Horse Gram: A Comprehensive Review of an Underutilized Nutraceutical Pulse Crop

Pranav Padmanabhan1, Lerin Biji Mathew1, Anugrah Krishna1, Karthik Mohan1, Chhavi Kulshrestha1, Rafeeya Shams1, Qurat ul eain Hyder Rizvi2 and Kshirod Dash3

1Department of Food Technology and Nutrition, Lovely Professional University, Phagwara, Punjab, India
2Department of Food Technology, Dr. Khim Singh Gill Akal College of Agriculture, Eternal University, Himachal Pradesh, India
3Department of Food Processing Technology, Ghani Khan Choudhury Institute of Engineering and Technology, West Bengal, India

Abstract

Horse gram, an underutilized pulse with a rich history in traditional medicine, stands out for its diverse nutraceutical benefits. Esteemed for its efficacy in addressing health issues ranging from respiratory conditions to gastrointestinal disorders, kidney stones, and anthelmintic needs, horse gram offers a myriad of therapeutic potentials often overlooked. Historical records and traditional uses emphasize its significance in managing various ailments, showcasing anthelmintic properties, and demonstrating hypoglycemic, hypolipidemic, and antimicrobial effects. The seeds, particularly rich in dietary antioxidants, serve as remedies for hiccups, fungal and bacterial infections, and parasitic worms. Moreover, horse gram’s non-digestible carbohydrates contribute to diabetes management, while its extracts exhibit anti-hypercholesterolemic effects. Beyond its medicinal applications, horse gram is recognized as a versatile crop, serving both as livestock feed and human food. Its potential as a nutraceutical, forage, and food source in drought-prone and malnourished areas holds considerable untapped promise for further exploration.

Keywords

Antinutritional factors, Health benefits, Bio-active compounds, Horse gram

Introduction

Food legumes, which have been a fundamental component of human diets for over a thousand years, stand as the second most essential group of crops. They are also recognized as the second most important source of nutrition for both animals and humans [1]. Within developing nations, a select few conventional legumes exert substantial control over both the market and production chains, and they hold a pivotal role in addressing protein malnutrition. Nevertheless, certain untapped indigenous legumes, such as horse gram (Macrotyloma uniflorum (L.) Verde), possess significant potential to enhance nutritional security within marginalized rural and tribal regions. Horse gram, a member of the fabaceae family, is a highly valuable grain legume known for its remarkable nutritional and therapeutic qualities, as well as its ability to thrive in challenging environmental conditions [2]. It stands out as an ideal choice for intercropping alongside various cereals like sorghum, maize, little millet, finger millet, and pearl millet. Horse gram, known as “kulantha” in sanskrit and by various other names in different languages, is a highly nutritious pulse vegetable crop with significant ethno-medical properties [3].

In times of drought, dry seasons, and famines, underutilized legumes play a crucial role in enhancing the dietary intake of rural households. In numerous instances, these legumes are hailed as saviors for millions of impoverished indi-
Horse Gram: A Comprehensive Review of an Underutilized Nutraceutical Pulse Crop

Padmanabhan et al.

Individuals residing in regions where the primary challenge lies in securing food and adequate nutrition. This is particularly evident in areas where traditional agricultural systems struggle to ensure survival. Nowadays focusing more on unexploited legumes is growing for the discovery of new alternate sources of protein to meet the demand for vegetable protein is ever increasing. This often overlooked and underappreciated crop possesses significant untapped potential in aiding small-scale rural farming communities. Agriculture plays a pivotal role in ensuring people have access to vital food and nutrition, while also serving as a means of income generation. Additionally, it plays a significant part in safeguarding the genetic resources required to tackle present and future environmental issues [4]. Intercropping maize with improved horse gram varieties results in reduced labor costs due to the decreased need for weeding in the intercropped fields. This is because horse gram effectively suppresses weed growth.

Moreover, in the majority of instances, intercropping has no adverse impact on the yield of the maize crop or the availability of fodder. Growing finger millet and horse gram together can yield higher profits compared to cultivating finger millet alone [5]. Despite being a rich source of various micronutrients, dietary fiber, phytochemicals, and proteins, horse gram seeds are often overlooked as an underappreciated food legume [6]. In various regions of India and across the globe, this particular ingredient finds its way into soups and sprout dishes. It is commonly referred to as the "humble man's legume," primarily serving as livestock fodder rather than a staple for human consumption. Additionally, it features prominently in traditional remedies for conditions such as hypertension, obesity, kidney stones, and diabetes treatment. The legume known as horse gram has garnered significant interest due to its documented trypsin inhibitory capabilities, antioxidant properties, and its impact on angiotensin-converting enzyme [6].

Furthermore, the α-amylase inhibitor found in horse gram seeds has been suggested to possess anti-diabetic qualities. Recent research indicates that horse gram offers numerous health benefits, such as its potential to reduce cholesterol and glucose levels. It also appears to combat insulin resistance by inhibiting the protein tyrosine phosphatase while demonstrating significant antioxidant activity [7]. Additionally, horse gram is rich in essential vitamins like thiamine, niacin, carotene, vitamin C, and riboflavin, along with important minerals such as iron (Fe) and phosphorus (P). Horse gram is recognized for its potential medicinal and therapeutic advantages, although many of these benefits await further scientific confirmation. It has also been employed as an Ayurvedic remedy for conditions such as piles, edema, and renal stones. This legume is rich in polyphenols, which exhibit strong antioxidant properties. Additionally, it contains calcium (Ca), which facilitates the transport of oxygen to cells and contributes to the formation of hemoglobin in the blood, as well as molybdenum, which plays a role in regulating Fe absorption [8].

Horse gram is a valuable supplier of haemagglutinin, a substance or agent responsible for causing the clumping of red blood cells. Horse gram seeds possess significant antiurolithic properties. Horse gram is widely grown for various purposes, including human consumption as a food source, as livestock fodder, and pulse crop, for medicinal use, and as a green manure. In recent times, the consumption of sprouted horse gram seeds has gained popularity due to their nutritional value and their ability to mitigate the risk of several diseases while offering a range of health benefits [9]. In traditional medicine, horse gram seeds are used for treating piles, urinary diseases, and urinary stones, help in recovering the irregular menstrual cycle, and also act as a tonic, astringent, as well as for treating calculus afflictions, corpulence, hiccups, and worms. Furthermore, it is believed that the prepared concoction made from horse gram seeds infused with spices serves as a highly effective treatment for throat infections, the common cold, and fever. Additionally, the soup derived from this mixture is thought to generate warmth. Due to their potential medicinal and nutritional benefits, there is a growing interest in investigating underutilized legume to mitigate the risk of various illnesses and combat malnutrition in developing nations. M. uniflorum is a great source of carbohydrates, essential amino acids, molybdenum, energy, proteins, and low content of P, Fe, lipids, and vitamins like niacin, riboflavin carotene, vitamin C, and thiamin [10].

Horse gram is singled out for its unique combination of nutritional richness and therapeutic properties, making it a standout choice for various applications. Not only does it boast a diverse array of nutrients, including high levels of protein, dietary fiber, essential fatty acids, and minerals such as Fe, Ca, and molybdenum, but it also stands as an exceptionally affordable and protein-rich lentil. Its distinctive nutritional profile, particularly in terms of higher lysine content compared to other commonly cultivated pulses, positions it as an excellent dietary element, especially in addressing amino acid imbalances. Moreover, horse gram’s non-digestible carbohydrates, resistant starch, and prebiotic qualities contribute to its notable benefits in diabetes management and digestive health. Beyond its nutritional value, horse gram has a rich historical significance in traditional medicine, further justifying its selection for exploration. With its resilience to pests, versatility as both livestock feed and human food, and potential as a cost-effective source of fodder, green manure, and supplementary fuel, horse gram emerges as a holistic and underutilized resource worthy of deeper investigation and utilization [11].

**Nutritive components**

Grain legumes, commonly known as the "poor man’s meat," are a significant provider of nutrients, particularly in developing nations [11]. Horse gram has gained recognition for its exceptional protein content and a wide array of other essential nutrients. The nutritional quality of this Horse gram crop matches that of other commonly cultivated pulse crops in all respects, while also highlighting its significant content of molybdenum, Fe, and Ca [12]. Horse gram, which includes being a good source of dietary fiber, protein, phytochemicals, and various micronutrients, horse gram seeds are often overlooked as a food legume. They are primarily consumed by farming communities in remote regions and individuals with lower incomes. Proximate composition tests showed that germinated horse gram is a decent source of protein, crude fiber, and carbohydrate content [13].
Carbohydrates

Commonly consumed legumes have carbohydrate contents that typically range from 50% to 60%. Carbohydrates in these legumes consist of monosaccharides, starch, polysaccharides, and other oligosaccharides. Among these components, starch stands out as the primary source of available carbohydrates in legume seeds, accounting for a significant portion (ranging from 22% - 45%), along with dietary fiber (ranging from 4.3% - 25%) and oligosaccharides (ranging from 1.8% - 18%). The carbohydrate content in dehulled horse gram seeds ranges from 51.9% - 60.9%, while in whole horse gram seeds, it falls between 56.8% and 66.4%. In 100 g of dry matter, raw horse gram seeds typically contain approximately 36 ± 1.17 g of starch.

Among this starch content, about 85% is readily digestible, 14.47% is classified as resistant starch, and an additional 3.38% is attributed to resistant starch linked with insoluble dietary fiber (IDF). Horse gram is notable for its higher percentage of non-digestible carbohydrates, which leads to a reduced release of glucose into the bloodstream. This property can have significant benefits in the dietary management of diabetes. The resistant starch found in horse gram is considered a prebiotic and is part of the new generation of dietary fibers, as described by Samanta et al. [14]. Horse gram seeds have a total soluble sugar content of 6.38%, with approximately 55 - 65% consisting of raffinose family oligosaccharides (RFO), including verbascose and stachyose, which are known to cause flatulence. The percentage of oligosaccharides can be altered through various processing methods such as sprouting, soaking, and cooking. Germinated horse gram contains slightly decreased carbohydrate content (58.11%), respectively. Carbohydrates in most people's diets provide the bulk of the nutrition. This is a good source of energy [13] since it provides energy for oxidative metabolism readily accessible.

Protein

Horse gram stands out as an exceptionally affordable and protein-rich lentil, suitable for both humans and animals. Its seeds boast double the protein content compared to cereal grains, and its protein value is nearly identical to that of winged beans (Psophocarpus tetragonolobus), soybeans (glycine max), and chickpeas (Cicer arietinum) [15]. The wild horse gram variety, with a true seed protein percentage of 34.88%, has been documented to have roughly twice the protein content compared to commonly cultivated horse gram lines. In the wild horse gram species, Macrotyloma sar-garhwalensis, the crude protein content is found to be approximately 38.37% (with a margin of ± 1.03%). Notably, horse gram protein contains a higher level of lysine compared to chickpeas and pigeon peas. In cereal-based diets, this quality makes it an excellent dietary element, especially when methionine is the primary amino acid in short supply, and tryptophan and threonine are the other amino acids with minor limitations. The protein content of horse gram increased on germination and found to contain 24.10%. An increase in protein content might be due to biosynthesis of protein as a result of germination [13].

Dietary fiber

Sufficient dietary fiber plays a crucial role in maintaining the optimal operation of the digestive system and has been associated with a reduced likelihood of developing several chronic conditions, such as certain cancers, cardiovascular disease, and diabetes. Fiber is composed of components such as pectin, mucilage, gum, cellulose, lignin, and hemicelluloses [16]. Grain legumes commonly consumed as pulses by humans typically have fiber content ranging from 8.0% to 27.5%, with soluble fiber ranging from 3.3% to 13.8%. In contrast, horse gram seeds boast a higher total dietary fiber content of 28.8%, primarily composed of soluble dietary fiber (SDF) at 1.13%, with a ratio of IDF to SDF at 24.6, and IDF accounting for 27.82%. Conversely, horse gram flour contains a total dietary fiber content of 16.3%, with 1.4% being soluble fiber, 14.9% insoluble fiber, and an additional 2.2% in the form of resistant starch [6]. Horse gram seeds are known for their rich IDF content [17].

This dietary fiber plays a crucial role in supporting normal lower intestinal function in humans. In the context of horse gram flours, their elevated dietary fiber content can be beneficial by contributing to favorable effects on colon physiology and intestinal health, in addition to other therapeutic and homeostatic functions in human nutrition [6]. Furthermore, fiber derived from pulses, such as horse gram, can influence energy expenditure, fat oxidation, substrate utilization, and even the deposition of visceral adipose tissue [18]. Horse gram seed contains 28.8% total dietary fibers, mainly insoluble dietary fiber (IDF) 27.82% and soluble dietary fiber (SDF) 1.15% with IDF: SDF 24.6, whereas horse gram flour contains 16.3% total dietary fiber (14.9% insoluble and 1.4% soluble and 2.2% resistant starch) [19]. Horse gram seeds contain more insoluble dietary fiber required for normal lower intestinal function in humans.

Fat

The fat content in horse grams typically falls within the range of 0.6% to 2.6%. Interestingly, when horse gram seeds are dehulled, their crude fat content increases, ranging from 0.81% - 2.11%, compared to whole seeds, which range from 0.70% - 2.06%. These seeds are a rich source of essential fatty acids, with saturated fatty acids accounting for 27.5% of the total, including 2.85% arachidic acid, 21.97% palmitic acid, and 0.36% myristic and stearic acid. Furthermore, they contain 72.49% unsaturated fatty acids, comprising 16.15% oleic acid, 13.56% linolenic acid, and 42.78% linoleic acid. Among these unsaturated fatty acids, linoleic acid has demonstrated potential benefits in addressing cardiovascular diseases and diabetes [20]. Balancing the intake of essential fatty acids such as linoleic acid and α-linolenic acid is a potential strategy to mitigate the risk of Alzheimer’s and Parkinson’s diseases. These fatty acids are pivotal for supporting the formation of healthy cell membranes and the proper development of the nervous system and brain function. Consequently, incorporating more legume seeds into one’s diet could potentially provide advantageous effects for health [21]. Furthermore, it is important to highlight that horse gram lipids contain phytosterol esters. These constituents play a role in promoting the healing and protective properties against alcohol-induced acute gastric ulcers [22].
Ash and moisture content

Horse gram seeds generally have a moisture content of approximately 11.39%. However, it’s worth noting that the moisture level in these seeds can fluctuate depending on when they are harvested. Typically, at the time of harvesting, it tends to be higher, ranging from 18 - 25%. To ensure safe storage for pulses, it is advisable to maintain a moisture content within the recommended range of 9 - 12% [23]. Higher ash content is a sign of elevated mineral content, and when it comes to horse gram, its leaves stand out as a noteworthy leafy vegetable due to its considerably higher mineral content, measuring approximately 4.50%. This is in stark contrast to the mineral content found in other common vegetables, which typically ranges from 1.5% - 2.4%, [24]. The horse gram contains a wide range of microminerals such as iron (Fe), copper (Cu), nickel (Ni), zinc (Zn), and manganese (Mn), with concentrations varying between 1.0 and 95.0 μg per gram of dry weight.

Additionally, it also contains macro minerals including potassium (K), Ca, P sulfur (S), and magnesium (Mg), with concentrations ranging from 1.3 - 14 mg per gram of dry weight. In its raw form, horse gram seeds contain approximately 5.89 to 7.44 mg of Fe and 244 - 312 mg of Ca per 100 g of seeds. The bio-accessibility of these nutrients when assessed in vitro varies between 0.26 - 0.85 mg of Fe and 22.50 - 38.50 mg of Ca per 100 g of seeds [25]. It is important to highlight that procedures like roasting, cooking, and germination have been demonstrated to notably enhance the in vitro bio-accessibility of both Fe and Ca [25]. Germinated horse gram has a moisture content of 7.60%. In general, more moisture content of raw horse gram was observed but the germinated horse gram stage increased. Germinated horse gram ash content is 3.07% respectively. Ash content decreased from raw horse gram to treated stage but increased as seen in germinated stage [13].

Non nutrient bioactive compounds

Pulses are recognized for their content of various antinutritional components that can hinder the absorption of nutrients. Among these, horse gram flour stands out for its elevated levels of phytic acid, trypsin inhibitor activity, polyphenols, and oligosaccharides [6]. However, the utilization of horse gram as a human food source is constrained due to its comparatively higher concentrations of haemagglutinin, enzyme inhibitors, polyphenols, tannins, phytic acid, and oligosaccharides when compared to other legumes [26]. Fortunately, these undesirable components can be reduced to a more acceptable level through various traditional processing techniques such as cooking, germination, roasting, and dehusking. This results in an improved nutritional profile and overall acceptability of horse gram as a human food source. In the context of anti-nutritional factors, it’s important to highlight that certain compound traditionally classified as such, such as tannins, phytic acid, and phenols, are increasingly being acknowledged for their potential as antioxidants that can offer health-enhancing advantages. Notably, phytic acid has demonstrated properties that include anticarcinogenic effects, the ability to lower blood sugar levels and antioxidant capabilities. Therefore, depending on consumer preferences, there is flexibility in either removing or retaining these constituents in horse gram-based food products [27].

Merit of protease inhibitor

Protease inhibitors

Horse gram possesses protease inhibitors that have the ability to diminish the breakdown of dietary proteins in the intestines. They achieve this by forming an irreversible bond with trypsin enzymes, akin to the action of other Bowman-Birk protease inhibitors. These inhibitors are distinguished by their lower molecular weight, increased disulfide content, and limited presence of aromatic amino acids. These unique characteristics enable them to effectively hinder and attach to chymotrypsin and trypsin, either in a concurrent or autonomous manner [29]. Notably, horse gram flour exhibits significantly higher trypsin inhibitor activity compared to cowpea and chickpea flour [6]. Horse gram protease inhibitors can inhibit various proteases, including chymotrypsin and trypsin, with Kunitz and Bowman-Birk (BBI) being the most extensively studied types. Despite their reputation for reducing protein digestibility, some research suggests that Bowman-Birk protease inhibitors may have anticarcinogenic properties. Chymotrypsin and trypsin inhibitors are extensively researched components found in horse gram. Multiple studies have examined the emergence and vanishing of specific electrophoretic protease inhibitors in horse gram during germination. The existence of these inhibitors in the early stages of seed development and in vegetative portions may have a significant impact on the plant’s innate defense mechanisms.

Merit of non-nutrient bioactive compounds

Non-nutrient bioactive compounds found in horse gram, such as polyphenols, tannins, and oligosaccharides, contribute to its potential health benefits. These compounds, while traditionally classified as antinutritional, have demonstrated antioxidant properties that can offer health-enhancing advantages. For instance, phytic acid, often considered an antinutrient, has shown anticarcinogenic effects, the ability to lower blood sugar levels, and antioxidant capabilities. Similarly, tannins, despite contributing bitterness and astringency, offer health benefits such as cicatrizing, anti-inflammatory, and anti-HIV functions. The presence of oligosaccharides, though known to cause flatulence, can function as prebiotics, promoting the growth of beneficial bacteria in the colon and improving overall gut health [28].

Demeer of non-nutrient bioactive compounds

On the downside, non-nutrient bioactive compounds can also pose challenges. Some of these compounds, such as lectins or phytoagglutinins found in horse gram, like D biflorus agglutinin (DBA), may have allergenic properties. Lectins, if not adequately addressed through proper processing methods like soaking or cooking, can pose risks to individuals sensitive to them. Additionally, high levels of certain compounds like tannins may contribute to bitterness, affecting the palatability of horse gram-based products. Furthermore, these bioactive compounds, if not reduced through appropriate processing techniques, could potentially hinder the absorption of essential nutrients, impacting overall nutritional bioavailability. Thus, striking a balance between retaining the potential health benefits and minimizing any adverse effects becomes crucial in the utilization of non-nutrient bioactive compounds [28].
in their pivotal role in treating viral infections, notably HIV. By inhibiting the activity of protease enzymes crucial for the replication of the virus, these inhibitors effectively impede the progression of the infection. This has proven instrumental in enhancing the quality of life for individuals living with HIV. Moreover, protease inhibitors demonstrate versatility, extending their utility beyond antiviral treatments. They are utilized in various therapeutic applications, including the treatment of certain cancers and neurodegenerative diseases. The precision with which protease inhibitors target specific enzymes contributes to their therapeutic effectiveness, making them valuable tools in the arsenal against various medical conditions [30].

**Demerit of protease inhibitor**

Protease inhibitors, while effective in treating certain medical conditions, come with notable demerits. One significant drawback is the potential for adverse side effects. Patients undergoing protease inhibitor therapy may experience gastrointestinal discomfort, metabolic disturbances, and other systemic issues. Moreover, these inhibitors often interact with various medications, complicating treatment regimens and requiring careful consideration of potential drug interactions. Another concern is the development of drug resistance over time. Prolonged use of protease inhibitors can lead to the emergence of resistant strains of pathogens, diminishing the efficacy of the treatment. This underscores the importance of continuous research and vigilant monitoring to address these demerits and enhance the overall effectiveness and safety of protease inhibitor therapies [30].

**Tannins and total free phenolics**

Plants synthesize tannins and phenolic compounds as vital phytochemicals to protect themselves from predators and adapt to different stressors [31]. These naturally occurring plant components are greatly valued for their capacity to improve the taste, visual appeal, and flavor of various products, in addition to their potential positive effects on human health. Tannins, with their complex structures and widespread presence among phenolic compounds, are known to contribute bitterness and astringency to plants while also having the ability to precipitate proteins [32]. Horse gram seeds are notable for their high content of polyphenols and tannins compared to other legumes. They exhibit relatively elevated levels of tannins, ranging from 763.7 to 895.9 mg/100 g, and total free phenolics at 1.670 g/100g [33]. It is worth mentioning that brown horse gram seeds have lower amounts of total phenolics and tannins, while black seeds are rich in both tannins and total phenolics. Extracts derived from the horse gram plant have been identified as promising sources of phenolic components. Among the eight phenolic acids analyzed, p-hydroxy benzoic acid was found to be present at 7.81 mg, and p-coumaric acid at 8.95 mg per 100 g of dry sample [34].

In recent times, phenolics have garnered significant attention from health and food scientists due to their antioxidant properties and potential health-related applications. Tannins offer a wealth of health benefits, including cicatrizant, anti-inflammatory, and anti-HIV functions, in addition to their role in protecting plants against environmental stresses like atmospheric pollution, drought, and UV-B radiation, as well as against harmful insects, herbivores, and microbial pathogens [32].

**Merit of tannins and total phenolics**

Tannins and total phenolics, both plant-derived compounds, offer several merits in various biological contexts. One significant advantage lies in their antioxidant properties. Tannins and total phenolics help combat oxidative stress by scavenging free radicals, potentially reducing the risk of chronic diseases such as cardiovascular disorders and certain cancers. Furthermore, these compounds contribute to the plant’s defense mechanisms against pathogens and herbivores, showcasing their role in ecological interactions. Beyond health benefits, tannins also play a role in leather tanning and form complex compounds with metals, aiding in water purification. The diversity of applications underscores the multifaceted merits of tannins and total phenolics in ecological, industrial, and medicinal contexts [35].

**Demerit of tannins and total phenolics**

Tannins and total phenolics, while possessing certain health benefits, also come with notable drawbacks. One significant demerit is their interference with nutrient absorption. Tannins, found in various plant foods, can bind to minerals like Fe and reduce their bioavailability, potentially contributing to nutrient deficiencies over time. Moreover, these compounds may impart a bitter or astringent taste to foods, affecting their palatability. Excessive intake of tannins has been associated with digestive issues, as they can inhibit enzymes involved in the breakdown of carbohydrates and proteins. Additionally, some individuals may be sensitive to phenolic compounds, experiencing allergic reactions or intolerance. It’s essential to strike a balance in consumption, appreciating the benefits while being mindful of potential adverse effects on nutrition and taste [35].

**Oligosaccharides**

Oligosaccharides such as raffinose, verbascose, and stachyose have been identified in horse gram. Anaerobic bacteria from the clostridia group metabolize these oligosaccharides in the large intestine, resulting in the production of gases like \( \text{H}_2, \text{CH}_4, \text{CO}_2, \text{NH}_3, \) and \( \text{H}_2\text{S} \) as well as short-chain fatty acids [36]. Additionally, these oligosaccharides can function as indigestible carbohydrate sources, not only providing various positive physiological effects but also stimulating the growth of beneficial bacteria in the colon. This prebiotic effect contributes to improving the overall health of the host. Indeed, numerous indigestible food components possessing prebiotic characteristics promote the proliferation and activity of bacteria within the gastrointestinal tract. These substances find widespread application in various food items, including but not limited to soft drinks, cereals, cookies, baby foods, and confectionery products. The cotyledon fractions of horse gram contain a higher percentage of oligosaccharides, including verbascose, raffinose, and stachyose, accounting for 39% of the total soluble sugars. Stachyose is particularly abundant in both embryonic axe fractions and cotyledon, while verbascose is the primary oligosaccharide in the seed coat fractions of horse gram. Additionally, significant levels of verbascose and
raffinose were also detected in the embryonic axe fractions and cotyledon [37].

**Merit of oligosaccharides**

Oligosaccharides, short chains of sugar molecules, offer several merits in the realm of human health and nutrition. One notable advantage lies in their prebiotic properties, serving as a source of nourishment for beneficial gut bacteria. By promoting the growth and activity of these microorganisms, oligosaccharides contribute to a balanced gut microbiota, which is linked to improved digestion and overall health. Furthermore, oligosaccharides have been associated with enhanced immune function, as they modulate the immune response and may help prevent certain infections. In the context of food, oligosaccharides contribute to the sweetness and palatability of certain products without causing a rapid spike in blood sugar levels, making them a favorable alternative to simple sugars. As researchers delve deeper into the intricate interactions between oligosaccharides and the human body, their potential health benefits continue to make them a subject of interest in both scientific and nutritional studies [38].

**Demerits of oligosaccharides**

Oligosaccharides, though present in various foods and known for their potential health benefits, also come with certain demerits. One notable drawback is their association with digestive discomfort. Oligosaccharides, such as those found in certain legumes and vegetables, can be challenging for the human digestive system to break down completely. This undigested material then reaches the colon, where fermentation by gut bacteria produces gas, leading to bloating and flatulence. Furthermore, some individuals may experience gastrointestinal distress due to the osmotic effects of oligosaccharides, attracting water into the intestine and causing diarrhea. Despite these drawbacks, it’s important to note that oligosaccharides also serve as prebiotics, promoting the growth of beneficial gut bacteria, highlighting the complexity of their role in human health [38].

**Haemagglutinins**

Haemagglutinins, also known as lectins or phytoagglutinins, are proteins found in various leguminous plants, widely distributed throughout these plant species. Within the context of horse gram, one crucial dietary lectin is D. biflorus agglutinin (DBA), which is recognized as an allergen. The seeds of horse gram are particularly rich in lectins, and DBA exhibits differential expressions in various parts of the plant, including stems, seeds, leaves, and roots [1]. Notably, horse gram seeds possess a high hemagglutinating activity, and the lectin from these seeds displays specificity for the 'A' blood group, allowing for differentiation between A1 and A2 blood groups. Consequently, it finds utility in blood banks for blood group testing [39]. To ensure the removal of lectin toxicity, it is essential to soak horse gram seeds before cooking or subject them to autoclaving, as recommended in prior studies. Haemagglutinins refer to a group of components that possess the unique ability to agglutinate red blood cells.

**Merit of haemagglutinins**

Haemagglutinins, primarily known for their role in influenza viruses, possess several merits in the context of virology and vaccine development. These glycoproteins are crucial components in the initial stages of viral infection. By binding to sialic acid receptors on host cell surfaces, haemagglutinins facilitate the entry of influenza viruses into target cells. Understanding and targeting these proteins have been pivotal in the development of influenza vaccines. Vaccines are designed to induce an immune response against haemagglutinins, promoting the production of antibodies that can neutralize the virus. The ability to target specific strains of haemagglutinins enables the creation of vaccines tailored to prevalent viral variants, contributing to the prevention and control of influenza outbreaks [40].

**Demerits of haemagglutinins**

Haemagglutinins, while integral to certain biological processes, also pose potential drawbacks. One notable demerit is their involvement in the influenza virus. Influenza A viruses utilize haemagglutinins to bind to host cells, facilitating viral entry. This interaction is a key factor in the seasonal flu, and mutations in haemagglutinin can contribute to the virus’s ability to evade immunity from previous infections or vaccinations. Additionally, the agglutination of red blood cells by haemagglutinins can lead to complications in blood transfusions if not carefully matched, causing transfusion reactions. Despite their significance in understanding viral infections and blood compatibility, the presence, and actions of haemagglutinin necessitate ongoing research and caution in medical applications [40].

**Phytic acid**

In legumes, a significant portion of the total P is found in the form of phytic acid. The availability of P in the form of phytate depends on factors such as the age of the experimental animals, the level of phytase activity in the intestinal tracts of specific species, and the species itself. Phytic acid, or phytate when in its salt form, serves as a predominant store of P, accounting for as much as 85% of the overall P content in legumes and cereals [41]. It possesses the capacity to form bonds with crucial minerals such as Zn, Ca, Mg, and Fe, making them biologically inaccessible for absorption. Moreover, phytic acid creates bonds with proteins and starches, resulting in decreased mineral absorption, including Fe, Zn, Ca, Cu, Mg, and Mn. Additionally, it hinders the enzymatic breakdown of both starch and proteins. Interestingly, phytic acid also offers health benefits by serving as a protective agent against various diseases, including cancer, coronary heart disease, renal stones, and diabetes mellitus, while also acting as an antioxidant. Horse gram flour contains a high amount of phytic acid, comparable to chickpeas, cowpeas, black lentils, red kidney beans, and white kidney beans [6]. Basic techniques such as cooking, sprouting, fermenting, roasting, and soaking have been shown to effectively decrease the phytic acid levels in legumes.

**Merits of phytic acid**

Phytic acid, also known as inositol hexaphosphate or IP6, possesses several merits in various biological contexts. One notable benefit is its role as an antioxidant. Phytic acid demonstrates the ability to chelate metal ions, which can contribute to reducing oxidative stress and preventing cellular damage.
caused by free radicals. Moreover, phytic acid has been associated with potential health benefits, such as anticancer properties. Studies suggest that it may inhibit the growth of certain cancer cells, making it a subject of interest in cancer research. Additionally, phytic acid exhibits anti-inflammatory properties and has been explored for its potential in managing conditions related to inflammation. While phytic acid is commonly recognized for its presence in certain foods, understanding its positive contributions to health underscores its significance in nutritional and therapeutic contexts [42].

**Demerits of phytic acid**

Phytic acid, despite its presence in many plant-based foods, has notable demerits. One primary concern is its role as an anti-nutrient, as it binds to essential minerals like Ca, Mg, and Zn, hindering their absorption in the digestive tract. This property can contribute to mineral deficiencies, particularly in diets heavily reliant on plant sources. Furthermore, phytic acid may impede the activity of enzymes involved in digestion, potentially causing gastrointestinal discomfort. While some argue that moderate phytic acid intake may have antioxidant properties, excessive consumption, or diets predominantly rich in phytic acid-containing foods may pose challenges to nutrient absorption and overall digestive health. Balancing dietary choices and considering food preparation methods that reduce phytic acid content can help mitigate these demerits [42]. Table 1 provides an overview of the potential pharmacological activities associated with different parts of horse gram.

**Horse gram as food and feed**

Horse gram is a versatile crop that serves both as livestock feed and human food, as recommended by experts worldwide. Its remarkable medicinal properties, robust resistance to pests, and nutritious composition make it a valuable and cost-effective source of fodder, food, green manure, and a supplementary fuel source [43]. As public awareness about nutraceuticals and overall health consciousness continues to rise, there has been a noticeable uptick in the consumption of potential antioxidants found in legumes like horse gram. These antioxidants play a significant role in mitigating the risk of a range of health conditions, including diabetes, gastrointestinal disorders, dental caries, and coronary heart disease. This is primarily attributed to the presence of bioactive constituents within horse gram.

**Table 1: Potential pharmacological activity of different parts of horse gram.**

<table>
<thead>
<tr>
<th>Part</th>
<th>Extract</th>
<th>Pharmacological activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant</td>
<td>Aqueous and ethanol</td>
<td>Antihypercholesterolemic</td>
</tr>
<tr>
<td></td>
<td>Ethyl acetate</td>
<td>Antimicrobial</td>
</tr>
<tr>
<td>Leaves</td>
<td>Aqueous</td>
<td>Antibesity</td>
</tr>
<tr>
<td></td>
<td>Ethanolic</td>
<td>Antihelmintic</td>
</tr>
<tr>
<td></td>
<td>Methanolic</td>
<td>Antidiabetic</td>
</tr>
<tr>
<td>Seeds</td>
<td>Acetone</td>
<td>Anticholelithic</td>
</tr>
<tr>
<td></td>
<td>Ethanolic</td>
<td>Antihistaminic</td>
</tr>
<tr>
<td></td>
<td>Hydroalcoholic</td>
<td>Anti-peptic ulcer</td>
</tr>
<tr>
<td></td>
<td>Chloroform, ethanolic and methanolic</td>
<td>Antioxidant</td>
</tr>
<tr>
<td></td>
<td>Aqueous</td>
<td>Antiirolithiastic against calcium phosphate crystals</td>
</tr>
</tbody>
</table>

Notably, raw horse gram seeds are particularly rich in antioxidant activities, with the highest concentration found in the seed coat.

Therefore, incorporating unprocessed raw horse gram seeds into food items may offer greater health benefits, especially for individuals with hyperglycemia. The proteins found in horse gram seeds exhibit free radical scavenging capabilities, making them valuable as natural antioxidants, food supplements, and potential therapeutics for human health. The sprouts and seeds of *M. uniflorum* serve as prime examples of "functional food" due to their significant role in reducing the risk of various ailments and promoting overall health, in addition to their nutritional value. Furthermore, the process of sprouting enhances the taste, digestibility, and availability of essential nutrients. In several regions of India, horse gram leaves are also employed as a vegetable [24]. These leaves possess additional health-enhancing properties, such as anthocyanins, which serve as potent antioxidants by neutralizing free radicals and exhibiting anti-inflammatory effects. Ethnobotanical usage of non-toxic extracts from the aerial parts of horse gram is justified [44].

Furthermore, horse gram is an economical legume with favorable cooking qualities, a high protein content, and the potential for diverse product development. Furthermore, horse gram flour boasts excellent functional characteristics, including swelling capacity, oil absorption capacity, water solubility index, swelling index, and water absorption capacity, making it suitable for the formulation of functional foods. Horse gram flour, once subjected to basic processing methods like drying, soaking, or roasting to eliminate antinutritional components, becomes a valuable source of dietary fiber, protein, and Ca. This transformed horse gram flour can be utilized in a variety of food products. While whole horse gram seeds are traditionally employed as livestock feed and are typically prepared through boiling, they can also be integrated into the diets of growing animals without any adverse effects. This is evident from the enhanced feed efficiency observed in egg-type chicks and growing animals fed with 10% raw horse gram seeds. Horse gram seed meal is safe for human consumption, non-toxic, and holds great potential as a dietary supplement, capable of promoting growth and sustaining animal nutrition [45]. With
its remedial properties and high nutritional value, horse gram has the potential to serve as a nutraceutical, forage, and food source in drought-prone and malnourished areas. There is considerable untapped potential for further exploration of horse gram, including the discovery of new phytochemicals, the development of cost-effective medicinal and functional food products, and its use in therapeutic applications. Additional information on the role of horse gram in adding value to various products can be found in table 2 and figure 2.

**Nutraceutical properties of horse gram**

Horse gram, with its rich history in traditional medicine, possesses numerous therapeutic potentials that often go unnoticed. Horse gram seeds have been valued for their efficacy in addressing various health issues, including the treatment of conditions such as piles, bronchial asthma, abdominal lumps, and hiccups. They are also recognized for their ability to regulate perspiration and control excessive sweating [3]. According to historical documents, they emphasize their effectiveness in managing conditions such as kidney stones, bronchitis, asthma, leukoderma, hemorrhoids, urinary issues, and heart ailments. Additionally, horse gram exhibits anthelmintic properties, making it suitable for infant diets to combat worm infestations. In several regions, it is employed for dissolving kidney stones and preventing urinary stone formation.

Moreover, horse gram extracts demonstrate hypoglycemic and hypolipidemic effects and have proven beneficial for urinary issues, sunburn, gastritis, kidney stones, constipation, female health concerns, colic due to wind, rheumatism, intestinal worms, hemorrhagic diseases, and more [3]. It finds application in cases of water retention, jaundice, Fe deficiency, weight loss diets, and temperature regulation during winter. During the colder months, rural communities commonly call it “Garmi dal” and incorporate it into their diet. Horse gram seeds are recognized for their high dietary antioxidant content and anti-inflammatory properties, while also serving as a remedy for hiccups, fungal and bacterial infections, and parasitic worms [46]. Furthermore, they contain functional components that can aid in managing obesity and hypercholesterolemia.

Horse gram emerges as a nutritional powerhouse, boasting a rich content of non-digestible carbohydrates, specifically resistant starch classified as a prebiotic. This unique composition allows these carbohydrates to traverse the digestive system without complete breakdown, consequently leading to a controlled release of glucose into the bloodstream. This characteristic renders horse gram beneficial for diabetes management [14]. Moreover, extracts from horse gram demonstrate a substantial anti-hypercholesterolemic effect, proving effective against hypercholesterolemia and obesity. A five-week study administering both water and ethanol extracts resulted in a significant reduction in low-density lipoprotein (LDL), total cholesterol (TC), triglycerides, SGOT, SGPT, and very low-density lipoprotein (VLDL) levels. Impressively, the group treated with the ethanol extract exhibited a notable increase in cholesterol excretion through feces compared to the water extract-treated group.

Adding to its impressive repertoire, horse gram showcases antimicrobial properties, demonstrating significant activity against bacteria such as *Staphylococcus aureus*, *Bacillus subtilis*, *Pseudomonas aeruginosa*, and *Escherichia coli* [44]. Furthermore, the seeds of *M. uniflorum*, a key component of horse gram, exhibit anthelmintic properties, presenting a potential solution for eliminating worms. Extracts derived from these seeds showcase robust anthelmintic efficacy comparable to albendazole [47]. Additionally, specific extracts, such as the 70% acetone extracts from the brown variety of *M. uniflorum* and raw and dry-heated samples of the black variety, exhibit elevated levels of hydroxyl radical-scavenging activity. While

<table>
<thead>
<tr>
<th>Table 2: Value added products from horse gram.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product</strong></td>
</tr>
<tr>
<td>Horse gram instant soup</td>
</tr>
<tr>
<td>Bread fortified germinated horse gram flour</td>
</tr>
<tr>
<td>Instant idli and khakra</td>
</tr>
<tr>
<td>Horse gram based instant dosa mix</td>
</tr>
<tr>
<td>Horsegram flour incorporated chapati</td>
</tr>
<tr>
<td>Cookies fortified with horse gram malt</td>
</tr>
<tr>
<td>Enhancing the nutritional value of Indian dosa, made from finger millet, by incorporating horse gram flour</td>
</tr>
</tbody>
</table>

**Figure 2:** Potential health benefits of horsegram.
these extracts demonstrate impressive antioxidant performance in the linoleic acid emulsion system, their effectiveness remains notably lower compared to the synthetic antioxidant BHA \cite{48}. Notably, horse gram flours, characterized by increased dietary fiber content, hold promise for positively impacting colon and intestine physiology, along with offering therapeutic and homeostatic benefits in human nutrition \cite{3,6}.

**Conclusion**

The following review provides an extensive exploration of *M. uniflorum*, commonly known as horse gram, encompassing its historical medicinal uses, nutritional content, and its potential as a valuable source of both nutrients and antioxidants. Upon comparing its nutritional profile to other pulse crops, horse gram emerges as a standout, exhibiting elevated levels of radical scavenging properties and antioxidants, in addition to its traditional role in supplying carbohydrates and proteins. The inclusion of naturally occurring bioactive substances like phenolic acids, phytic acid, and fiber adds to its allure, presenting substantial promise in addressing a range of conditions such as throat infections, the common cold, asthma, fever, urinary stones, leukoderma, bronchitis, and more. Of note are the proteinase inhibitors known as BBIs, which hold promise in addressing obesity, mitigating inflammation, and managing autoimmune and degenerative conditions. Nevertheless, there remains a gap in understanding the specific health-promoting substances present in horse gram. Given its immense potential for enhancing health and well-being, it is imperative to explore its application in both the food and nutraceutical industries.

**Current and Future Perspective**

The current and future perspectives of horse gram position it as a multifaceted crop with substantial potential in both agricultural and health-related domains. In the present scenario, horse gram stands out as an underutilized pulse with remarkable nutraceutical benefits. Its rich content of non-digestible carbohydrates, including resistant starch acting as a prebiotic, positions it as an ally in managing diabetes. Moreover, the anti-hypercholesterolemic and antimicrobial properties showcased by horse gram extracts broaden its applications, addressing concerns related to hypercholesterolemia, obesity, and bacterial infections. The seeds of *M. uniflorum*, a vital component of horse gram, exhibit anthelmintic properties, adding to its repertoire of therapeutic attributes. The exploitation of these extracts, such as the 70% acetone extracts and various processing methods, further unveils its potential as a source of natural antioxidants. Looking ahead, the future of horse gram appears promising with opportunities for product development, cost-effective medicinal applications, and as a valuable dietary supplement. Its resilience in diverse climates, economical cultivation, and versatile use as livestock feed, human food, and green manure position horse gram as a sustainable and valuable resource for regions facing challenges like drought and malnutrition. Continued research holds the key to unlocking new phytochemicals, expanding functional food products, and enhancing therapeutic applications, making horse gram a dynamic player in the agricultural and health sectors.

**Acknowledgements**

None.

**Conflict of Interest**

None.

**References**


2. Durst PB, Bayasgalanbat N. 2014. Promotion of underutilized indigenous food resources for food security and nutrition in Asia and the Pacific.


