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Nutritional Profile and Therapeutic Properties of Horse Gram (*Macrotyloma uniflorum*)

Review Article

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Abstract

Horse gram (*Macrotyloma uniflorum*) is highly nutritious an underutilized legume predominantly grown in India, particularly in semi-arid and hilly regions. It is recognized for its rich nutritional and medicinal properties. It is an excellent source of plant-based protein, essential amino acids, dietary fiber, essential minerals such as calcium and iron. Beyond its macronutrient and micronutrient content, horsegram is rich in bioactive phytochemicals including phenolic acids, flavonoids, phytosterols, tannins, saponins, and phytic acid, which contribute to its antioxidant, anti-inflammatory, anti-diabetic, and lipid-lowering activities. It has been traditionally used for managing various ailments such as kidney stones, inflammation, and other metabolic disorders. Horse gram remains underutilized in mainstream diets despite its traditional use, and medicinal and health-promoting properties. Recent studies have demonstrated its potential role in preventing and managing chronic disorders such as cardiovascular diseases, diabetes, and obesity. Its application in traditional medicine, support its therapeutic efficacy. Despite these benefits, horse gram remains neglected in modern diets and agricultural system. This review aims to highlight the nutritional profile, bioactive phytochemical constituents, anti-nutritional factors, and therapeutic properties of horse gram..

Keywords: Horse Gram; *Macrotyloma uniflorum*; Underutilized Legume; Bioactive Compounds; Phytochemicals; Anti-Nutritional Factors; Functional Food

Introduction

Horse gram (*Macrotyloma uniflorum*) is a drought-resistant pulse crop belonging to the family *Fabaceae* and genus *Macrotyloma*. It is widely cultivated in India for its highly nutritious seeds. This pulse crop has its origin in Southeast Asia and tropical Africa, and Southern India is recognized as its primary center of origin. In India, Horse gram is mainly cultivated in the states of Karnataka, Andhra Pradesh, Odisha, Tamil Nadu, Madhya Pradesh, Chhattisgarh, Bihar, West Bengal, and Jharkhand as well as in foot hills of Uttarakhand and Himachal Pradesh in India [1–3].

Horse gram (*Macrotyloma uniflorum*) is an indigenous legume that has historically played an important role in the traditional diets of rural and hilly regions of India. Though categorized as a neglected underutilized pulse crop, recent scientific interest has spotlighted its potential as a nutrient-dense, climate-resilient food with a wide range of therapeutic properties. Horse gram is known by various regional names such as *kulthi, kulattha, kollu, gahat, kurti-kalai, kolatha, ullavallu*, and *madras gram*. Horse gram is well adapted to semi-arid and marginal environments and requires minimal agricultural input, making it highly suitable crop for sustainable farming systems [1–2]

From a nutritional perspective, horse gram is rich in plant-based protein, complex carbohydrates, dietary fiber, essential minerals, and vitamins. It provides a well-balanced amino acid profile and is particularly abundant in iron, calcium, phosphorus and molybdenum and many vitamins like niacin, thiamine, and riboflavin [1, 4]. In addition to its macronutrient and micronutrient profile, horse gram contains a rich array of bioactive compounds, including

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polyphenols, flavonoids, phytosterols, tannins, saponins, and phytic acid. These compounds have been associated with antioxidant, anti-inflammatory, antidiabetic, hypolipidemic, and antimicrobial activities [5-8]. These nutritional attributes have led researchers to classify horse gram as a promising crop for addressing protein-energy malnutrition and micronutrient deficiencies in low-income populations [9].

Increasing evidences from both in-vitro and in-vivo studies underscores the therapeutic potential of horsegram as a functional food or nutraceutical. In Uttarakhand, horse gram is traditionally known as "*Gahat*" and it is an integral part of the local diet and culture. It is consumed especially during winter in the form of traditional dishes such as *gahat dal, gahat paratha, and gahat soup*. Its warming properties are believed to help in maintaining body heat and strength during the cold season. It is well known in local folk medicine as it is effective in managing kidney stones and urinary tract health, due to its traditional use as a diuretic and litholytic agent [4, 6]. Its traditional use in Ayurveda and Siddha medicine systems also highlights its role in treating ailments such as common cold, throat infections, fever, asthma, abdominal lumps, piles, hiccups, piles, and perspiration diabetes, jaundice, cholesterol, jaundice, and menstrual disorders (amenorrhea), bile stones, diabetes, flatulence, edema, goiter. Studies have demonstrated that the consumption of horse gram helps in reducing oxidative stress, managing blood glucose levels, lowering cholesterol, and even improving kidney function [3, 6, 10-11].

Despite its nutritional value and resilience, horse gram has declined in cultivation due to dietary changes, migration, and limited market access. It remains underutilized in mainstream agriculture and global trade, largely due to low consumer awareness and demand. Horse gram represents a valuable link between traditional diets and modern nutrition. Promoting its use can enhance biodiversity, support food security, and combat under nutrition and lifestyle-related diseases. Since it is a nutritious pulse this review explores nutritional profile, bioactive phytochemical constituents, anti-nutritional factors, and therapeutic properties of horse gram (*Macrotyloma uniflorum*).

Nutritional Composition of Horse Gram (*Macrotyloma uniflorum*)

Horse gram is known for its rich nutritional profile, offering macronutrients and micronutrients, essential minerals, dietary fiber and phytochemicals. Its composition varies slightly depending on the variety and growing conditions.

1. Macronutrient Composition

Carbohydrates

Horse gram (*Macrotyloma uniflorum*) is a rich source of complex carbohydrates, accounting for approximately 55-65% of its dry seed weight, including starches and non-digestible oligosaccharides such as raffinose and stachyose [6, 12]. The carbohydrate content in dehulled horse gram seeds ranges from 51.9% - 60.9% [13]. Horse gram contains about 3.69% oligosaccharides, along with smaller amounts of disaccharides (sucrose and maltose) and monosaccharides (glucose, fructose, galactose, arabinose, and inositol). These complex carbohydrates contribute to its low glycemic index, which supports better glycemic control and reduces the risk of metabolic disorders. The slow and sustained release of glucose into the bloodstream makes it particularly beneficial for diabetic diets [5, 14]. The resistant starch found in the horse gram is considered a prebiotic and part of the new generation of dietary fibers [6].

Protein and Amino Acids

Horse gram (*Macrotyloma uniflorum*) is a rich source of plant-based protein [12, 14], ranging from approximately 17.9 to 25.3% on a dry weight basis [4]. It contains appreciable levels of essential amino acids such as lysine, leucine, valine, histidin and arginine, contributing to its nutritional value as a legume-based protein source. However, like many other legumes, horse gram is low in methionine and trptophan [1, 12, 15].

Lipids and Fatty Acids

Horse gram (*Macrotyloma uniflorum*) contains a low amount of total fat, generally ranging from 0.6% to 2.9% on a dry weight basis, depending on the genotype and processing method [4, 16]. The lipid fraction is mainly composed of unsaturated fatty acids such as linoleic, oleic, linolenic, and palmitic acids, while smaller quantities of stearic, myristic, and arachidic acids are also present. Horse gram seeds possess very low levels of oxidized fatty acids. Linoleic acid, an essential fatty acid, accounts for about 45.58% in raw seeds and 40.33% in toasted seeds [1, 6, 12]. The crude fat content of whole seeds (0.70–2.06%) is slightly less than that of dehulled seeds (0.81–2.11%). Overall, raw seeds of horse gram serves as a good source of essential fatty acids, comprising approximately 27.5% saturated (21.97% palmitic, 2.85% arachidic, 2.32% stearic, and 0.36% myristic acids) and 72.49% unsaturated fatty acids (42.78% linoleic, 16.15% oleic, and 13.56% linolenic acids). These unsaturated fatty acids are associated with improved cardiovascular function and lipid metabolism [17].

2. Micronutrient Composition

Minerals

Horse gram (*Macrotyloma uniflorum*) is a rich source of essential minerals, including calcium, phosphorus, magnesium, potassium, iron, and zinc. Horse gram provides high calcium content compared to other legumes, and appreciable levels of molybdenum, manganese, and copper, as well as trace amounts of nickel. These minerals contribute to bone health, hemoglobin formation, muscle function, and enzymatic activity [1, 4].

Vitamins

Horse gram (*Macrotyloma uniflorum*) contains moderate levels of B-complex vitamins, particularly thiamine (B_1), riboflavin (B_2), niacin (B_3), folate (B_9) and vitamin C. Horse gram has a lower vitamin content compared to other legumes. Germination has been shown to enhance riboflavin and niacin levels, although thiamine content may slightly decrease [4-5].

Dietary Fiber

Horse gram (*Macrotyloma uniflorum*) is abundant in dietary fiber, including resistant starch and oligosaccharides. Horse gram is

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a good source of both soluble and insoluble dietary fiber including β-glucan, cellulose, hemicellulose, lignin and pectin. It contains approximately (28.8%) total dietary fiber, with the majority as insoluble fiber (27.82%) and a smaller portion as soluble fiber (1.13%), whereas horse gram flour contains 16.3% total dietary fiber (14.9% insoluble and 1.4% soluble and 2.2% resistant starch). Resistant starch is considered a key prebiotic component and contributes significantly to horse grams value as a functional food. This fiber profile supports bowel regularity, helps lower serum cholesterol, and contributes to better glycemic control [5, 9, 13-14].

Moisture and ash content

Higher mineral content in horse gram corresponds to higher ash content. Horse gram seeds contain 10.80% moisture and 4.26% ash content [2]. Germinated horse gram has reduced moisture 7.60% and ash content 3.07% [18-19].

(Table 1) summarizes the nutritional composition of horse gram:

Bioactive Compounds and Phytochemical Constituents of Horse Gram (*Macrotyloma uniflorum*)

Horse gram (*Macrotyloma uniflorum*) is not only a rich source of basic nutrients it also contains a wide range of bioactive compounds that contribute significantly to its functional and therapeutic properties. Horse gram contains various phytochemicals such as phenolic acids, flavonoids, tannins, saponins, phytosterols, phytic acid, and enzyme inhibitors. Many of these compounds possess antioxidant, anti-inflammatory, anti-diabetic, and anti-urolithiatic

Table 1: Nutritional Composition of Horse gram (per 100g edible portion) Source: [20]

Nutrient	Amount (unit)
Energy	321 kcal
Protein	22.0 g/100g
Fat	0.5 g/100g
Carbohydrates	57.2 g/100g
Dietary Fiber	5.3 g/100g
Leucine	540 g/100g
Lysine	520 g/100g
Valine	390 g/100g
Histidin	190 g/100g
Arginine	530 g/100g
Methionine	70 g/100g
Calcium	287 mg/100g
Iron	6.77 mg/100g
Phosphorus	311 mg/100g
Magnesium	156 mg/100g
Manganese	1.57 mg/100g
Zinc	2.8 mg/100g
Potassium	762 mg/100g
Copper	1.81 mg/100g
Molybdenum	0.749 mg/100g
Thiamine (B1)	0.42 mg/100g
Riboflavin (B2)	0.20 mg/100g
Niacin	1.5 mg/100g
Vitamin C	1 mg/100g
Moisture	11.8 g/100g

Table 2: Major Bioactive Compounds in Horse Gram

Phenolic Compounds and Their Content in Horse gram			
Compound	**Value (unit, DW)**	**Sample**	**Sources**
Total free phenolics	1.670 mg GAE/100g	Seeds	[1, 32]
Polyphenols	46.53 ± 1.13 mg GAE/g 52.33 ± 0.57 mg GAE/g	Ungerminated Flour Germinated flour	[33]
Total Polyphenolic Content	3.09±0.11 mg GAE/g 3.88±0.21 mg GAE/g	Seeds (ANK brown) Seeds (ANK black)	[21]
p-coumaric acid	8.95 µg/g 24.5±1.8 µg/g 40.9±3.2 µg/g 21.4±1.3 µg/g	Seed flour Seed coat Cotyledon Embryonic axe	[25, 1] [4, 22, 26]
p-hydroxybenzoic acid	7.81 µg/g 28.8±1.4 µg/g 20.1±0.8 µg/g 13.1±0.5 µg/g	Seed flour Seed coat Cotyledon Embryonic axe	[25, 1] [4, 22, 26]
Gallic acid	5.5 ± 0.06 µg/g 26.9 ± 1.3 µg/g 19.8 ± 0.8 µg/g	Seed coat Cotyledon Embryonic axe	[4, 22, 26]
Vanillic acid	42.4 ± 3.6 µg/g 58.4 ± 3.3 µg/g 53.2 ± 5.1 µg/g	Seed coat Cotyledon Embryonic axe	
Syrinigic acid	18.4 ± 1.0 µg/g 4.5 ± 0.02 µg/g -	Seed coat Cotyledon Embryonic axe	
Sinapic acid	3.7 ± 0.002 µg/g 9.7 ± 0.009 µg/g -	Seed coat Cotyledon Embryonic axe	
Ferulic acid	37.5 ± 2.5 µg/g 70.1 ± 5.1 µg/g 31.4 ± 2.4 µg/g	Seed coat Cotyledon Embryonic axe	
Chlorogenic acid	22.5 ± 1.1 µg/g 160.8 ± 9.8 µg/g 26.8 ± 2.1 µg/g	Seed coat Cotyledon Embryonic axe	
Protocatechuic acid	23.1 ± 1.2 µg/g 39.0 ± 2.0 µg/g 11.8 ± 0.4 µg/g	Seed coat Cotyledon Embryonic axe	
Flavonoid Compounds and Their Content in Horse gram			
Total Flavonoid Content	1.40±0.04 mg QCE/g 0.88±0.03 mg QCE/g	Seeds (ANK brown) Seeds (ANK black)	[21]
Quercetin	129.5±11.3 µg/gm 9.7±0.55 µg/gm 113. ±6.0 µg/gm	Seed coat Cotyledon Embryonic axe	[22, 26]
Kaempferol	117.2±10.5 µg/gm 6.0±0.25 µg/gm 67.4±3.7 µg/ gm	Seed coat Cotyledon Embryonic axe	
Myricetin	35.5±5.2 µg/gm 2.4±0.07 µg/gm 32.9±3.3 µg/gm	Seed coat Cotyledon Embryonic axe	
Daidzen	0.94±0.03 µg/gm 4.1±0.08 µg/gm 22.2±1.3 µg/gm	Seed coat Cotyledon Embryonic axe	
Genistein	44.7±3.22 µg/gm	Embryonic axe	

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properties, supporting the use of horse gram as a functional food and nutraceutical food [1, 5, 21–22].

1. Phenolic Compounds

Phenolic compounds are the most abundant class of bio-actives present in horse gram (*Macrotyloma uniflorum*). Phenolic compounds, though reported to exhibit mild anti-nutritional effects at higher concentrations, are primarily recognized for their potent bioactive and health promoting roles in horse gram. They exhibit strong antioxidant and anti-inflammatory properties. These properties contribute to free radical scavenging, reduction of oxidative stress, and the prevention of chronic diseases such as cardiovascular disorders, diabetes, obesity, cancer, and neurodegenerative conditions [1, 5]. Variations in the total phenolic content have been documented and are significantly influenced by cultivars, extraction methods, and processing techniques such as soaking, germination, and thermal treatments [23-24]. Several phenolic acids have been identified in horse gram including gallic acid, vanillic acid, syringic acid, chlorogenic acid, sinapic acid, ferulic acid, ellagic acid, p-hydroxybenzoic acid and p-coumaric acid. These compounds contribute significantly to its antioxidant capacity and potential health benefits [1, 7, 14, 25].

2. Flavonoids

Flavonoids are an important group of polyphenolic compounds present in horse gram. Horse gram (*Macrotyloma uniflorum*) contains flavanoids such as quercetin, kaempferol, myricetin, daidzein, genistein, luteolin, and apigenin. These compounds are associated with antioxidant, anti-inflammatory, anti-diabetic, anti-hyperglycemic, and cardioprotective potential, contributing to the overall health promoting properties of horse gram. These compounds modulate biological processes by influencing cellular signaling pathways, inhibiting oxidative enzymes, and regulating glucose metabolism [1, 5-6, 22].

3. Phytosterols

Horse gram also contains phytosterols, particularly β-sitosterol and stigmasterol. β-Sitosterol, detected in the seeds and roots of horse gram, is considered one of its key phytosterols and may contribute to its traditional applications in managing urinary disorders and urolithiasis. Beyond this, β-sitosterol is recognized for its cholesterol-lowering and anti-inflammatory properties and protection against benign prostatic hyperplasia [7-8, 26-27].

4. Tannins

Tannins are a class of polyphenolic compounds responsible for the characteristic astringency and, to some extent, the anti-nutritional effects of legumes. However, at moderate concentrations, they exhibit several health-promoting effects, including antioxidant, antimicrobial, anti-inflammatory, wound-healing (cicatrizant), and anti-HIV properties [1, 28]. Tannins also support digestive health and, along with total phenolics, help combat oxidative stress by scavenging free radicals, thereby reducing the risk of chronic diseases such as cardiovascular disorders and certain cancers. Horse gram contains substantial amounts of tannins, particularly condensed tannins [1]. Processing methods such as soaking, boiling, and germination have been shown to significantly reduce tannin content, thereby

Table 3: Other Bioactive Compounds in Horse gram

Phytosterol Compounds and Their Content in Horse gram			
Compound	**Value (unit, DW)**	**Sample**	**Sources**
β-sitosterol Campesterol Stigmasterol	47.56 mg/100g 3.41 mg/100g 11.57 mg/100g	Seeds	[34]
Tannins Content in Horse gram			
Tannins	2.31±0.01 mg/100gm	Seeds	[31]
	3.19 mg/g	Seeds	[15]
	0.901±0.02 %	Seeds	[24]
	16.18 ± 0.06 10.28 ± 0.02	Ungerminated Flour Germinated flour	[33]
Saponins Content in Horse gram			
Saponins	24.85±0.53 mg/g	Seed coat	[35]
	10.06±0.73 mg/g 11.52±0.78 mg/g	Seeds (ANK brown) Seeds (ANK black)	[21]
Phytic Acid Content in Horse gram			
Phytic Acid	10.2±0.4 mg/g	Flour	[14]
	10.26 mg/g	Seeds	[15]
	10.37±0.06 mg/100gm	Seeds	[31]
	4.55 mg/g 2.60 mg/g	Seeds (ANK brown) Seeds (ANK black)	[21]
	1.02±0.09 8.42±0.41 3.81±0.11	Seed Coat Cotyledon Embryonic axe	[26]

Table 4: Anti-nutritional Factors in Horse gram

Oxalate and Oxalic Acid Content in horse gram			
Compound	**Value (unit)**	**Sample**	**Sources**
Oxalate	3.18±0.01 mg/g	Flour	[33]
Oxalic acid	417 mg/100 g	Seeds	[20]
Oligosaccharides and Their Content in Horse gram			
Oligosaccharides Verbascose Raffinose Stachyose	26.8 mg/g 4.1 0.08 mg/g 7.1 0.08 mg/g 15.6 0.48 mg/g	Flour	[14]
Oligosaccharides	3.69 g/100g	Seeds	[12]
Total Soluble Sugars	6.38 g/100g	Seeds	[12]
Verbascose	1.05± 0.04 mg/g 3.75± 0.2 mg/g 1.3±8 0.04	Seed Coat Cotyledon Embryonic axe	[4, 26]
Raffinose	0.96 ±0.03 mg/g 6.35±0.26 mg/g 2.86±0.09 mg/g	Seed Coat Cotyledon Embryonic axe	
Stachyose	0.70±0.05 mg/g 14.84±0.91 mg/g 6.38±0.38 mg/g	Seed Coat Cotyledon Embryonic axe	
Trypsin Inhibitor Content in Horse gram			
Trypsin Inhibitor	12.18±0.04 mg TIA/100g	Seeds	[31]
	9246±18 units/g	Flour	[14]
	944±22.61 units/g	Seeds	[24]
	0.65±0.02 mg/g 0.69±0.01 mg/g	Seeds (ANK brown) Seeds (ANK black)	[21]

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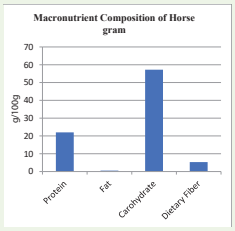

Figure 1: Macronutrient Composition of Horse gram.

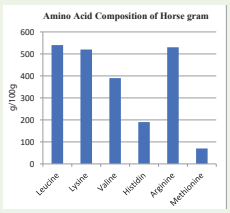

Figure 2: Amino Acid Composition of Horse gram.

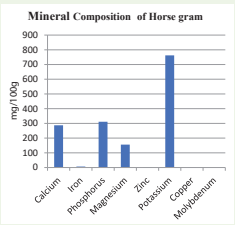

Figure 3: Mineral Composition of Horse gram.

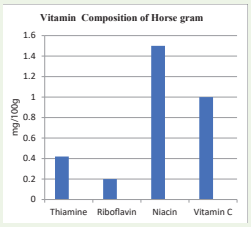

Figure 4: Vitamin Composition of Horse gram.

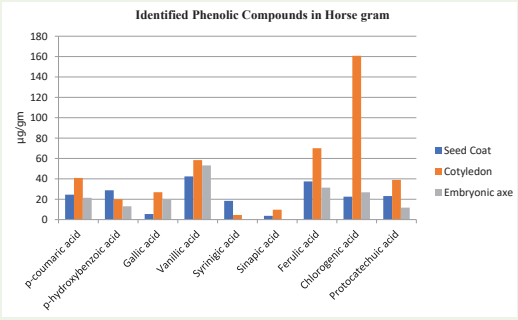

Figure 5: Identified Phenolic Compounds in Horse gram.

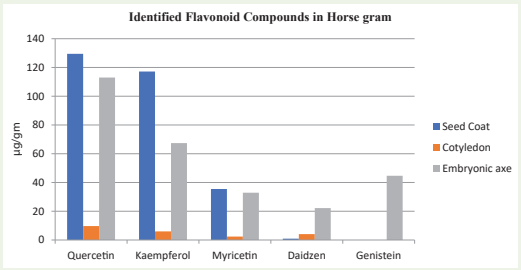

Figure 6: Identified Flavonoid Compounds in Horse gram
Source: Values for figure 5 and figure 6 are based on [4, 22, 26]

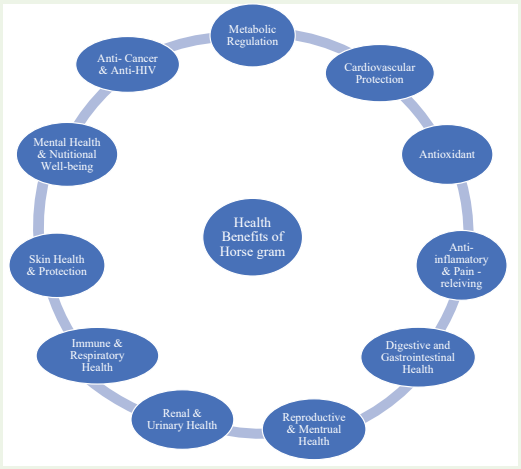

Figure 7: Overview of the key therapeutic and health-promoting effects of Horse gram. Detailed compound-specific mechanism and supporting references are provided in the accompanying text.

enhancing nutrient availability and overall nutritional quality [15, 29-30]. In horse gram seeds, the tannin content was significantly reduced by 69.3% after fermentation and by 54.6% during germination [29]. Fermented germinated and fermented cooked horse gram flours have been reported to be effective in reducing tannin content (61.3% and 62.5%) [30].

5. Saponins

Saponins are bioactive compounds naturally present in horse gram. They are known for their cholesterol-lowering, antioxidant, anti-inflammatory, and immune-supporting properties. In traditional medicine, the presence of saponins in horse gram has been associated with its use in managing diabetes, hyperlipidemia, and kidney stones [4]. These compounds may also improve nutrient absorption by increasing the functional capacity of the intestinal epithelium. However, excessive intake can lead to digestive discomfort. The saponins content in horse gram seeds generally ranges from 1.0% to 2.5% of the dry seed weight [21, 14]. As saponins are heat-sensitive, thermal processing methods such as boiling and roasting significantly reduce their content, while non-thermal treatments like soaking and germination also help decrease saponin levels and improve the digestibility and palatability of the seeds [21, 29-30].

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6. Phytic Acid

Phytic acid is a naturally occurring phosphorus compound found in horse gram, with a dual role. Phytic acid is a known anti-nutrient, as it can inhibit the absorption of minerals such as iron, zinc, and calcium by forming insoluble complexes. It also exhibits antioxidant, anti-cancer, anti-aging and anti-inflammatory properties when consumed in moderation. It reduces the risk of heart disease, renal stones, and diabetes mellitus and neurodegenerative diseases [4, 13-14]. Raw horse gram seeds typically contain 0.83% to 1.1% phytic acid by weight. Processing methods such as soaking, germination, fermentation, and thermal treatment are effective in significantly reducing phytate levels, thereby enhancing mineral bioavailability without compromising the health benefits. While phytates may hinder mineral absorption, they also play a protective role by inhibiting lipid peroxidation [15, 31]. In horse gram seeds, the phytic acid content was significantly reduced by 69.5% after fermentation and by 61.6% during germination [29]. Fermentation of germinated and cooked horse gram flours has been reported to be effective in reducing phytate content (54.1% and 46.8%) [30].

Tannins, saponins, and phytic acid, though commonly regarded as anti-nutritional factors, possess strong antioxidant and therapeutic properties that contribute significantly to the health-promoting potential of horse gram. Hence, these compounds have been discussed under bioactive compounds in this review to emphasize their beneficial roles along with their anti-nutritional aspects.

Anti-nutritional Factors in Horse gram

1. Oxalates

Horse gram (*Macrotyloma uniflorum*) contains oxalates, anti-nutritional factors that bind with essential minerals like calcium, iron and magnesium, forming insoluble complexes which reduce mineral absorption and may increase the risk of kidney stones. The principal oxalate present in horse gram is oxalic acid in significant amount [29, 36]. Many traditional processing methods have been shown to reduce oxalate levels, among which fermentation is considered the most effective, as it not only decreases oxalate content but also enhances the biochemical and microbial qualities of horse gram [29-30]. The oxalate content was significantly reduced by 66.7% after fermentation and by 61.6% during germination [29].

2. Oligosaccharides

Horse gram (*Macrotyloma uniflorum*) is rich in non-digestible oligosaccharides, mainly raffinose, stachyose, and verbascose, belonging to the raffinose family oligosaccharides (RFOs). These sugars constitute a major portion of the soluble carbohydrates in the seed. The cotyledon fraction shows the highest concentration, where RFOs account for about 39% of the soluble sugars. Stachyose predominates in cotyledons, verbascose in the seed coat, and both raffinose and verbascose occur in the embryonic axis. While RFOs exhibit prebiotic benefits, excessive intake may cause gastrointestinal discomfort [4, 13, 26]. However, their levels can be significantly reduced through common processing methods such as soaking, germination, and cooking [37].

3. Lectins (Hemagglutinins)

Lectins, also referred to as hemagglutinins or phytoagglutinins, are carbohydrate-binding proteins commonly found in leguminous seeds. In horse gram, lectins are present at moderate levels and are considered one of the key anti-nutritional factors [1]. Horse gram seeds contain lectins, mainly D. biflorus agglutinin (DBA), which specifically recognize the 'A' blood group and can distinguish between A1 and A2 types, making it useful in blood banks for blood group testing. DBA is found in varying amounts across in the seeds, stems, leaves, and roots of horse gram. These lectins can be toxic or allergenic. However, lectins are heat-sensitive and can be inactivated by soaking, autoclaving, or traditional cooking methods, such as boiling, roasting, and pressure cooking, improving the safety and digestibility of the seeds [38-39].

Anti-Nutritional Enzyme Inhibitors in Horse gram

The major enzyme inhibitors present in orse gram are as follows:

Trypsin Inhibitors in Horse gram

Horse gram contains trypsin inhibitors, a class of anti-nutritional factors that interfere with protein digestion by inhibiting the enzyme trypsin. These inhibitors may cause pancreatic hypertrophy due to overstimulation of enzyme production. Processing methods such as soaking, germination, roasting, and autoclaving have been shown to effectively reduce trypsin inhibitor activity in horse gram. These treatments enhance protein digestibility and improve the overall nutritional quality of the seeds [15, 29, 31]. Among these, germination proved particularly effective, with a 72-hour germination period resulting in a 28.57% reduction in trypsin inhibitor content [31]. Although excessive levels can impair protein utilization, moderate amounts may help regulate glucose release into the bloodstream. Moreover, trypsin inhibitors possess anti-inflammatory and anticancer properties and contribute to maintaining digestive health and reducing obesity [40].

Protease inhibitors and Urease inhibitors

Horse gram contains protease and urease inhibitors which can reduce protein digestibility by forming stable complexes with digestive enzymes such as trypsin and chymotrypsin [1]. The protease inhibitors found in horse gram are similar to Bowman-Birk type inhibitors, which are characterized by low molecular weight, high disulfide content, and the ability to inhibit both trypsin and chymotrypsin independently or simultaneously. While excessive amounts may affect nutrient utilization, these compounds also contribute to gut health and exhibit antimicrobial properties [4, 13]. Processing techniques such as boiling, roasting, and fermentation can reduce their concentration, thereby enhancing the nutritional quality of horse gram [30]. Furthermore, protease inhibitors exhibit therapeutic potential against HIV, cancer, and neurodegenerative diseases by specifically targeting key enzymes [41].

Health Benefits of Horse gram (*Macrotyloma uniflorum*)

Horse gram (*Macrotyloma uniflorum*) is a highly nutritious legume with a wide range of health benefits, especially valued in traditional and functional foods. Its rich composition of bioactive

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compounds such as phenolics, flavonoids, and protein fractions contributes to its therapeutic potential. Several studies across India have demonstrated the positive effects of horse gram consumption on various health outcomes.

Antioxidant Properties

Horse gram (*Macrotyloma uniflorum*) possesses strong antioxidant properties mainly due to its high levels of phenolic and flavonoid compounds. Its seed extracts effectively scavenge free radicals, reduce oxidative stress, and protect the liver from damage caused by toxins or high-fat diets [42-44].

Anti-Diabetic Properties

Horse gram contains α-amylase and α-glucosidase inhibitors, which slow carbohydrate digestion and glucose absorption. Horse gram exhibits hypoglycemic activity due to high dietary fiber and polyphenolic content. It slows glucose absorption and enhances insulin sensitivity. Studies indicate its efficacy in lowering postprandial blood glucose levels [7, 45-47].

Anti-Obesity Properties

Horse gram promotes satiety and improves digestion due to its fiber and protein content. It also improves lipid metabolism, supporting obesity management. Polyphenols and dietary fiber in horse gram help in reducing body weight and serum cholesterol by enhancing fat metabolism and bile acid excretion [3, 46-47].

Anti-Hyperlipidemic, and Cardioprotective Properties

Horse gram is rich in polyphenols and flavonoids which act as natural antioxidants, preventing oxidative stress. This contributes to the prevention of chronic diseases such as cardiovascular disease [10]. Its consumption helps reduces LDL cholesterol, increases HDL levels, regulate blood pressure, improving overall cardiovascular function [46].

Anti-Urolithiatic Activity

Horse gram (*Macrotyloma uniflorum*) has long been used in traditional medicine for preventing and managing kidney stones. Studies have shown that its seed extracts possess diuretic and stone-dissolving properties. These effects help reduce urinary oxalate, calcium, and phosphate levels, which lowers the risk of stone formation [45, 47].

Antibacterial and Antimicrobial Properties

Horse gram is known for its anti-inflammatory and antimicrobial properties, due to its bioactive compounds like phenolic acid, flavonoids, and tannins. Horse gram extracts have demonstrated antimicrobial activity against several pathogenic bacteria, including *E. coli, Staphylococcus aureus, Bascillus subtilis*, and *Pseudomonas aeruginosa* [1, 48-49].

Anti-Inflammatory and Analgesic Properties

Horse gram seed extracts demonstrate strong wound healing, anti-inflammatory and analgesic effects, inhibiting inflammatory mediators and reducing pain [50-51].

Anti-Allergic and Anti-Anaphylactic Properties

Horse gram (*Macrotyloma uniflorum*) shows anti-allergic and anti-anaphylactic properties. It helps relieve allergic conditions such as hay fever, atopic dermatitis, food allergies, and severe allergic reactions like anaphylaxis, and may also help reduce allergic asthma symptoms by lowering leukocyte and eosinophil counts. It further helps minimize reactions caused by allergens such as pollen, dust, animal fur, insect bites or stings, and certain foods or medicines [52].

Anthelmintic Activity

Helminth infections are caused by parasitic worms known as helminthes and the infection is prevalent, particularly in tropical and subtropical regions. Horse gram (*Macrotyloma uniflorum*) exhibits strong anthelmintic activity against *Pheretima posthuma*. This activity is mainly attributed to the presence of alkaloids and phytosterols, which interfere with the worm's energy metabolism by disrupting oxidative phosphorylation [53].

Anti-Cancer Properties

Horse gram (*Macrotyloma uniflorum*) seeds are rich in natural compounds called protease inhibitors, which have shown promising potential against cancer. Studies indicate that both the seeds and seed coat can inhibit the growth of cancer cells in laboratory experiments. These effects have been observed in several types of cancer cells, including human bone cancer cells (osteosarcoma) and mouse skin cancer cells (melanoma), suggesting that horse gram may serve as a natural source of anticancer agents [35, 41, 49].

Anti-HIV Activity

HIV is a serious disease, and its frequent changes make it hard to develop effective drugs. Compounds called dolichin A and dolichin B, found in horse gram (*Macrotyloma uniflorum*), may help. These natural bioflavonoids can interact with important HIV enzymes that the virus needs to replicate. Studying these interactions could help scientists understand how horse gram works against HIV and assist in designing new AIDS treatments [54].

Prevent Nutritional Deficiencies

Horse gram (*Macrotyloma uniflorum*) is a nutrient-rich legume, high in iron, calcium, and molybdenum, which contribute to preventing anemia and supporting bone health, especially in at-risk populations. It is also rich in protein and folic acid and has good digestibility, making it an excellent food for combating anemia and protein-energy malnutrition [3, 9].

Digestive Health Benefits

Horse gram (*Macrotyloma uniflorum*) is rich in dietary fiber, flavonoids, tannins, phenolics, and beneficial lipids, which promote gut health and support the treatment of gastrointestinal issues. Its fiber regulates bowel movements, reduces bloating, and protects against gastric discomfort. Flavonoids and tannins provide anti-diarrheal and anti-ulcer effects, while the lipids and fiber aid in healing and preventing ulcers. Additionally, the fiber and roughage help prevent piles by promoting smooth bowel movements and reducing strain. Ayurvedic practices also recommend consuming horse gram for its gut-protective and ulcer-healing properties [22, 43, 46].

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Reproductive Health Benefits

Horse gram is traditionally used for relieving menstrual discomfort. Its high iron content aids in maintaining hemoglobin levels, and prevent anemia associated with heavy menstrual bleeding and excessive vaginal discharge (leucorrhea). It also alleviates menstrual discomfort and regulates menstrual cycle. Additionally, its antioxidant compounds may contribute to overall reproductive well-being [1, 4].

Immune and Respiratory Health Benefits

Horse gram is traditionally used to support the immune system and manage common respiratory ailments such as cold, cough, and fever asthma, bronchitis, throat infection. Its nutrient profile including, proteins, vitamins, and minerals may help strengthen immunity and reduce susceptibility to infections [3-4].

Skin Health Benefits

Powdered or paste forms of horse gram improve boils, rashes, bacterial and fungal infections, and excessive sweating. Its flavonoids and phenolic compounds protect the skin from UV-induced oxidative damage [11, 55].

Anti-Depressant Activity

Horse gram (*Macrotyloma uniflorum*) extracts (methanol and ethanol) can be used as an antidepressant agent and showed significant result against depression [56-57].

Conclusion

Horse gram (*Macrotyloma uniflorum*) is a nutrient-dense legume rich in macronutrients and micronutrients. It contains various bioactive phytochemicals such as phenolics, flavonoids, phytosterols, tannins, saponins, and phytic acid. These bioactive compounds contribute to its antioxidant, anti-inflammatory, and other health-promoting properties, making it a valuable functional food. Although it contains certain anti-nutritional factors, their adverse effects can be substantially reduced by appropriate processing methods such as dehulling, soaking, boiling, roasting, germination, fermentation, and autoclaving. Horse gram offers a sustainable, nutritionally rich food option with proven health benefits. Including horse gram in the regular diet can be a sustainable and affordable intervention for managing chronic diseases. Scientific evidence and traditional knowledge highlight its potential benefits across multiple health aspects, including immune support, management of respiratory ailments, metabolic regulation, reproductive health, and chronic disease prevention. The high protein and mineral content, along with its bioactive compounds, make horse gram suitable for incorporation into public health nutrition strategies, particularly in resource-limited settings.

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