



Research Article

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Medicinal and Nutritional Values of *Macrotyloma uniflorum* (Lam.) Verdc (Kulattha): A Conceptual Study



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Abstract

Macrotyloma uniflorum (Lam.) Verdc commonly known as horse gram is a kind of legume of tropics and subtropics. Its medicinal uses are known to Ayurveda and Sri Lankan traditional physicians for centuries. Present study was undertaken to collect data on medicinal uses and nutritional values of *M. uniflorum*. Ayurveda pharmacodynamic properties of *M. uniflorum* are *Kashaya Rasa*, *Laghu*, *Ruksha*, *Tikshna Guna*, *Ushna Veerya* and *Katu Vipaka*. Various medicinal preparations such as Dhanyamla and decoctions are prepared using seeds of *M. uniflorum*. It is mainly used as a tonic, astringent, diuretic and also recommended in rheumatism, neuralgia and other several diseases. Horse gram seeds are rich in natural phenols; mostly phenolic acids, flavonoids and the major anti-oxidants. Horse gram is considered as animal fodder and its full potential as a part of human diet has not been exploited completely. It can be consumed as seeds, as sprouts or as meal by itself. Horse gram is an excellent source of protein (22-24%). Seeds contain carbohydrates (57.2%), fat (1.1%), vitamins, minerals (3.2%) and good amount of soluble fibers. Extract of these seeds shows potent anti-adipogenic, anti-hyperglycemic anti-hypercholesterolemic activities. It acts against oxidative stress. It is concluded that Horse gram can be used as a multifaceted treatment as well as a wholesome food.

Keywords: *M. uniflorum*; Kulattha; Dhanyamla; Anti-oxidants; Food

Introduction

Medicinal plants are used as a source of drugs for treatment of various illnesses all over the world, from ancient times to the present day. They serve as sources of important raw materials for manufacturing traditional and modern medicines. Food legumes, an essential component of balanced human diet are recognized as the second most important group of crops after cereals [1]. *M. uniflorum* (horse gram) is one of the legumes which are having high nutritious as well as ethno-medicinal values in the developing countries. Nowadays, to meet the ever increasing demand for vegetable protein there is an increase demand towards underutilized legumes as new alternate protein sources [2]. Besides nutritional importance; *M. uniflorum* has been known to its excellent remedial values due to presence of non-nutritive bioactive substances.

The seeds of *M. Uniflorum* contain bioactive substances such as phytic acid, phenolic acid, fiber, enzymatic/proteinase inhibitors which have significant metabolic and physiological effects [3]. Hence, in view of immense medicinal and nutritional importance of *M. uniflorum*, this review is an effort to compile the information reported on its phytochemical and pharmacological

activities. This collection will be helpful to generate interest towards the plant and may be useful in developing new medicinal formulations which are more effective and have more therapeutic values.

Materials & Methods

Data was collected from Ayurvedic and Sri Lankan traditional medical texts, interviews conducted with traditional physicians, scientific journals and using web sources. The collected data was analyzed.

Results

Taxonomic classification [4]

1. Kingdom: Plantae
2. Class: Magnoliopsida- Dicotyledons
3. Subclass: Rosidae
4. Order- fabales
5. Family: Fabaceae
6. Subfamily: Faboideae

7. Tribe: Phaseoleae
8. Subtribe: Phaseolinae.
9. Genus: Macrotyloma (Wight & Arn.) Verdc - macrotyloma
10. Species: Macrotyloma uniflorum (Lam.) Verdc.

Plant profile

Synonyms of *M. uniflorum* (Lam.) Verdc [5,6]

Scientific Name: *Dolichos biflorus*

Sanskrit Name: Kulattha, Kulathika, Sweta beeja

Sinhala Name: Kollu

Tamil Name: Kaanam, Kollu

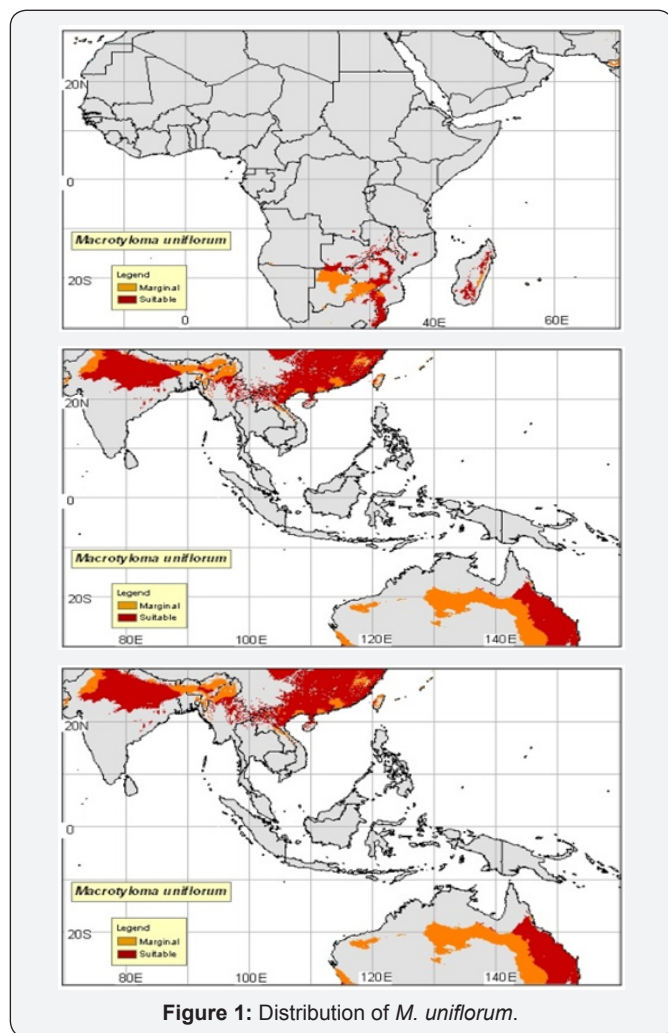
English Name: Horse gram, madras gram, poor man’s pulse

Hindi Name: Kulit, Kultthi

Arabic Name: Habbul Kulth

Chinese Name: Bian Dou

Distribution of *M. uniflorum* (Lam.) Verdc



M. uniflorum is native to African countries such as Angola, Ethiopia, Kenya, Namibia, Somalia, South Africa, Tanzania; Asian countries such as Bhutan, China, India, Nepal, Pakistan, Philippines, Sri Lanka and Taiwan and Australasian countries such as Australia [7] (Figure 1).

Morphological Characters

Morphological characters of *M. uniflorum* (Lam.) Verdc are given in (Table 1), (Figure 2).



Table 1: Morphological characteristics of the parts of *M. uniflorum* [8,9].

Part	Characters
Habit	wining, sub-erect annual, 60 cm tall in pure stands, or 60–90 cm with support framework
Stem	with cylindrical, slightly hairy to tomentose stems
Leaves	about 3.5–7.5 cm long, trifoliolate; stipules 7–10 mm long
Leaflets	acute or slightly acuminate, ovate, rounded at the base. Terminal leaflet symmetrical, laterals asymmetrical. 2–4 cm broad, fimbriolate. Softly tomentose on both surfaces and paler beneath.
petioles	2.5 cm long
Flowers	panicles, nodding, bisexual, 3 stamens having spikelets usually having one flower which is jointed on very short stalks.
Calyxes	10.5 mm long, 7–8 mm broad, shaped in standard oblong. Wings about as long as the keel, 8–9.5 mm long
Pods	about 2.5–6 cm long, 6 mm broad, slightly curved, smooth or tomentose, linear-oblong, with a point about 6 mm long and shortly stipitate
Pedicles	0.3-0.5 cm long
Bracts	lanceolate-linear upto 0.4 cm long
Seeds	ovoid in shape, 4–6 mm long, 3–5 mm broad. Colored with pale fawn, light red, brown, or black. Decorated with faint mottles or with small, scattered black spots with hilum central. Each pod contains 5–8 seeds, One kilogram contains about 33,000–75,000 seeds

Microscopic features	i. Testa: Epidermis is single layered, thin walled and shining cells because mucilage in this layer.
	ii. Endosperm: Endosperm form bulk of the seed with thick walled polygonal parenchymatous cells.
	iii. Alueron: Outer portion of the seed contains alueron grains which are protein in nature.
	iv. Embryo: In the mid of the seeds, embryo can be seen which provide nutrition

Ayurvedic Pharmacodynamic Properties

Ayurvedic pharmacodynamic properties of *M. uniflorum* are tabulated below Table 2 [10,11].

Table 2: Ayurvedic Pharmacodynamic Properties of *M. uniflorum* (Lam.) Verdc.

Property	Description
Rasa (taste)	Kashaya (astringent), Madhura (sweet)
Guna (attributes)	Laghu, Ruksha, Teekshna, Ushna
Veerya (potency)	Ushna (hot)
Vipaka (end result of digestion)	Katu (pungent)
Prabhava (special attributes)	Bhedana
Dosha Karma	KaphaVata Shamaka
Other properties	Krimighna (anthelmintic), Ashmarinasha (antilithiatic), Swedakaraka (diaphoretic), Mutrakaraka (diuretic), Artavajanana (emmenagogue), Kaphaghna (reduce vitiated Kapha Dosha) Jvaraghna (febrifuge), Chakshushya (opthalmic), Lekhana (lipolytic)

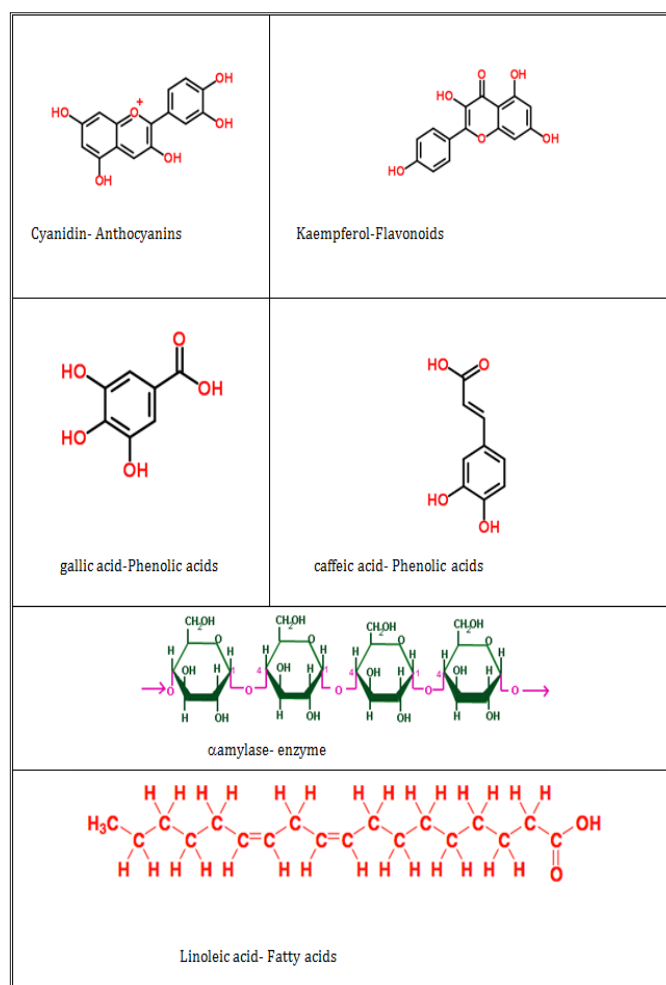
Phytochemicals isolated from *M. uniflorum* (Lam.) Verdc

Therapeutic properties of medicinal plants may possibly be due to existence of various phytochemical components. Phytochemical screening studies reveal the existence of flavonoids, urease, glycosides, lenoleic acid, polyphenols, beta Sitosterol, amino acids- glycine, alanine, cysteine, serine, isoflavones, genistein, isoferririn, cumesterol, psoralidin, galactosidase, glucosides and streptogenin [12]. The seeds of *M. uniflorum* contain extractable total phenolics and tannins. Dry heated samples were found to have considerable amounts of phenolics and tannins than in raw samples [13,14]. Phenolic acids are isolated from the ethanolic extract of the seeds of *M. uniflorum* by reversed phase HPLC. There were eight phenolic acids components and the most abundant was p-coumaric acid and p-hydroxy benzoic acid. The successive extracts of root, seeds of *M. uniflorum* have revealed the presence of alkaloids, flavonoids, glucosides, lignins, phenols, saponins, tannins and sterols. Alkaloids are the lead molecules of curative importance from *Macrotyloma* species. Phytochemicals containing in *M. uniflorum* and their structures are given in (Table 3 & 4).

Table 3: Phytochemicals isolated from *M. uniflorum* (Lam.) Verdc.

Category	Phytoconstituents
Anthocyanins	cyanidin, delphinidin, malvidin, petunidin [12,13]
Flavonoids	daidzein, genistein, kaempferol, myricetin, quercetin [12,13]
Phenolic acids (benzoic acid derivatives)	gallic acid, protocatechuic acid, p-hydroxybenzoic acid, syringic acid, vanillic acid [14]
Phenolic acids (cinnamic acid derivatives)	caffeic acid, chlorogenic acid, ferulic acid, p-coumaric acid, sinapic acid [14]
Enzyme source	a amylase [15] a and b glucosidase [16], b- N-acetylglucosaminidase, urease [17]
Haemagglutinins	agglutinin and lectins [18]
Tannins	[18]
Phytic acid	[19,20]

Table 4: Chemical structures of some compounds isolated from *M. uniflorum* (Lam.) Verdc.



Traditional uses of *M. uniflorum* (Lam.) Verdc

Various parts of the plant *M. uniflorum* are used in medical systems such as Ayurveda, Siddha and Unani for thousands of years for various ailments both internally and externally.

Internal applications of *M. uniflorum* (Lam.) Verdc

The decoction of dry seeds of *M. uniflorum* is used in traditional medicine for amenorrhea, with rock salt for urolithiasis, bile stones, conjunctivitis, rheumatism, piles, with rock salt for diabetes mellitus, dysuria, colic and flatulence (with Asafoetida), oedema, with pepper for mumps, goiter and phlegmatic conditions [21]. Decoction of seeds is also useful in the management of postpartum syndrome or to promote the discharge of lochia [8]. Infusion of whole seed is an excellent remedy for rheumatic pain and hypertension. Infusion of seeds with cow's milk is useful in the management of helminthes disorders [22]. Kanji (gruel) of dry seeds with jaggery is a remedy for jaundice. Anjana (collyrium) made with powder of seeds is applied for conjunctivitis. Dumapana (inhalation of the smoke) is beneficial for patients suffering from hiccough. The powder of toasted seeds is consumed with curd for gastric ulcers [23]. Intake of horse gram seed powder with some water

is beneficial in skin rashes and boils. Seeds boiled with water are indicated for obesity. Soup prepared from seeds is administered for haemorrhoids, splenomegaly and hepatomegaly. Decoction of root is given for leucorrhoea. Juice of plant provides a good cure in diarrhea [24].

External applications of *M. uniflorum* (Lam.) Verdc

Powder of baked seed is rubbed over the body to manage excessive perspiration. Poultices of seeds are used to induce sweating. Paste of seeds is applied over the skin to enhance complexion. Paste of seeds is also applied for the goiter and mumps [25].

Prepared Medicines by using *M. uniflorum* (Lam.) Verdc

The seeds of *M. uniflorum* are used to prepare drugs such as Kulaththadi Pralepa (paste), Kulaththadi Gruta (ghee), Kulaththa Yusha, Dhanyamla (sour gruel) and Dantimuladi Kwatha [26,27].

Pharmacological Investigation

Pharmacological activities of *M. uniflorum* (Lam.) Verdc are tabulated in Table 5.

Table 5: Pharmacological activities of *M. uniflorum* (Lam.) Verdc.

Part	Extract	Pharmacological activity
Entire plant	aqueous and ethanolic	Antihypercholesterolemic [28]
	ethyl acetate	Antimicrobial [29-31]
Leaves	aqueous	Antiobesity [32,33]
	ethanolic	Antihelminthic [34,35]
Seeds	methanolic	analgesic and anti-inflammatory [36]
		Antidiabetic [37,38]
	acetone	Anticholilithiatic [39]
	ethanolic	Antihistaminic [40]
	hydroalcoholic	anti peptic ulcer [41]
	chloroform, methanolic and ethanolic	Antioxidant [42- 45], free radical scavenging [46]
	alcohol	Antiobesity [32,33]
	aqueous	antiurolithiatic against calcium oxide crystals [47- 51]
		antiurolithiatic against calcium phosphate crystals [52]
		antiurolithiatic against uric acid crystals [53]
	methanolic and ethanolic	Diuretic [54]
	butanolic	Haemolytic [55]
	methanolic	Hepatoprotective [56]
		larvicidal (a-amylase inhibitors) [57]
		proeinase inhibition [58,59]
	hydro-methanolic	nephrotoxicity management [60]
phenols	ACE-1 inhibition (antidiabetic and antihypertensive activity) [61,62]	

Researches carried out to find Pharmacological activities of *M. uniflorum* (Lam.) Verdc

Anti-hypercholesterolemic effect: Kumar, et al. [28] demonstrated that *M. uniflorum* extracts have strong activities against hypercholesterolemia and obesity. Antihypercholesterolemic effect of *M. uniflorum* extract is examined in rats by assessing its effects on food consumption, weight gain, serum lipid profile, serum glutamate oxaloacetate transaminase (SGOT), serum glutamate pyruvate transaminase (SGPT) and body fat [28]. Researchers reported that the consumption of ethanol and water extract of the plant for 5 weeks resulted a significant decrease ($p < 0.01$) of total cholesterol (TC), triglycerides, low-density lipoprotein (LDL), very low density lipoprotein (VLDL) SGOT and SGPT levels. There was a significant increase in high-density lipoprotein (HDL) ($p < 0.01$). They also discovered ethanol extract-treated group has shown a significantly higher fecal excretion of cholesterol level than those treated with water extract. Body weight of rats in the water extract-treated group was significantly lower than that in the ethanol extract-treated group.

Anti-microbial activity: According to Kawsar, et al. [29], Ram, et al. [30] and Gupta, et al. [31] extracts from *M. uniflorum* seeds had shown significant activity against *Bacillus subtilis*, *Staphylococcus aureus*, *Escherichia coli* and *Pseudomonas aeruginosa* [29-31].

Anti-helminthic activity: The seeds of *M. uniflorum* have anthelmintic activity which can be beneficial in eliminating worms [34]. Philip, et al. tested the alcohol extracts of *M. uniflorum* seeds for their anthelmintic activity. These extracts exhibited potent anthelmintic activity against *Pheretima posthuma* and its activity was comparable with that of the standard, albendazole [35].

Analgesics and anti-inflammatory effect: Giresha et al., assayed the aqueous extracts of *M. uniflorum* coat and pulp by *in-vitro* method for inhibition of human secretory phospholipase A2 (sPLA2) as a function of anti-inflammatory activity. The extract effectively neutralized indirect hemolytic activity and showed similar potency in neutralizing the *in vivo* PLA2 induced mouse paw edema [36].

Anti-diabetic activity: Gupta et al., investigated the antidiabetic effect of α -amylase inhibitor isolated from the seeds of *M. uniflorum* in streptozotocin- nicotinamide induced diabetic mice. They have determined the biochemical parameters such as serum total cholesterol, aspartate aminotransferase (AST) and alanine aminotransferase (ALT) levels [38]. Purwar, et al., found that *M. uniflorum* α -amylase inhibitor (MUAI) inhibited both the mouse pancreatic and human salivary α -amylase. MUAI reduced the serum glucose level in the treated diabetic mice. Histological findings revealed minimum pathological changes in the treated diabetic mice as compared to the diabetic control [38].

Anti-choliolithic activity: Bigonia, et al. found that *M. uniflorum* seed exerted antilithogenic influence by decreasing

the formation of lithogenic bile in mice. Both the methanolic and acetone extracts (ME and AE) were capable of decreasing cholesterol hyper-secretion into bile and increasing the bile acid output. The maximum effect was found in the AE as it decreased the papillary proliferation of gallbladder and hepatic fatty degeneration. Antioxidant property of polyphenol and tannin in AE may provide its potential antilithogenic effect [39].

Anti-histaminic activity: Suralkar et al., screened the ethanolic extract of *M. uniflorum* seeds for their anti-histaminic activity by using histamine induced contraction on goat tracheal chain preparation and histamine induced bronchoconstriction in Guinea pigs. Histamine induced contraction of isolated goat tracheal chain preparation was significantly subdued by the ethanolic extract of *M. uniflorum* seeds. The guinea pigs were significantly protected against histamine induced bronchospasm as indicated by delay in the preconvulsivedyspnoea time (PCT) following the exposure of histamine aerosol [39].

I. Anti-peptic ulcer activity: Panda, et al., evaluated the antiulcer activity of the hydroalcoholic extract of the seeds of *M. uniflorum* (MUSE) and p-coumaric acid against indomethacin (non-steroidal anti-inflammatory drug) and absolute ethanol (necrotizing agent) induced ulcers in rats. A dose-dependent decrease in the ulcer index could be seen in both models after the pre-treatment with MUSE and p-coumaric acid. MUSE and p-coumaric acid elicited significant antioxidant activity by attenuating the ulcer elevated levels of malondialdehyde and restored the ulcer-depleted levels of reduced glutathione and the antioxidant enzymes superoxide dismutase, catalase, glutathione peroxidase and glutathione reductase [40].

II. Anti-oxidant activity: Singh, et al. reported the *in-vitro* antioxidant activity of ethanolic seed extracts of *M. uniflorum* [42]. As per Ravishankar, et al. administration of *M. uniflorum* extract to rabbits with high-fat diet induced oxidative stress, showed improvement in anti-oxidant enzymes such as superoxide dismutase, catalase and increased glutathione concentration [41].

III. Free radical-scavenging capacity: Siddhuraju, et al. revealed that among the various extracts, 70% acetone extracts of dry-heated samples of brown variety of *M. uniflorum* as well as raw and dry-heated samples of black variety exhibited significantly ($P < 0.05$) higher hydroxyl radical-scavenging activity. Generally all extracts showed good antioxidant activity (53.3-73.1%) against the linoleic acid emulsion system but were significantly ($P < 0.05$) lower than the synthetic antioxidant, BHA (93.3%) [44].

IV. Anti-urolithiatic activity: *M. uniflorum* was found to be effective in preventing the deposition of the stones in experimental rats. Chaitanya, et al. reported the antiurolithiatic activity of aqueous and alcohol extracts of *M. uniflorum* seed on ethylene glycol induced urolithiasis

in albino rats [46]. Das, et al. noticed an excessive urinary excretion of oxalate, calcium and phosphate was resulted after the feeding of ethylene glycol [47]. As per their findings of Atodariya, et al. and Bijarnia, et al. the seeds of *M. uniflorum* are endowed with significant antiurolithiatic activity and the alcoholic extract of *M. uniflorum* showed better anti urolithiatic activity than aqueous extract [48,49].

V. Diuretic activity: Ravishankar, et al. explored the diuretic effect of ethanolic seed extracts of *M. uniflorum* in albino rats. The urine volume, Sodium, Potassium, Chloride and Bicarbonate contents were measured after the oral administration of extracts at doses of 200mg/kg and 400mg/kg. Diuretic effect was significant in experimental animals treated with of *M. uniflorum* extracts compared to the control, Furosemide (5mg/kg) [53].

VI. Hemolytic activity: The 1-butanol extract showed the significant hemolytic activity by mouse erythrocytes. Kawsar, et al. reported the presence of compounds such as methyl ester of hexadecanoic, ethyl ester of hexadecanoic acid mixture and n-hexadecanoic could be constituted a possible chemotaxonomic marker [54].

VII. Hepatoprotective activity: Parmar, et al. discovered the significant hepatoprotective properties of *M. uniflorum* seeds against D-Galctosamine and paracetamol induced hepatotoxicity in rats [55].

VIII. Toxicological studies: Kawsar, et al. analyzed the aerial parts of *M. uniflorum* for their cytotoxicity effects. Crude extracts of dichloromethane (CH₂Cl₂), ethyl acetate (EtOAc), 1-butanol (1-BuOH) and aqueous (H₂O) were screened by using the brine shrimp lethality bioassay technique. Most of the extracts were found to be non-toxic and this indicates that the ethnobotanical use (oral applications) of the *M. uniflorum* is justified [62].

IX. Nutritional Values of *M. uniflorum* (Lam.) Verdc: *M. uniflorum* seeds are known as the poor man's pulse crop in Asian countries, especially India. It is commonly used for both food and fodder. The use of dry seeds of horse gram is limited due to their poor cooking quality. Recently, the US National Academy of Sciences recognized this legume as an upcoming potential food resource [63].

X. Methods of consuming: Seeds are the edible part of the plant and consumed as a whole (boiled) seed, as sprouts, as a curry or as whole meal in Asia, popular especially in

southern Indian states. Procedures such as de-husking, germination, cooking, and roasting can be undertaken to enhance the nutritional quality of horse gram [64].

XI. Protein content: Horse gram is the most protein-rich lentil found on the planet. The seeds have twice the protein content as of cereal grains. Mean protein value of horse gram seeds is almost equivalent to winged bean (*Psophocarpus tetragonolobus*), gram (*Cicer arietinum*) and soybean (*Glycine max*) [65,66].

XII. Carbohydrate (CHO) content: *M. uniflorum* seeds contain common and abundant forms of CHO, viz sugars, fibers, and starches. The digestibility of starches as a legume is lower than that of cereal. Contain less carbohydrate (55-65%) and energy compared to cereals. CHO available in *M. uniflorum* seeds has low glycemic index [67].

XIII. Fatty acid content: Saturated fatty acids level in the seeds of *M. uniflorum* is considerably low. It is about 72.49% unprocessed seeds and about 71.99% in toasted seeds. Seeds are rich sources of Linoleic acid, an essential fatty acid. Raw seeds contain 45.58% and toasted seeds contain 40.33% of Linoleic acid [18].

XIV. Dietary fiber content: Whole grains are the best sources to get fiber into a balance diet. Fibers are of two types, soluble and insoluble. Horse gram seed contains 28.8% total dietary fibers, mainly insoluble dietary fiber (IDF) 27.82% and soluble dietary fiber (SDF) 1.13% with IDF: SDF 24.6 [68]. Horse gram flour contains 16.3% total dietary fiber (14.9% insoluble and 1.4% soluble and 2.2% resistant starch) [69]. Seeds of *M. uniflorum* contain more insoluble dietary fiber than kidney bean (*Phaseolus aconitifolius*) [70].

XV. Micronutrient content: Horse gram has the highest calcium content among pulses. As a legume, Horse gram is deficient in methionine and tryptophan, though it is an excellent source of iron and molybdenum [71,72].

XVI. Anti-oxidant source: The unprocessed horse gram seed is loaded in polyphenols, flavonoids and proteins, the major anti-oxidants which are also available in fruits and other food materials. The greater part of anti-oxidant properties is limited to the outer coat of seed and its removal would eliminate these properties. Macro and micro nutrients composition of dry seeds of *M. uniflorum* is given in (Table 6 & 7).

Table 6: The nutritional value of the seeds of *M. uniflorum* (100g of dry seeds) [74,75].

Macro Nutrients		Micro Nutrients	
Protein	24.24%	Calcium	0.34 %
Carbohydrates	37.15 %	Iron	72.00%
Fat	1.10 %	Manganese	37.00%
Unsaturated fat	72.49%	Zinc	0.28%

Saturated fat	27.51%	Phosphorus	0.27%
Starch	31.86 %	Magnesium	0.17%
Sugar	5.81 %	Copper	19.00 %
Crude fiber	5.63 %	Vitamin A	2.1%
Ash	3.34%	Vitamin C	1.4%
Moisture	8.9%	Ascorbic acid	0.7%
		Niacin (Vitamin B3)	1.5%
		Ribloflavin (Vitamin B2)	0.09%
		Thiamin (Vitamin B1)	0.42%

Table 7: Amino acid and fatty acid composition of *M. uniflorum* [76].

Amino acids	Arginine	8.80%
	Cysteine	1.96%
	Histidine	3.15%
	Isoleucine	6.14%
	Leucine	8.96%
	Lysine	8.63%
	Methionine	1.16%
	Phenylalanine	6.31%
	Threonine	3.82%
	Tryptophane	1.16%
	Valine	6.47%
Fatty acids	Linoleic acid	40.3 – 45.6%
	Linolenic acid	11.6 – 14.3%
	Oleic acid	8.9 – 16.8%

Amino acid composition of *M. uniflorum*

A. Anti-nutritional factors: Anti-nutritional factors reduce the bioavailability of nutrients [73]. Horse gram flour also contains such factors viz, trypsin inhibitor (9246±18 TIU/g), phytic acid (10.2±0.4mg/g), polyphenols (14.3±0.4mg GA/g) and oligosaccharides (26.8mg/g) [70]. The consumption of horse gram as a human food is limited due to existence of high level of enzyme inhibitors, haemagglutinin activities, oligosaccharides, tannins, polyphenols and phytic acid compared to the other legumes [77,78]. Conventional processing methods such as de-husking, germination, cooking, and roasting have been shown to produce beneficial effects by decreasing the content of undesirable components which results in enhanced acceptability and nutritional quality in addition to optimal utilization of horse gram as human food [79].

M. uniflorum plant is relatively high in iron, but the availability of the iron is reduced by the phylates, tannins and oxalic acid it contains. However these generally considered antinutritional compounds like phytic acid, phenols and tannins are now being measured as potential antioxidants having health promoting effects. The phytic acid has now been shown to possess rich antioxidant, anticarcinogenic and hypoglycaemic activities. Hence depending upon consumer preferences retaining or elimination of these compounds could be facilitated [80].

B. Protease inhibitors: Horse gram habitually contains inhibitors of proteases that reduce the digestibility of dietary proteins. Protease inhibitors form irreversible trypsin enzyme and trypsin inhibitor complex in the intestine. These protease inhibitors resemble other Bowman-Birk protease inhibitors and characterized by low molecular weight, high disulfide content with low content of aromatic amino acids. They can bind as well as inhibit trypsin and chymotrypsin either independently or simultaneously [81,82]. Trypsin inhibitor activity is significantly higher in horse gram flour (9246 TIU/g) as compare to chickpea (6452 TIU/g) and cowpea (6981 TIU/g) flour [70]. In germinated seeds trypsin inhibitor activity is 16% less than that of un-germinated horse gram seeds (950 x 103 TIU/g seed) [83]. As germination induces changes in the Bowman-Birk type proteinase inhibitors in both qualitative and quantitative ways, it facilitates protein hydrolysis for utilization in germination process [84]. Trypsin inhibitors are thermo-labile and their inhibitory activity can be reduced noticeably by thermal treatment [85].

Discussion

According to Ayurvedic pharmacodynamic properties *M. uniflorum* is capable of pacifying vitiated Vata Dosha by its Madhura Rasa, Ushna Guna and Ushna Veerya. It pacifies vitiated Kapha Dosha, due to Kashaya Rasa, Laghu Guna, Ruksha Guna and Ushna Veerya. Therefore it can be used to treat a variety of

ailments, originating through a multitude of causes. Seeds are having scientifically proven bioactivities such as anti-diabetic, antihyperlipidemic, diuretic, antioxidant and chemo modulatory. Therefore it can be beneficial in the management of the diseases such as diabetes mellitus, hyperlipidaemia, hypertension and stroke.

M. uniflorum seeds reduce blood sugar levels and post-prandial hyperglycemia, decrease absorption of the carbohydrate from the gut and abundant of soluble fiber. Therefore the seeds are useful in the treatment of diabetes mellitus. Further *M. uniflorum* seeds reduce serum cholesterol levels, inhibit the hepatic cholesterol genesis, increase excretion of fecal sterol and decrease insulin activates lipoprotein lipase which leads to hypertriglyceridemia. Seeds are also capable to possess hepatoprotective and anti-hyperlipidemic activities. All the above-mentioned effects can contribute potentially toward reduction of hypercholesterolemia and obesity. Seeds of *M. uniflorum* are excellent sources of polyphenols. They are capable of removing free radicals, chelating metal catalysts, activating antioxidant enzymes, reducing tocopherol radicals and inhibiting oxidase. Due to its anthelmintic properties, the seeds of *M. uniflorum* are useful in treating amoebic dysentery, bowel hemorrhage and colic pains.

Conclusion

Administration of horse gram can be used as a multifaceted treatment as well as a wholesome food that should be included in our diet on a regular basis.

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