OHDA:** Synthetic L-Dopa in the 6-hydroxydopamine, **NADH:** Nicotine adenine dinucleotide; **LH:** Luteinizing hormone; **PRL:** Prolactin;

FSH: Follicle-stimulating hormone; **L-Dopa:** Non-protein amino acid 3-(3,4dihydroxyphenyl)-l-alanine.

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