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Therapeutic Potential and Nutritional Benefits of Horse Gram: A Review

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ABSTRACT

Horse gram is an underutilized legume crop that can grow under a variety of challenging climatic circumstances. It contains a plethora of nutrients like protein, minerals and vitamins as well as bioactive compounds like fiber, enzymatic/proteinase inhibitors, phytic acids and phenolic acids that have significant physiological and metabolic effects on human health. The therapeutic effect of horse gram is widely known for preventing kidney stones, piles, urinary illnesses, colds, throat infections, fever, *etc.* Horse gram is acclaimed for its therapeutic effect that minimizes the possibility of intestinal disorders, diabetes mellitus, cardiovascular disease, tooth cavities and other conditions. In light of the growing demand for food having nutraceutical properties horse gram-incorporated food products are a significant contribution to the development of ready-to-eat value-added foods for healthy living. The present review paper elaborates overview of nutritional quality, therapeutic activities and medicinal properties with value-added products of horse gram to expand the opportunities for researching horse gram as a source of nourishment and many other health-related aspects of it.

Key words: Anti-nutritional factors, Antioxidants, Bioactive compounds, Horse gram, Therapeutic.

Food legumes are the second major group of crops after grain, which have been an integral part of human nutrition for centuries. They are also the second-most useful plant-origin source of nourishment for individuals as well as animals, according to research studies (Rakash *et al*., 2013). Legumes make a tremendous rotational crop because they increase soil carbon levels and decrease the requirement for fossil fuels in agriculture and the symbiotic relationship increases the fertility of the soil (Liu *et al*., 2018; Stagnari *et al*., 2017). Due to changes in farming practices, such as improvement methods and consumption of animal-derived proteins, the promotion of legume proteins is important (Geraldo *et al*., 2022). In addition to providing an adequate meal and addressing human protein requirements, legumes are rich in fiber, carbohydrates, vitamins and micronutrients (Ganesan and Xu, 2017).

Due to the wide range of cultivable locations and vulnerability to pests and diseases, the revenue of legumes is very irregular and underrated. Horse gram [*Macrotyloma uniflorum* (Lam.) Verdc.] is a versatile diploid legume, widely farmed for seed and feed in dry regions of Asia, Africa and Australia (Chahota *et al*., 2013). This legume has a variety of beneficial nutraceutical properties, including phytonutrient-mediated activity, ROS (Reactive oxygen species) scavenging propensities and blood pressure regulating propensities. Particularly for herbivores in underdeveloped nations such as India, in which the majority of the community is susceptible to hypoproteinemia, horse gram's nutritional value in the diet is exceptional (Gautam and Chahota, 2022). It has a high amount of non-digestible carbohydrates, which release glucose more gradually and allow for the management of diabetes. One of the most recent dietary fibers, resistant starch, is present in substantial amounts in horse gram and is regarded as a key prebiotic (Sudhagar *et al*., 2023). This legume is regarded as a healthy food because it contains 23% protein, less than 1% fat and 60% carbohydrates. However, the absorption and bioavailability of nutrients decline as a result of the existence of non-nutritive bioactive substances that are lectins, trypsin inhibitors and phytic acid. By using traditional processing techniques, it is possible to maximize the nutrients' utilization, which raises the nutritional value of the horse gram qualitatively as well as quantitatively. Furthermore, it offers several biologically active compounds in such amounts that have pertinent physiological and/or metabolic impacts. As a result, the under-utilized protein option, horse gram, can be incorporated into food processing to create functional foods with plant-based proteins (Sharma and Thakur, 2022).

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Horse gram history

Horse gram belongs to the family *Fabaceae* which is native to countries in Africa, Asia and Australia (Rlds and Erhs, 2017). The south Deccan region, northwest of Haryana and western Gujrat were the regions, where horse gram was found initially as wild species. After that, some wild species were domesticated and used as ingredients in regional agricultural products in a few states such as Andhra Pradesh, Karnataka and some parts of Tamil Nadu (Ingle *et al*., 2020).

Botanical description

The legume belongs to the Kingdom: Plantae, Genus: *Macrotyloma* and Species: *M. uniflorum*. Stipules on the trifoliate, 3.5-7.5 cm long leaves of the plant measure 7-20 mm in length. The leaflets have a rounded base and an acute or scarcely acuminate tip. The 2.5 cm long petioles of the bisexual flowers include three stamens. The pedicles are typically between 0.3 and 0.5 cm long, while the calyx is 10.5 mm long and 7-8 mm wide. Petioles typically measure 2.5 cm long. Each pod bears 5-8 ovoid-shaped seeds with occasional black lines that measure 3-5 mm in width and 4-6 mm in length (Bharathi and Anand, 2016).

Nutrient composition

Horse gram is referred to in Asia, particularly India, as the "poor man's pulse crop." It frequently serves as both food and fodder. This legume is stated as the "potential food source for the future" by the National Academy of Sciences, US (Rlds and Erhss, 2017). It is an excellent source of protein, carbohydrates, soluble and insoluble fiber, minerals and biologically active compounds (Pal *et al*., 2016). The composition of macro-nutrient composition in horse gram is mentioned in Table 1.

Proteins

Proteins are essential nutrients for human health. Horse gram legumes contain approximately 22 to 24 per cent protein twice that of cereal grains. Because its protein contains more lysine than pigeon peas and chickpeas, it is an excellent supplement to a grain-rich diet (Patil *et al*., 2019).

Carbohydrates

Sugars, fibers and starches are all common and plentiful types of CHO found in horse gram. As a legume, starches are less easily digestible than cereal. Compared to cereals, they are lower in energy and carbohydrates (55-65%). Horse gram has a low glycemic index because of the complex carbohydrates which lowers the risk of lifestyle disorders (Prasad and Singh 2015).

Fatty acids

Horse gram seeds are remarkably low in oxidized fatty acids *(*Rajagopal *et al*., *2017)*. Linoleic acid, an essential fatty acid is present in raw seeds of 45.58% and toasted seeds 40.33% (Bhartiya *et al*., 2015).

Dietary fiber

The finest sources of fiber for a balanced diet are whole grains. A satisfactory dietary fiber is required for appropriate gut function and has been associated with a lower risk of developing a range of illnesses, including diabetes, several cancers and cardiovascular disease. Pectin, gum, cellulose, hemicelluloses and lignin are all components of fiber (Khogare *et al*., 2012).

Micronutrients

Horse gram has the most calcium content than any other legume. It is the legume that is low in tryptophan and methionine but high in iron and molybdenum as depicted in Table 2 (Bhartiya *et al*., 2015).

Anti-nutritional factors

Anti-nutritional components are biological molecules found in food that may decrease nutrient absorption or utilization, impairing intestinal processes and the functioning of the metabolism (Nagraj *et al*., 2020). Horse gram has several

Table 1: Macronutrient composition per 100 g.

Macronutrients	Nutritional composition	References
Carbohydrates	58.86±0.57 (Variety AK 42)	Pagar *et al*., 2021
	57.24 gm	Aditya *et al*., 2019
Protein	21.73 gm	Aditya *et al*., 2019
	21.06±1.05 (Variety AK 42)	Pagar *et al*., 2021
Fat	0.62 gm	Aditya *et al*., 2019
	1.36±0.05 (Variety AK 42)	Pagar *et al*., 2021
Fiber	16.3% [Insoluble (14.9), Soluble (1.4%) and resistant starch (2.2)]	Sreerama *et al*., 2012
	5.01±0.19 (Variety AK 42)	Pagar *et al*., 2021
	7.88 gm	Aditya *et al*., 2019
Moisture	10.3±0.21 (Variety AK 42)	Pagar *et al*., 2021
	9.28 gm	Aditya *et al*., 2019
Ash	4.50% (in leaves)	Mandle *et al*., 2012
	3.47±0.01 (Variety AK 42)	Pagar *et al*., 2021

anti-nutritional factors that are reduced by soaking, de-husking, sprouting, heating and roasting, such as hemagglutinin activity, trypsin inhibitor, phytic acid and tannin (Bhokre *et al*., 2012). Anti-nutritional factors also cause the "hard-to-cook" phenomenon in beans by decreasing protein digestion and mineral absorption (Moktan and Ojha, 2016).

Multiple studies have found that soaking for 12 to 18 hrs. is the optimum approach to reduce the levels of anti-nutritional chemicals such as phytic acid and proteolytic enzyme inhibitors that are entirely or partially dissolved in steeped water (Rizvi *et al*., 2022). The different processing methodologies used to reduce the antinutritional components of horse gram are shown in Fig 1.

Due to fermentation, anti-nutritional components were dramatically reduced, especially oxalate levels, tannin and phytic acid, which decreased by 66.7, 69.3 and 69.5%, respectively, compared to reductions of 61.6, 54.6 and 61.6% after germination. However, soaking and roasting decreased the amount of polyphenols and flavonoids. In the meantime, an increase in phytochemicals by 86.9% and 53.8% was seen during both fermentation and germination respectively. The anti-oxidant concentration decreased during soaking by 59.9% and increased during roasting, germination and fermentation by 29.1%, 51.6% and 59.9% respectively (Ojha *et al*., 2020).

Horse gram flour's anti-nutritional content can be reduced by soaking it for 18 hours, allowing it to germinate for 72 hours and then drying it at 70°C. This flour can then be utilized to make a variety of foods with enhanced value. Because of the substantial modifications that occur by soaking and germination, horse gram is one of the most nutritious legumes, which can be consumed regularly by people of all age groups (Handa *et al*., 2017).

According to (Agume *et al*., 2017), the amount of phytic acid significantly lowers due to roasting and soaking, but only roasting reduced tannins content. After germination, the phytate, oxalate and tannin content decreased, according to (Afam *et al*., 2016). Germination and fermentation processes, significantly reduced the levels of oxalate, tannin and phytic acid in horse gram (Ojha *et al*., 2018).

When compared to raw horse gram, iron, protein, calcium and phosphorus did not change significantly, however, tannins and phytates were found reduced during processing (Thirukkumar and Gurumeenakshi, 2015). According to (Sarvani *et al*., 2020), when processing and fermentation were combined anti-nutritional components were reduced more than when processing was used alone. Additionally, it was shown that flour that had been boiled

Table 2: Micronutrients composition per 100 gm.

Vitamins and minerals	Composition	References
Calcium	269 mg	Aditya *et al*., 2019
Iron	8.76 mg	Aditya *et al*., 2019
Magnesium	152 mg	Aditya *et al*., 2019
Phosphorus	296 mg	Aditya *et al*., 2019
Potassium	1065 mg	Aditya *et al*., 2019
Thiamine	0.32 mg	Aditya *et al*., 2019
Riboflavin	0.24 mg	Aditya *et al*., 2019
Niacin	1.82 mg	Aditya *et al*., 2019

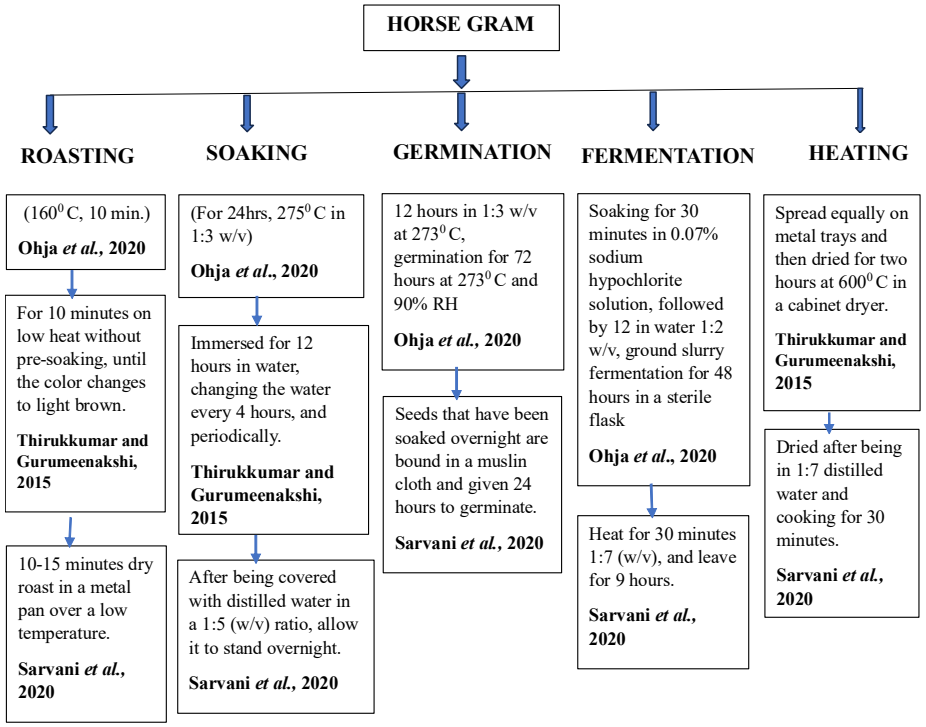


Fig 1: Various home-scale processing methods to reduce the anti-nutritional factors present in horse gram.

and germinated on fermentation produced a substantially larger reduction in anti-nutritional components, boosting its use as a primary or secondary ingredient in functional foods.

Therapeutic potential

Major bioactive components of horse gram include substances such as proteinase inhibitors, phenolic acid and phytic acid, which have profound impacts on metabolism and physiology and are responsible for many therapeutic activities described in Table 3 (Kashid and Talekar, 2021).

Phytic acid

A primary type of phosphorylated inositol, phytic acid or inositol hexa-phosphate IP6 is a simple ringed carbohydrate with six phosphate groups attached to each carbon. The three different forms of phytic acid-free acids, phytate and phytin-are all exchangeable. The phytic acid in horse gram demonstrated that the embryonic axe fraction included a sizable amount (Kumar *et al*., 2019). It has positive antioxidant benefits and protects against many cancers, coronary heart disease, diabetes mellitus and kidney stones, among other diseases, so it has a positive health impact on human health (Prasad and Singh, 2015).

Phenolic acid

Due to their antioxidant properties, such as protection against oxidative damage, phenolic compounds have the most favorable positive impact on human wellness. The main phenolic components of horse gram seeds are ferulic acids, vanillic and p-hydroxybenzoic as well as flavonols like quercetin, kaempferol and myricetin. Phenolic acids are a diverse group of secondary metabolites that are commonly found as esters of quinic and caffeic acids and have derivatives of both cinnamic and benzoic acids. They are responsible for a variety of positive effects in a wide range of disorders (Kumar *et al*., 2019).

Proteinase inhibitor

A category of enzymes known as proteases has the catalytic activity to hydrolyze (Break down) the peptide bonds in proteins. Proteases are necessary for organism upkeep and their existence, but they can be toxic in high amounts, thus their activity must be regulated. Traditional examples of functioning serine proteinases include subtilisin, thrombin, plasmin, cathepsin G, chymase, elastase, chymotrypsin and trypsin. Adequate home-scale processing techniques can certainly reduce proteinase inhibitor and benefits the health of consumers (Kumar *et al*., 2019).

Horse gram seeds possess various therapeutic activities such as anti-hypertensive, anti-diabetic, anti-oxidant, anti-inflammatory, analgesic, anti-peptic ulcer, anti-histaminic, anti-cholelithiasis, anti-hypercholesterolemic, anti-microbial, anti-obesity, anti-helminthic, diuretic, hemolytic and hepato protective property, which shows in Table 3 (Kaundal *et al*., 2019).

Medicinal properties of horse gram

Due to the innate ability to create several secondary metabolites that are effective in treating a variety of diseases, horse gram has been used as a medication for an extended time. The presence of bioactive compounds in horse gram lowers the risk of cardiovascular diseases, diabetes mellitus, gastrointestinal diseases, prevention of tooth decay, *etc* (Bhartiya *et al*., 2015).

Decoction of dry seeds of horse gram has been used as a traditional medicine for amenorrhea, bile stones, diabetes, flatulence, edema, goiter and some other self-controlled conditions. Hypertension, helminths and rheumatoid arthritis discomfort can be treated by the infusion of whole seeds. The powder of horse gram seeds can benefit the situation of boils and skin rashes. To treat hiccups, bacterial and fungal infections this legume can be used as a medication (RIds and Errhss, 2017). To control excessive sweating, baked seed powder is applied to the body. Seed paste can be applied to the skin to improve complexion (Rana and Agnihotri, 2018).

Phytic acid, dietary fiber and phenolic acids are healthy substances present in horse gram that have the potential to prevent several illnesses, including albinism, asthma, bronchitis, colds, throat infections, fevers and urinary stones (Chauhan, 2022).

Ready-to-eat value-added products from horse gram

Horse gram being nutritious and having therapeutic aid can be incorporated into food products for value addition. Some of the value-added food products from horse gram are shown in Fig 2.

Instant soup mix

The soup premix was made from germinated horse gram flour and powdered radish leaves and the sensory qualities and shelf life of the premix were assessed. The prepared premix was accepted based on sensory attributes and since no harmful organism development was observed throughout the sample's one-month storage in laminated pouches, it can be kept in an airtight container for at least a month. The components in the soup mix are known to function well to manage and prevent diabetes (Sudarsan *et al*., 2017).

Idly premix powder

The idly mix powder was made with rice, black gram dal and horse gram as its base ingredients and analyzed for sensory qualities, nutritional content, microbiological analysis and antioxidant activity. the idly premix was highly acceptable and it was found to be a good source of protein, calcium, vitamin C, antioxidants and phytochemicals. For analyses of shelf life, it was sealed in high-density polyethylene for 30 days and after that time, no microbiological growth occurred that exceeded a safe limit, showing that the premix had a one-month shelf life. It was also stated as being useful for managing diabetes (Sudarsan and Santhanam, 2017).

Table 3: Therapeutic potential of horse gram.

Therapeutic activity	Methodology used	Result observed	References
Anti-histaminic effect	Using Milk-induced eosinophilia, anaphylaxis and leukocytosis 47. After making the ethanolic extract using the cold maceration method, it was tested on mice and rats	Rats pretreated with ethanolic extract displayed notable degranulation protection	(Suralkar, 2013)
Anti-inflammatory effect	Human secretory phospholipase A2 (sPLA2) suppression response to anti-inflammatory effect utilizing M. Uniflorum coat and pulp aqueous extracts *in vitro*	The extract effectively neutralized in vivo PLA2-induced mouse paw edema and successfully counteracted indirect hemolytic activity	(Giresha *et al*., 2015)
Anti-calcifying effect	Effect of Dolichosbiflorus immature seeds *in vitro* on calcium phosphate crystallization.	Anti-calcifying activity was observed to be eliminated after treatment with activated charcoal that was not recovered or eluted by solvent	(Kashid and Talekar 2021)
Anti-chalcolithic effect	Gallbladder bile in rats fed a 1% cholesterol and 0.5% cholic acid diet for eight weeks became hypersaturated with cholesterol, which promotes the formation of cholesterol gallstones (CGSs)	By feeding ME and AE 300 mg/kg, liver cholesterol and TG were considerably reduced. Apolipoprotein levels that were altered by the LG diet were dramatically reversed by AE	(Bigoniya *et al*., 2014)
Anti-diabetic and anti-urolithiasis effect	To generate the AgNPs, horse gram aqueous extract was utilized	The produced AgNps and seed flour extracts demonstrated characteristics of herbal remedy with potential mineral content and anti-diabetic and anti-urolithiatic capabilities	(Sudha and Saral, 2023)
Anti-helminthic activity	The anthelmintic activity of horse gram seed ethanolic extract against adult Indian earthworms was investigated	Using M. uniflorum seed alcohol extracts can help get rid of worms. showed significant anthelmintic efficacy against Pheretimaposthuma	(Sree *et al*., 2014)
Anti-HIV activity	Two ligands namely Dolichin A and Dolichin B, interacted with three enzymes used for replication (Integrase, protease and reverse transcriptase)	Protease enzymes can dock with the ligands Dolichin A and Dolichin B better than reverse transcriptase, protease and integrase	(Auxilia *et al*., 2013)
Anti-bacterial activity	The impact of various methanolic fractions on certain microorganisms from *D. biflorus* seeds.	A few active chemicals isolated from seed extract and methanol showed significant action against various test organisms	(Chirania and Sharma, 2021)
Anti-obesity activity	*Dolichos biflorus* (Horse gramme) hot extract on body weight in overweight or obese volunteer	Significant anti-obesity activity was shown by the *Macrotyloma uniflorum*	(Bhuvaneshwari *et al*., 2014)
Anti-oxidant activity	scavenging of 2, 2-diphenyl-1-picrylhydrazyl (DPPH), reducing power, ferric reducing power tests	High reduction power activity and high ferric reducing power activity in horse gram were reported	(Petchiammal and Hopper, 2014)

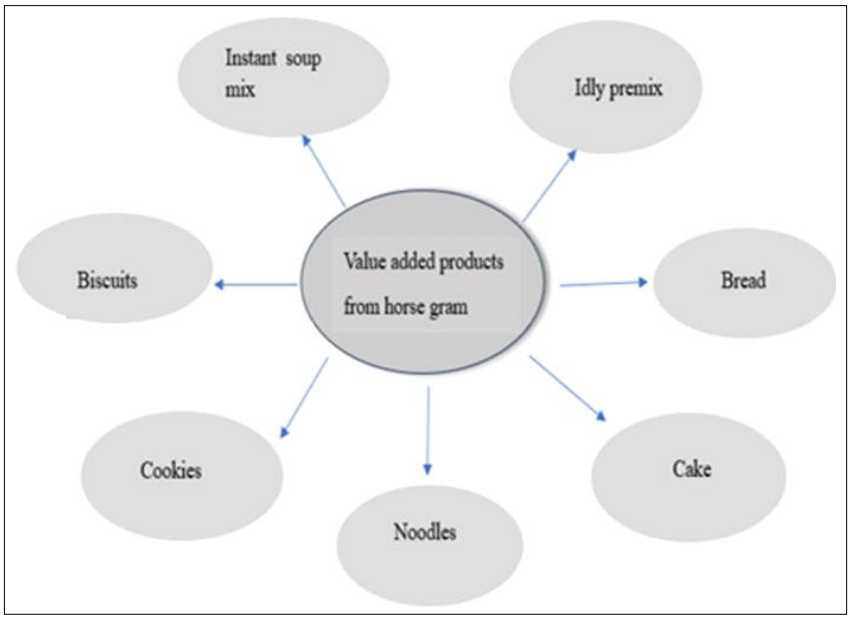


Fig 2: Ready-to-eat value-added food products from horse gram.

Bread

Bread enriched with horse gram germinated flour had acceptable terms of sensory properties with nutritional profile. The bread with 6% GHF was found to be the most palatable by sensory evaluation and also had higher levels of protein, fat and fiber as well as polyphenols with antioxidant qualities and minerals including calcium and iron (Moktan and Ojha, 2016).

Cake

Horse gram enriched cake that contained 10% beetroot powder was highly acceptable and also contained tannins, saponin, starch, terpenoids, alkaloids, glycosides, carbohydrates, phenols and flavonoids (Mathangi and Balasaraswathi, 2019).

Cookies

The cookies were prepared with protein extracted from the horse gram. The protein extracted was found to be similar to the soy protein. Sensory and physical parameters of cookies with supplementation of 25% extracted horse gram protein were acceptable out of all the samples. The study revealed that extracted protein from horse gram could be used for fortification in food to prevent protein-energy malnutrition (Banerjee *et al*., 2022).

Biscuit

Horse gram baked biscuit was combined with whole-wheat flour and biscuits with a 25% addition of horse gram to whole-wheat flour were preferable according to sensory analyses and the evaluated spread ratio of the horse gram biscuits increased. The study resulted in the conclusion that adding horse gram to baked goods could increase their nutritious content as well as physical characteristics (Joshi and Awasthi, 2020).

Noodles

The physicochemical qualities, pasting properties and physical appearance of the flour were significantly impacted by the addition of germinated horse gram flour to refined wheat flour. With a rise in the concentration of germinated horse gram flour, the capacity for absorbing water and oil both increased (by 41 and 8.06 per cent, respectively), but the viscosity of the flour for pasting decreased. The cooking, textural and sensory qualities of cooked noodles were significantly affected by the addition of germinated horse gram flour at various concentration levels to refined wheat flour. Noodles made from GHF blended flour were less sticky than noodles made from control ingredients. The GHF-blended cooked noodles have a pleasant texture and are softer than control noodles, which may be related to a reduction in hardness (Narwal and Yadav, 2022).

CONCLUSION

The demand for horse gram is increasing among consumers due to its excellent source of nutrition and therapeutic potential. Horse gram provides natural bioactive substances like antioxidants, phytic acid, phenolic compounds and dietary fiber, which may promote better control of blood sugar, common cold, throat infection, fever, urinary stones, asthma, bronchitis, obesity, stroke and heart diseases. Soaking and germination increased the physicochemical and functional properties and decreased the anti-nutritional factor from horse gram. Nutritious ready-to-eat products like horse gram instant soup mix, cookies, bread and biscuits are the most often-consumed foods and also ideal protein supplementation for all vulnerable age groups and malnourished people.

Conflict of interest

There is no conflict of interest among the authors.

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