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Nutraceutical potential of *Mucuna pruriens* seeds for livestock production

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Abstract

Mucuna pruriens is a leguminous plant having rich nutritional and phytochemical content. The most available literature of *M. pruriens* in animals cites the use of processed *Mucuna pruriens* seeds as unconventional feedstuffs to utilize their nutrient content only. Various phyto-constituents in *Mucuna pruriens* seeds include alkaloids, triterpenes, glycosides, tannins, phytosterols, flavonoids, phenolic & polyphenolic compounds exhibiting varied physiological and pharmacological activities. Several scientific studies in humans and laboratory animals have demonstrated the herbal supplement potential of raw powdered *M. Pruriens* seeds in terms of antioxidant, antistress, anti-cholestrolemic, anti-diabetic, fertility-enhancing, anti-inflammatory, and anti-microbial properties. The presence of bioactive substances limits the use of raw *Mucuna pruriens* seeds in animal feeding to meet the nutritional requirement of animals. Seeds are generally processed by various treatment to reduce phytochemical content. This processing makes *Mucuna pruriens* seeds suitable for nutritional feeding at higher levels for livestock but destroys bioactive substances of health beneficial properties. Thus raw *Mucuna pruriens* seeds fed at lower scientifically determined levels may provide both nutritional and health benefits, thus overcoming the adverse effect of high levels of *M.pruriens* seed feeding in animals. The present review cites literature regarding nutritional, health and therapeutic potential of *Mucuna pruriens* seeds for livestock production.

Keywords: Mucuna Pruriens, Nutraceutical, Phytochemicals, L-DOPA

Introduction

Sustaining nutritional requirement of livestock is one of the important task for livestock management. Various unconventional feed stuffs are used to meet the nutritional requirement of livestock during scarcity period. Presence of antinutritional factors limits the use of these plants in animal diet. Besides nutritional component, Some unconventional feeds were found to possess

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medicinal value which can be used as herbal feed supplement to increase digestibility, disease resistance, physiological adaptability, antioxidant status, ameliorate stress and to improve production performance of animals. Use of herbal feed additives is gaining importance in livestock production to improve health status, heat tolerance level and immunity of the animal. The use of plants or herbs as antioxidants in treating oxidative stress is becoming increasing important in the field of medicine as an alternative to synthetic antioxidants.

Phytochemicals in *M. Pruriens* seeds

The pharmacological study has shown that the seeds contain a wide array of phyto-constituents viz. alkaloids, triterpenes glycosides, tannins, phytosterols, flavonoids, phenolic and polyphenolic compounds (Shanmugavel and Krishnamoorthy, 2018). These phytochemicals are known to exhibit varied physiological and pharmacological activities. Although wide varieties of phytochemicals are present in *M. pruriens* seeds, acute toxicity studies also demonstrated that *M. pruriens* extract was relatively safe at low doses (Majekodunmi et al., 2011). Known alkaloids in *M. pruriens* are mucuadine, mucuadinine, and prurienidine. *M. pruriens* seeds also small amounts of nicotine, various amino acids, serotonin, β-sitosterol, glutathione. lecithin, vernolic acid and gallic acid. (Deokar et al., 2016). They have also reported a good number of other bioactive substances, including tryptamine, alkylamine, phytosterols, flavonoids, coumarins, cardenolide, metals like magnesium, copper, zinc, manganese, and iron (Misra and Wagner, 2007). Adebowale et al. (2005) reported the presence of fatty acids such as oleic acid, linoleic acid, and palmitic acid. *M. pruriens* seed reported to contain 5- indole compounds like tryptamine, 5-hydroxytryptamine (serotonin), and nicotine also contributes to the stress-relieving effect. (Tripathi and Upadhyay, 2001) GC-MS analysis of *M. pruriens* seed extract revealed the presence of fatty acids derivatives, namely pentadecanoic acid, 14- methyl-methyl ester of dodecanoic acid, 9, 12-octadecadienoic acid, methyl ester of 9, 12 octadecadienoic acid, and myristoyl glycinamide. These compounds are known to have a neuroprotective, antioxidant, anti-inflammatory, anti-cancer, hepatoprotective, and antimicrobial effect (J Saikarthiken et al., 2017).

Deli et al. (2021) reported *M. pruriens* seeds to have several compounds with bioactive properties. The phytic acid of *M. Pruriens* possesses antioxidant, anti-carcinogenic, and hypoglycemic activities and is effective at low concentrations. Saponins are shown to have hypo-cholesterolemic as well as anti-carcinogenic effects. The cholesterol-lowering effect in animals and humans through the formation of mixed micelles with bile acids by saponins has been reported by Liener (1994). He reported that the protease inhibitors in *M. Pruriens* seeds enhance the

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pancreatic secretary activity. Polyphenols present in *M. pruriens* are important phytochemicals due to their free radical scavenging and *in vivo* biological activities, as reported by many investigators (Dhanasekaran et al., 2008). Consumption of *M. pruriens* seed having high phenolics may be associated with reduction of cardio-cerebrovascular diseases and cancer mortality (Bhat et al., 2007).

One of the most important compound in seed responsible for neuroprotective effect is L-dihydroxy phenylalanine (L-DOPA) (Natarajan et al., 2012). The seeds of the plant contain about 3.1 to 6.1% of L-DOPA. The white variety was reported to have a higher L-DOPA concentration (4.96%) than the black variety (4.39%). A study by P Sidharaju and K becker (2001) showed that *M. pruriens* and L-DOPA were ruminally degraded, making it less toxic to the ruminants. However, HPLC analysis demonstrated that only residual L-dopa was left after 24 h of L-DOPA incubation in ruminal fluid in the batch culture. Numerically, higher (69%) L-DOPA concentration than control in lambs fed *M. pruriens* as replacement shows that some ingested L-DOPA was absorbed.

Ingested L-DOPA is decarboxylated to dopamine by the enzyme L-aromatic amino acid decarboxylase in the intestinal mucosa. Only about 1% of the orally ingested L-DOPA crosses the blood-brain barrier into the central nervous system and the basal ganglia. It is rapidly decarboxylated and converted to the active constituent, dopamine, by L-aromatic amino acid decarboxylase or DOPA decarboxylase. Similar blood concentrations of L-DOPA and its metabolites, dopamine, 3-O methyldopa, DOPAC, and homovanillic acid in lambs fed with *M. pruriens*, suggests that ingested *M. pruriens* L-DOPA was extensively metabolized in the gastrointestinal tract and liver of lambs (Malunga et al., 2008).

Several studies in humans and laboratory animals have demonstrated the beneficial effects of these phytochemicals. Very little available literature in livestock cites that raw *M. Pruriens* seeds have better potential to be used as an herbal health supplement for animal feeding. e.g., the inclusion of small quantities of dried *M. pruriens* seed meal in the diet of rabbit buck at 0,1.5 and 3 % showed dose-dependent increased mounting frequency sperm motility and concentration serum albumin and protein concentration and decrease in sperm morphological alteration, intromission latency and mounting latency serum cholesterol and urea (Mutwedu et al., 2019). *M. pruriens* seed powder supplementation to west African dwarf bucks at 25,50,75 and 100 mg /body weight via oral route for 30 days showed a dose-dependent increase in weight gain, testicular

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weight, scrotal width sperm motility with 100 mg/kg body weight proved to be most effective (Daromala et al., 2015).

Therefore besides its use as unconventional feed stuff to meet the nutritional requirement of livestock, research needs to be also focused on its nutraceutical potential for animal use. Some of the cited therapeutic properties of *M. Pruriens* have been reviewed in the below section.

Therapeutic and health potential of *M. Pruriens* seeds

All parts of the *M. pruriens* plant possess medicinal properties (Sathiyanarayanan and Arulmozhi, 2007). But raw *M. Pruriens* seeds are known to be extensively used in Indian traditional medicine due to their cited therapeutic value. According to Ayurveda, *M. Pruriens* seeds are used as an astringent, laxative, anthelmintic properties useful in leucorrhoea, spermatorrhoea, and menstrual disorders. Several scientific studies have evaluated the herbal supplement potential of powdered *M. Pruriens* seeds in terms of antioxidant, antistress, anticholesterolemic, antidiabetic, fertility-enhancing, anti-inflammatory, and antimicrobial properties (Misra and Wagner, 2007). *M. Pruriens* is one of the major constituents in polyherbal extract formulations for treating different ailments.

Observed beneficial effect of powdered *M. Pruriens* seeds includes reduced body fat, increased bone density, and reversal of osteoporosis, increased lean muscle mass, increased energy levels, improved cholesterol profile, strengthening effect on the nervous and immune system (Deokar et al., 2016). This plant is pharmacologically studied for various activities like anti-diabetic, aphrodisiac (Rajeshwar et al., 2005[a],2005[b]), antineoplastic, antiepileptic, antimicrobial activities, anti-inflammatory (Alam et al., 2020) of seeds of *M. Pruriens*. Tripathi et al. (2001) have proven that *M. Pruriens* possesses dose-dependent protection against superoxide generation, hydroxyl radical production, and $FeSO_4$-induced lipid peroxidation. The protective action is through their removal of free radicals or by direct chelation of free iron.

Anti-stress and cardio-protective effect of *M.pruriens* seeds

Anti-stress activity is demonstrated by attenuating behavior anomalies exhibited by olfactory bulbectomised rats by chronic *M. Pruriens* treatment (Pati et al., 2010). The main anti-stress and neuroprotective compound identified in *M. pruriens* is L-DOPA. According to Manyam et al. (2004), *M. pruriens* has a significant neuroprotective effect and restores norepinephrine in the nigrostriatal system and dopamine levels in the substantia nigra of animal models.

M. pruriens seeds have been shown to exhibit neuroprotective effects by an increase in brain mitochondrial complex I activity and significantly restoring dopamine and norepinephrine levels

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in the parkinsonism animal model (Mundkinajeddu et al., 2021). Phenolics and flavonoids in *M. pruriens* are antioxidant substances helpful in reducing the risk of oxidative stress-related disorders, including cancer and parkinson's disease (Rai et al., 2015). Induced cerebral ischemia in the wistar rat model resulted in significant neurological damage in the brain of the rats not treated with methanolic extract of *M. pruriens* seeds as observed in the histopathology of the isolated brain of rats (Nayak et al., 2017).

M. pruriens is used in traditional medicine to control blood pressure. Aqueous and methanolic extract of *M. pruriens* seed showed angiotensin converting enzyme -1 (ACE-1) activity. It was further observed that ACE-1 inhibition was altered with respect to change in the content of L-DOPA in the extract of *M. pruriens* seed. Thus it can be assumed that L-DOPA is responsible for ACE-1 inhibition activity (Chaudhary et al., 2015).

Effect of *M. pruriens* on hemato-biochemical profile

M. pruriens extract administered to normal rats for 28 days significantly reduced the number of neutrophils and platelets. In haloperidol treated rats, *M. pruriens* extract reversed reduction in mean corpuscular hemoglobin, MCH and MCHC values and increased red blood cell count and PCV (Akindele et al., 2011). Hyper-aggregability is one of the risk factors in the pathogenesis of thrombosis and atherosclerosis. Antiplatelet agents are compound that reduces platelet aggregation. Aqueous fractions of *M. pruriens* seed were evaluated for antiplatelet activity using epinephrine as an agonist of platelet aggregation at different concentrations. 150 µM concentration of epinephrine 500 µg/ml of *M. pruriens* extracts exhibited anti-platelet activity equivalent to aspirin (Widowati and Ratnawati et al., 2010).

The presence of compounds like D-inositol and its derivatives have been identified by using NMR and chromatographic method in *M. pruriens* seeds (Donati et al., 2005). These cyclitols are known to have an insulin-mimetic effect. Further protease inhibitors in *M. Pruriens* seeds have been demonstrated to enhance pancreatic secretory activity. Anktar et al. (1990) reported that *M. pruriens* seeds at 500 mg/kg reduced plasma glucose level. An ethanolic extract of seeds of *M. Pruriens* on alloxan-induced diabetic rats by a single intraperitoneal injection of 150 mg/kg leads to a decrease in diabetic activity (Majekodunmi et al., 2011). Bhaskar et al. (2008) similarly found the hypoglycemic effect of an aqueous extract of *M. Pruriens* seeds in streptazocin-induced diabetic rats. They also observed the decrease in cholesterol and creatinine levels in streptozotocin-diabetic rats after administration of *M. pruriens* extract. They explained that this hypocholesterolemic activity is due to the presence of squalene content. Extract of *M.*

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pruriens treatment results in decreasing total cholesterol and the LDL-cholesterol, triglyceride increasing HDL-cholesterol in male wistar rat (Ratnawati and Widowati, 2011). A study to investigate the effect of *M. Pruriens* on some biochemical parameters in wistar rats revealed that *M. Pruriens* significantly reduced the cholesterol level dose-dependent manner. The urea and creatinine levels were also significantly reduced compared to the control. Thus, *M. Pruriens* may prove a potential drug to improve kidney functions (Adepoju and Odubena, 2009).

Effect of *M.pruriens* on antioxidant status

The crude extract of *M. Pruriens* has high antioxidant activity and contains high flavonoids (Ratnawati, 2011). Flavonoids are potent free radical scavengers. Isoflavones are flavonoids compounds found in a variety of legumes. An experiment on *in-vitro* lipid peroxidation of *M. Pruriens* seeds revealed concentration-dependent inhibition of ascorbate/$FeSO_4$ induced peroxidation by methanolic extract of *M. Pruriens.* The antioxidant effect on methanolic extract of *M. Pruriens* seed against Erlich Ascites Carcinoma (EAC) bearing Swiss albino mice were studied to estimate the liver lipid peroxidation (LPO), reduced glutathione (GSH), and antioxidant enzymes like superoxide dismutase (SOD), catalase, etc. Treatment with extract decreased the levels of lipid peroxidation and increased the levels of glutathione, superoxide dismutase, and catalase (Divya et al., 2016).

The polar extract fraction were found to have higher antioxidant activity than the nonpolar fraction and even higher than the crude extract. Due to the high concentration of phenolic compounds, it is expected that *M. Pruriens* seeds have a high antioxidant capacity. The alcohol extract showed significant antioxidant activity which was comparable with standard ascorbate and total phenol content (Sonpetkar et al., 2012).

Effect of *M.pruriens* on hormonal profile

Clinical studies have shown that *M. Pruriens* feeding significantly improved luteinizing hormone (LH), dopamine, adrenaline, and nor-adrenaline hormone levels (Misra and Wagner, 2004). The *in vitro* results indicate that the polar fraction of *M. Pruriens* seed extract modulated nitric oxide (NO) production through the expression of nitric oxide synthase (NOS) isoforms genes, and the intracellular cGMP level and thus could be effective in erectile dysfunction (Duangnin et al., 2017). *M. Pruriens* seeds are known to exhibit aphrodisiac and fertility-enhancing properties through their action on the hypothalamus-pituitary-gonadal axis. *M. Pruriens* significantly improved serum testosterone, luteinizing hormone levels. In animal studies, it has been shown that oral administration of *M. Pruriens* seed powder @ 100 mg/kg body weight to the

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bucks for 30 days improved male fertility by increasing sperm count and sperm quality of the buck (Daromala et al., 2015). The increase in the circulating levels of FSH and LH hormones following administration of *M. Pruriens* in female rats has been reflected in an increased number of growing follicles and matured graafian follicles (Noah et al.,2014).

Phytosteroid Estra-2-en-17-ol, 3yl benzoate is isolated from *M. Pruriens* seeds, making *M. pruriens* seeds effective in treating disorders of the male and female reproductive systems, Parkinson disease to increase libido in both men and women (Uchegbu et al., 2013). Suresh and Prakash (2012) demonstrated that the ethanolic seed extract of *M. Pruriens* is an excellent sexual enhancer and increases sperm count and motility in normal and diabetic rats. *M. Pruriens* was found to improve viability, reduce structural and functional abnormalities, reverse or protect the mitochondrial membrane potential from oxidative stress in aged rat sperm, improved sperm count, and increase fertility capacity in the diabetic male rat. Further, it has been cited that androgenic activities in adult male rats were sustained while improving the mass of the muscles (Singh et al., 2013). The *M. Pruriens* ethanolic extract administered in either sex rats significantly increased the mounting and intromission frequency, ejaculation latency and decreased the mounting and intromission latency, post-ejaculatory and inter-intromission interval (Kumar et al., 1994).

Effect of *M.pruriens* on gene expression

Microarray and real-time PCR gene expression analysis of *M. Pruriens* extract treatment against a control group in rat heart revealed 59 genes are differentially expressed. It included genes related to inflammatory, immune response, energy metabolism, apoptosis, eicosanoid synthesis, blood and wounding response, cardiac muscle, and nervous system having a protective effect on the heart (Fung et al., 2014). Yadav et al. (2017) showed that *M. Pruriens* seed extract @ 100 mg/kg body weight had reduced oxidative stress by mitigating the inducible nitric oxide synthase (iNOS) expression levels thus improving neurobehavioral in paraquat (PQ) induced parkinsonian mouse model. Gastroprotective effects of ethanolic extract of *M. pruriens* on ethanol induced gastric mucosal injuries in rats showed up-regulation of HSP-70 protein, down-regulation of bax (apoptosis related) protein, and increased mucosal healing (Golbabapour et al., 2013).

Thus *M. pruriens* seed has good potential to be used as an herbal feed supplement in livestock feeding. Low cost, wide availability, and reported beneficial properties *M. pruriens* suggest its promising nutraceutical potential. Further exploration is needed to study the utility of *M. pruriens* seeds in livestock health and production.

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