Underutilized legumes are important group of crops which has special significance in subsistence farming and nutritional security of resource poor masses in developing countries. Among underutilized legumes, horsegram (*Macrotyloma uniflorum*), family *Fabaceae* is one of the minor or lesser known neglected legume mainly cultivated in Asian and African countries as a dual purpose crop. It is a climate resilient legume which is well known for its drought hardiness and embraces favourable agronomic features suitable for cultivation on dry lands under poor fertility condition. It is comparable to other commonly consumed pulses in its nutritional value and serves as a cheap source of nutrition for unprivileged rural communities residing in inaccessible areas. Horsegram has excellent therapeutic properties and traditionally used to cure kidney stones, asthma, bronchitis, leucoderma, urinary discharges, heart diseases, piles etc. Besides, it also possess anti-diabetic, anti-ulcer activity and also helps in dietary management of obesity due to the presence of beneficial bioactive compounds. In the present review nutritional composition, antinutritional factors, medicinal properties and its possibilities to be exploited as functional/medicinal food for health benefits are summarised.

**Keywords:** Antinutritional factors, *Macrotyloma uniflorum*, medicinal properties, nutraceutical and nutritional composition

**INTRODUCTION**

Food legumes are second most important group of crops after cereals which have been a vital ingredient of balanced human diet since millennia (Bhadana et al., 2013) and recognised as second most valuable plant source for human and animal nutrition (Bhatt and Karim, 2009). In the developing countries, primarily a handful of conventional legumes dominating the production and market chains and playing crucial role in eradicating protein malnutrition still, some of the underutilized indigenous legumes like, horsegram (*Macrotyloma uniflorum* (L.) Verdc) has great significance in the nutritional security of rural, tribal and underprivileged masses (Tontisirin, 2014). Horsegram is one of the highly nutritious vegetable pulse crop with ethno-medical values in India, which is commonly known as *Kulattha* (Sanskrit), *Kurti-kalai* (Bengali), *Kollu* (Tamil), *Ullavallu* (Telgu), *Muthira* (Malyalam), *Gahot* (Kumaon and Garhwal) and etymologically, *Gahot* means “which destroys stone in initial stage” (Pati and Bhattacharjee, 2013; Pande, 1999). Underutilized legumes make a significant contribution to the diet of the rural households particularly, during drought, famine and dry season (Magbagbeola et al., 2010) besides, in many cases these are the life-savers for millions of resource poor people in the regions where ensuring food and nutritional security is one of the significant problems, particularly in traditional subsistence farming systems (Haq, 2002).

Presently, attention towards underutilized legumes is increasing for finding new alternate protein sources to meet the ever increasing demand for vegetable protein (Pugalenthi et al., 2005). This neglected and undervalorised crop has great untapped potential to support smallholder rural farming communities by providing income, food and nutritional security as well as sustaining the genetic resources needed to address present and future environmental challenges (Kahane et al., 2013).

Horsegram belongs to family *Fabaceae* is a potential grain legume having excellent nutritional and remedial properties with better climate resilience to adapt harsh environmental conditions (Kumar, 2006). It is one of the most important unexploited food legume being grown in almost all over the world including temperate and sub-tropical regions encompassing the countries in East and Northeast Africa, Asian countries particularly, India, China, Philippines, Bhutan, Pakistan, Sri Lanka and Queensland in Australia (Durga, 2012; Krishna, 2010). Horsegram is cultivated as a low grade pulse crop in southern Asia, mainly from India to Myanmar and also grown as a forage and green manure in many tropical countries especially, in Australia and South-East Asia (Brink, 2006).

Horsegram is a short day, twining, succulent, annual climbing herb which has trifoliate leaves, white coloured flowers, long linear pubescent pods with curved beak, flattened small seeds with light red, brown, grey, black or mottled testa (Singh, 1991) with photo and
It matures in 4 to 6 months (Singh, 1991) and yield varies based on genotype and management such as, at 60 kg/ha phosphorus (P₂O₅) level, 25% improvement in seed yield was recorded compared to control and a positive impact on seed yield with the increase in plant densities from 2.66 lakh/ha to 4.44 lakh/ha (Keshava et al., 2007). Similarly, horsegram sown during first fortnight of August and September yielded significantly higher grain yield with less disease incidence compared to sown during first fortnight of October (Ganesha, 2001). Seed yield of horsegram usually varies from 0.13 - 1.2 tonnes/ha in India to 1.1-2.2 tonnes/ha in Australia whereas, green forage yield varies from 5-14 tonnes/ha in India and 4.4 tonnes/ha in Australia (Haq, 2011). It is also grown as a cover crop for soil and water conservation in semi-arid regions as well as found useful for improving soil fertility and integrated fertility management in dry land agriculture (Reddy et al., 2008). This underexploited grain legume has great significance in sustainable agriculture (Anitha et al., 2006) as well as dry land agriculture in tropics and subtropics (Kadam and Salunkhe, 1985; Jinka et al., 2009). Horsegram germinates reasonably well in drought-prone areas with very poor soils (where other crops invariably fail to grow) due to Dehydrons (MuDHN1, MuDHN2 and MuDHN3) which appeared to be the principle stress-responsive genes in various abiotic stresses (Ramya et al., 2013) besides, it is relatively tolerant to low to moderate salinity levels with pH up to 8 (Mehra and Upadhyaya, 2013) and heavy metal stresses compared to other pulse crops grown in semi-arid regions (Reddy et al., 2008). However, it is sensitive to water logging (Smartt, 1990) and completely intolerant of frost (Jones, 1969). Drought tolerance capacity of horsegram is attributed in parts to various pathways like antioxidant and osmolyte biosynthesis, making it sturdy enough to withstand long periods of drought with minimum management (Bhardwaj et al., 2013). It also exhibits amazing defence against attack by pests/pathogens and the possible source of the indomitable pest resistance may be due to a dual-function protein that exhibits both lectin and lipoxygenase like functions (Roopashree et al., 2006). The crude extracts of horsegram plant possess compounds with antimicrobial properties with a broad-spectrum of activity against both gram-positive and gram-negative bacteria and fungi (Kawsar et al., 2008).

Horsegram is an excellent crop for intercropping with various cereals like sorghum, pearl millet, finger millet, maize and little millet (Krishna, 2010). Intercropping maize with improved varieties of horsegram reduced labour cost since less weeding required in the intercrop as the horsegram smothered weeds and in most cases intercropping did not have a yield-reducing impact on their maize crop or on the availability of fodder (Witcombe et al., 2008). In many parts of India, horsegram is traditionally grown as mixed crop, in Karnataka, Panch Dhani is a common practice in which seeds of horsegram, Indian bean, cow pea, niger and castor are mixed and grown to combat drought (Kumar, 2006). Similarly, it is a component crop in traditional mixed cropping “Barah Anaaja” practiced from centuries in Uttarakhand hills of India in which seeds of twelve food grains are mixed and grown (Zhardhari, 2001). Mixed cropping of finger millet with horsegram found more profitable as compared to millet mono crop (Prasad et al., 2010). Better growth and development of lower crop canopy and pods in horsegram + finger millet intercropping system due to improved light penetration (1.3% in sole horsegram to 6.9% in horsegram + finger millet) as well as higher net

It is mostly grown as catch crop especially under late summer

(Kharif) or with the rains after a prolonged drought condition (Prakash et al., 2002).
return and benefit: cost ratio reported under horsegram + finger millet (1:1) followed by horsegram + maize (2:1) under hilly agro-ecosystem of India (Kumar et al., 2010). Besides, intercropping allows lower inputs through reduced fertilizer and pesticide requirements, thus minimizing environmental impacts of agriculture (Lithourgidis et al., 2011). Horsegram is an ideal crop for a number of double/sequence/rotation combinations in different climatic and geographic zones with annuals, perennials, grasses etc. therefore, proved vital component in cropping system (Kumar, 2006).

Origin, habitat and climatic requirement: It is native to the old world tropics (Nene, 2006) and indigenous to India (Vavilov, 1951; Smartt, 1985). Archaeological investigations have revealed the use of horsegram as food especially in India as origin around 2000 BC (Mehra, 2000; Prakash et al., 2010). Horsegram belongs to the genus Macrotyloma contains 25 species indigenous to Africa and Asia (Lackey, 1981). Presence of wild or naturalized horsegram is recorded in Africa (Central, East and Southern Africa) and India (Verdcourt, 1982; Brink, 2006). The primary centre of origin and use of horsegram as a cultivated plant is in the plains and hills of low altitude extending southwards in the Western Ghats in South West India (Arora and Chandel, 1972). During Neolithic period through counter migration of human beings its cultivation was diffused to northern and western part of Indian subcontinent (Mehra, 2000; Fuller et al., 2004). It is generally grown under sub-humid to semi-arid climate with annual rainfall 300-600 mm (Krishna, 2010) and with less than 30 cm rainfall as dry land crop up to an elevation of 1800 m from mean sea level (Haq, 2011). Optimum temperature range for its growth is 25° to 32°C and can tolerate temperature up to 40°C but the growth rate declining markedly below 20°C (Krishna, 2010; Mehra and Upadhyaya, 2013).

Nutritional composition: Grain legumes are an important source of nutrients and renowned as poor man’s meat especially in developing countries (Hayat et al., 2014). Horsegram has been recognised as potential source of protein and other nutrients (Sreerama et al., 2012). It has high nutritional value (Table 1) equivalent to other commonly grown pulse crops in all aspects and also an excellent source of iron, molybdenum and calcium (Prasad et al., 2010; Tuteja, 2008; Bhokre, 2012). Horsegram seed contains carbohydrate (57.2%), protein (22%), dietary fibre (5.3%), fat (0.50%), calcium (287mg), phosphorous (311mg), iron (6.77mg) and calories (321 Kcal) (Gopalan et al., 1999) as well as vitamins like thiamine (0.4mg), riboflavin (0.2mg) and niacin (1.5mg) per 100g of dry matter (Boibhat and Dhumal, 2012). However, several factors like the genotype, soil, fertilizer application, cultural practices, weather and climatic factors, postharvest handling and storage can directly or indirectly affect the nutritional quality (Hornick, 1992). Horsegram seed is low in fat and is excellent sources of protein, dietary fibre, a variety of micronutrients and phytochemicals (Sreerama et al., 2012) still it has remained an underutilized food legume, consumed only by the farming communities of inaccessible areas and low-income groups (Aiyer, 1990).

Carbohydrate: Carbohydrate content ranges from 50-60% in commonly consumed pulses (Bains and Brar, 2005). Carbohydrate includes starch, monosaccharides, oligosaccharides and other polysaccharides (Ekanayake et al., 2000). In the legume seeds, starch is the major source of available carbohydrate and most abundant (22–45%) along with oligosaccharides (1.8-18%) and dietary fibre (4.3-25%) (Hoover and Zhou, 2003; Ofuya and Akhidue, 2005). In whole and dehulled horsegram seeds, carbohydrate content ranged from 51.9-60.9% and 56.8-66.4% respectively (Sudha et al., 1995). Carbohydrate of raw horsegram seeds comprises 36±1.17g starch per 100g dry matter in which approximately 85% digestible, 14.47% resistant starch is regarded as a prebiotic among the new generation of dietary fibres (Samantha et al., 2011). Horsegram seed contains 6.38% total soluble sugars (Bravo et al., 1999) of which 55–65% constitute flatulence-producing raffinose family oligosaccharides (RFO), stachyose and verbascose (Machaih and Pednekar, 2002) and processing such as soaking, cooking and sprouting may bring about changes in the levels of oligosaccharides.

Crude protein: Horsegram is one of the cheapest sources of protein for both human beings and animals (Katiyar, 1984). On an average, horsegram seed contains 22–24% protein, which is comparable to commonly consumed pulses like chickpea, pigeonpea, greengram and blackgram however, due to varietal difference large variability observed in protein content ranging from 18.5–31.16% (Begum et al., 1977; Murthy, 1980). The dehulled horsegram seeds exhibit higher protein content (18.4–25.5%) than the whole (17.9–25.3%) (Sudha et al., 1995). A wild species of horsegram (Macrotyloma sargarwalensis) contains 38.37±1.03% crude protein. The true seed protein (34.88%) content of this wild horsegram reported about two times higher than the other commonly grown horsegram lines (Yadav et al., 2004). Horsegram protein comprises higher lysine content than pigeonpea and chickpea making it a good complement to a cereal based diet (Venkatesha, 1999; Prasad et al., 2010) whereas methionine is the major limiting amino acid and threonine and tryptophan are the other minor limiting amino acids (Khader and Venkat Rao, 1986).
Dietary fibre: Adequate dietary fibre is essential for proper functioning of the gut and has also been related to risk reduction for a number of chronic diseases including heart disease, certain cancers and diabetes. Fibre includes pectin, gum, mucilage, cellulose, hemicelluloses and lignin (Khogare, 2012). In most grain legumes consumed as pulses by humans, the fibre content ranges from 8.0–27.5%, with soluble fibre in the range 3.3–13.8% (Guillon and Champ, 2002). Horsegram seed contains 28.8% total dietary fibres, mainly insoluble dietary fibre (IDF) 27.82% and soluble dietary fibre (SDF) 1.13% with IDF: SDF 24.6 (Khatoon and Prakash, 2004) whereas,

Table 1. Nutritional composition of horsegram [Macrotyloma uniflorum (Lam.) Verdc.]

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<tr>
<th>S. No.</th>
<th>Nutritional composition</th>
<th>References</th>
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<tbody>
<tr>
<td>1.</td>
<td>Carbohydrate 57.2%</td>
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<td></td>
<td>51.9%–60.9% (Whole) and 56.8%–66.4% (Dehulled)</td>
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<td></td>
<td>66.6±2.1%</td>
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<td>(i)</td>
<td>Starch 36± 1.17g/100g [Digestible (85%), Resistant (14.47%) and Resistant starch associated with dietary fibres (3.38%)]</td>
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<td>(ii)</td>
<td>TSS 6.38% Oligosaccharides 26.8 mg/g [ Raffinose (7.1± 0.0), Stachyose (15.6± 0.4) and Verbasose (4.1± 0.0)]</td>
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<td>(iii)</td>
<td>Dietary fibre 16.3% [Insoluble (14.9± 0.4%), Soluble (1.4%±0.0%) and Resistant starch (2.2±0.2%)]</td>
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<td>2.</td>
<td>Protein 22%</td>
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<td></td>
<td>17.9%–25.3% (Whole) and 18.4%–25.5% (Dehulled)</td>
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<tr>
<td></td>
<td>23%</td>
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<td></td>
<td>22.5±1.0%</td>
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<td>3.</td>
<td>Fat 0.5%</td>
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<td></td>
<td>0.70-2.06% (Whole) and 0.81-2.11% (Dehulled)</td>
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<tr>
<td></td>
<td>0.6-2.6%</td>
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<td></td>
<td>1.4± 0.0 %</td>
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<tr>
<td>(i)</td>
<td>Saturated 27.5% [Palmitic (21.97%), Arachidic (2.85%), Saturated Fatty Acids]</td>
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<td>(ii)</td>
<td>Unsaturated 72.49% [Linoelec (42.78%), Oleic (16.15%) and Unsaturated Fatty Acids Linolenic acid (13.56%)]</td>
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<td>4.</td>
<td>Moisture 11.39%</td>
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<td>11.55% (Whole) and 9.73% (Dehulled)</td>
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<td></td>
<td>6.8±2.0%</td>
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<td>5.</td>
<td>Ash 3.0%–3.8% (Whole) and 2.7–3.4% (Dehulled)</td>
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<td>4.50% (in leaves)</td>
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<td></td>
<td>2.7±0.0%</td>
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<tr>
<td>(i)</td>
<td>Macro minerals Ca [238mg/100g (Whole) and 223 mg/100g (Dehulled)]</td>
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<tr>
<td></td>
<td>Ca (244–312 mg/100g)</td>
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<td></td>
<td>Ca (287mg/100g)</td>
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<td></td>
<td>P (311mg/100g)</td>
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<td></td>
<td>Fe (5.89–7.44 mg / 100 g)</td>
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<td></td>
<td>Fe (6.77mg/100g)</td>
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<td>K (13.06 - 14.61 mg/g ), Ca (1.20 - 3.13 mg/g), P (3.83 - 4.43 mg/g), Mg (1.64 - 1.73 mg/g ) and S (1.85 - 2.46 mg/g)</td>
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<td>(ii)</td>
<td>Micro minerals Cu (10.28 - 13.16 μg/g ), Fe (68.25 - 92.95 μg/g ), Mn (31.26 - 59.85 μg/g ), Ni (1.04 - 1.33 μg/g), Zn (29.24 - 38.13 μg/g)</td>
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<td>6.</td>
<td>Vitamins Thiamine (0.4mg/100g), Riboflavin (0.2mg/100g) and Niacin (1.5mg/100g)</td>
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<td>Bolbhat and Dhumal, 2012</td>
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horsegram flour contains 16.3% total dietary fibre (14.9% insoluble and 1.4% soluble and 2.2% resistant starch) (Sreerama et al., 2010). Horsegram seeds contain more insoluble dietary fibre (Kawale et al., 2005) required for normal lower intestinal function in humans (Anderson et al., 1994). Crude fibre is only one-seventh to one-half of total dietary fibre (Trowell,1976) and the high content of dietary fibre in horsegram flours might be helpful in terms of maintaining positive effects on intestine and colon physiology, besides other homeostatic and therapeutic functions in human nutrition (Sreerama et al., 2012). Pulse derived fibre have been shown to alter energy expenditure, substrate trafficking and fat oxidation as well as visceral adipose deposition (Ramen et al., 2013).

Fat: The fat content of horsegram ranges from 0.6–2.6% (Sreerama et al., 2010). Dehulled horsegram seeds exhibit higher crude fat content (0.81–2.11%) than the whole (0.70–2.06%) seeds (Sudha et al., 1995). Horsegram seeds are a good source of essential fatty acids and contains 27.5% saturated fatty acids (21.97% palmitic, 2.85% arachidic, 2.32% stearic acid and 0.36% myristic), 72.49% unsaturated fatty acids (42.78% linoleic, 16.15% oleic and 13.56% linolenic acid) and among unsaturated fatty acids linoleic acid is useful for the treatment of diabetes and cardiovascular diseases (Mishra and Pathan, 2011). In an optimum balance, the essential fatty acids linoleic acid with α-linolenic acid may slow the onset of Parkinson’s and Alzheimer’s diseases and these fatty acids are important for healthy cell membrane formation and functional development of the brain and nervous system, therefore, increase intake of legumes can be beneficial to human health (Morris et al., 2013; Ryan et al., 2007). Further, horsegram lipids have anti-ulcer activity due to presence of phytoestrogen esters (Berger et al., 2004) which imparts protective and healing effect on acute gastric ulceration produced by alcohol (Jayraj et al., 2000).

Moisture and ash content: The moisture content in horsegram seeds is about 11.39 per cent (Gopala Krishna et al., 1997). However, moisture content in seeds depends on the stage and time of harvesting of the crop as it is generally on higher side (18-25%) at the time of harvesting and 9-12% is the optimum range for safe storage in pulses (Mohan et al., 2011). In whole and dehulled horsegram seeds, moisture content is found 11.55% and 9.73%, whereas ash content ranges from 3.0%–3.8% and 2.7–3.4 %, respectively (Sudha et al., 1995).Higher ash content is indicative of high mineral content. Horsegram is also used as leafy vegetable and its leaves contain relatively very high content (4.50%) of minerals as compared to other common vegetables (1.5–2.4%) (Mandle et al., 2012). In horsegram accessions, mean concentrations of macro minerals (Ca, K, Mg, P, and S) ranges from 1.3–14 mg and micro minerals (Cu, Fe, Mn, Ni, and Zn) ranges from 1.0–95.0 μg per gram dry weight (Morris et al., 2013). It is a fairly rich source of calcium which is 238mg in whole seed and 223 mg in dehusked seed per 100g seed (Sudha et al., 1995). In raw horsegram, the calcium and iron content ranges from 244–312 mg and 5.89–7.44 mg per 100 g of seed, respectively with in-vitro bio-accessibility of 22.50–38.50 mg of calcium and 0.26–0.85 mg of iron per 100 g of seeds (Khatun et al., 2013). Germination, cooking and roasting significantly increased the in-vitro bio-accessibility of calcium and iron (Khatun et al., 2013).

Antinutritional factors: Pulses contain several antinutritional factors that reduce the bioavailability of nutrients (Jain et al., 2009). Horsegram flour contains trypsin inhibitor activity (9246±18 TIU/g), phytic acid (10.2±0.4mg/g), polyphenols (14.3±0.4mgGA/g) and oligosaccharides (26.8mg/g) (Sreerama et al., 2012). The utilization of horsegram as human food is restricted due to presence of high level of enzyme inhibitors, haemagglutinin activities, oligosaccharides, tannins, polyphenols and phytic acid compared to the other legumes which can be reduced below their mischief potential through processing (Dhumal and Bolbhat, 2012; Sharma, 2011). Conventional processing methods such as dehusking, germination, cooking, and roasting have been shown to produce beneficial effects by decreasing the content of undesirable components which results in enhanced acceptability and nutritional quality in addition to optimal utilization of horsegram as human food (Kadam and Salunkhe, 1985). As far as the presence of antinutritional factors are concerned, some of the commonly considered antinutritional compounds like phytic acid, phenols, tannins are now being considered as potential antioxidants having health promoting effects. The phytic acid has now been shown to possess rich antioxidant, anticarcinogenic and hypoglycaemic activities, therefore, depending upon consumer preferences retaining or elimination of these compounds could be facilitated (Bhatt and Karim, 2009).

Protease inhibitors: Horsegram invariably contain inhibitors of proteases that cause decreased digestibility of dietary proteins by formation of irreversible trypsin enzyme and trypsin inhibitor complex in the intestine. The horsegram protease inhibitors resembles other Bowman-Birk protease inhibitors and characterized by low molecular weight, high disulfide content with low content of aromatic amino acids which can bind and inhibit trypsin and chymotrypsin either independently or simultaneously (Singh and Rao, 2002; Ramasarma et al., 1994). In horsegram flour, trypsin inhibitor activity is significantly higher (9246 TIU/g) as compare to chickpea (6452 TIU/g) and cowpea (6981 TIU/g) flour (Sreerama et al., 2012). High level of trypsin inhibitor activity (950 x 10^4 TIU/g seed) in ungerminated horsegram seeds reduced by 16% in 72 h germinated seeds (Subbulakshmi et al., 2012).
Germination induces changes in the Bowman-Birk type proteinase inhibitors of horsegram at both qualitative and quantitative levels (Gowda and Sreerama, 1998) and facilitates protein hydrolysis for utilization in germination process. Trypsin inhibitor is thermolabile and its inhibitory activity can be reduced considerably by thermal treatment (Liener, 1994).

**Total free phenolics and tannins:** Phenolic compounds and tannins are important phytochemicals, synthesized by plants for protection against predators and also under various stress conditions, plants accumulate phenolic compounds in their metabolism (Thenmozhi et al., 2012). These compounds are highly appreciated for their quality to add flavour, taste and appearance to the product (Pugalenthi et al., 2005) as well as impart health benefits for humans (Alonso and Arellano, 2005). Phenolic compounds are known to interact with proteins forming complexes which in turn, decrease the solubility of proteins and make protein complexes less susceptible to proteolytic attack (Reddy et al., 1985). Tannins are structurally more complex and wide spread phenolic compounds that contribute astringency and bitterness to plants as well as has the property to precipitate proteins (Chirinos et al., 2008; Furlan et al., 2010). Horsegram seeds are rich in tannins and polyphenols compared to the other legumes (Kadam and Salunkhe, 1985) and contains relatively high levels of total free phenolics (1.670g/100g) (Sundaram et al., 2013) and tannins (763.7-895.9mg/100g) (Sudha et al., 1995). Black seeds contain relatively high levels of total phenolics and tannins than the brown seeds (Siddhuraju and Manian, 2007). The extracts of horsegram plant examined as potential sources of phenolic compounds and out of eight phenolic acids, most abundant were p-coumaric acid (8.95 mg) and p-hydroxy benzoic acid (7.81 mg) per 100 g of dry sample (Kawser et al., 2008). Phenolics and tannins are water soluble which are concentrated to seed coat. Soaking and cooking process cause leaching of tannins and beneficial impact on nutritional value and marked reduction in tannin content (215.3–361.9 mg/100g) by dehulling as compared to whole seeds (763.7–895.9mg/100g) of horsegram (Sudha et al., 1995). Phenolics have attracted the attention of food and health scientists in recent times due to antioxidant properties and their uses in health care (Alonso and Arellano, 2005). There is ample proof of health benefits as anti-inflammatory, cicatrizant and anti-HIV functions of tannins together with their role in protection against environmental stresses (drought, UV-B radiation and atmospheric pollution), microbial pathogens, harmful insects and other herbivores in plants (Furlan et al., 2010).

**Haemagglutinins:** Haemagglutinins are cell agglutinating sugar specific proteins, widely distributed in leguminous plants and sometimes referred as phytoagglutinins or lectins (Srilakshmi, 2003; Kumar and Gopalrao, 1986). Excess consumption of lectins can cause severe intestinal damage, nutrient deficiencies and they can bind to erythrocytes simultaneously with immune factors, causing hemagglutination and anemia (Laura, 1991). However, oral administration of low doses can have many beneficial effects on digestive efficiency, the immune system and the body’s endocrine system with beneficial consequences for general metabolism (Zhang et al., 2008). In horsegram, *D. biflorus* agglutinin (DBA) is an important dietary lectin, identified as an allergen (Siddanakoppalu et al., 2006) and retarded growth observed in rats fed on this lectin (Manage et al., 1972). Horsegram seeds are rich in lectins and DBA differentially expresses in seeds, stems, leaves and roots (Beran et al., 2007). Horsegram seed lectin has ‘A’ blood group specificity which can distinguish between A1 and A2 blood groups therefore, commonly used in blood banks in blood group testing (Hamid and Masood, 2009; Shah, 2014). Preliminary soaking prior to autoclaving or cooking is required for complete elimination of the toxicity of lectins (Jain et al., 2009).

**Phytic acid:** Phytic acid (known as phytate when in salt form) acts as the primary phosphorus reservoir accounting for up to 85% of total phosphorus in cereals and legumes and has the ability to bind minerals, proteins and starch and forms complexes consequently lowers the bioavailability of minerals (zinc, iron, calcium, magnesium, manganese and copper) as well as inhibit enzymatic digestion of both proteins and starch (Pugalenthi et al., 2005). However, it exhibits beneficial health effects as it has a positive role as an antioxidant and in protection against a variety of cancer and coronary heart disease, diabetes mellitus and renal stones (Kumar et al., 2010). In horsegram seeds, phytate phosphorus (184±6.0mg/100g) accounted for 57% of the total phosphorus (320±8.5mg/100g) (Borade et al., 1984). The phytic acid content in horsegram flour (10.2±0.4mg/g) comparable to chickpea (12.1±0.5mg/g) and cowpea (14.0±0.7mg/g), black gram (11mg/g), lentil (12.5mg/g), red kidney bean (14.4mg/g) and white kidney bean (12.3mg/g) but higher than the levels reported for pigeon pea (2.2mg/g) (Sreerama et al., 2012). Simple processing like germination, cooking, roasting, soaking and fermentation cause significant reduction in phytic acid content in legumes (Khamgaonkar et al., 2013).

**Remedial properties:** Horsegram has long history as traditional medicine to cure many diseases, still it is neglected for its remedial potential. As per *Charak Samhita*, the seed of horsegram are useful for the cure of piles, hiccup, abdominal lump, bronchial asthma, in causing and regulating perspiration and in the *Sushruta Samhita* it is mentioned that the seed powder is useful in stopping excessive perspiration (Pati and Bhattacharjee, 2013). Traditional texts describes its use as traditional
medicine for curing kidney stones, asthma, bronchitis, leucoderma, urinary discharges, heart diseases and piles (Ghani, 1998; Yadava and Vyas, 1994). It also has anthelmintic activity which can be used as dietary food for infants to eradicate worms (Philip et al., 2009). It is supposed to have unique property of dissolving kidney stones, therefore, in many parts of the country it is given to prevent or cure urinary stones (Singla and Kumar, 1985). In seed extract of horsegram water soluble, heat stable, polar, non-tannin and non-protein crystallization inhibitors are reported and a marked decrease in anticalcifying activity observed with the post-harvest storage of seeds (Peshin and Singla, 1995). The extract of horsegram exerts a hypolipidaemic and hypoglycaemic actions (Senthil, 2009) and has also been found beneficial in urinary troubles, acid peptic disorder (gastritis), constipation, sun-burn, kidney stone, female diseases (leucorrhoea, menstrual troubles, bleeding during pregnancy, post partum excessive discharges), colic caused by wind, piles, rheumatism, hemorrhagic disease, intestinal worms etc. (Pati and Bhattacharjee, 2013). It is prescribed for persons suffering from jaundice, water retention, as part of a weight loss diet, iron deficiencies and also helpful for maintaining body temperature in the winter season (Ramesh et al., 2011). It is considered as Garmi dal and preferred during the winter months by rural communities (Khanal et al., 2009). Horsegram seed are rich source of dietary antioxidants (Siddhuraju and Manian, 2007) as well as has antidiabetic effect (Gupta et al., 2011). Extracts from horsegram seeds reported to have significant activity against B. subtilis, S. aureus, E. coli, and P. aeruginosa (Gupta et al., 2005). Horsegram used as medicine to treat hiccups, worms and in the treatment of bacterial and fungal infections (Kawser et al., 2008; Chunekar and Pandey, 1998). It has functional ingredients against hypercholesterolemia and obesity (Kumar et al., 2013).

Potential of horsegram as functional food and feed: Horsegram has great potential both as food and feed suggested by experiences worldwide. Its nutritious composition, medicinal properties and indolable pest resistance makes it a rich yet cheap source of food, fodder, fuel supplement and green manure (Bhardwaj et al., 2013). U.S. National Academy of Science has identified this legume as a potential food source for the future (NAS, 1979). The inception of nutraceutical concept and health consciousness among masses has increased the utilization of potential antioxidants from legumes including horsegram as it reduces the risk of intestinal diseases, diabetes, coronary heart disease, prevention of dental caries etc. due to presence of bioactive compounds (Prasad and Singh, 2014). The seeds, sprouts or whole meal of horsegram is used by large populations in rural areas (Kadam and Salunkhe, 1985). Raw horsegram seed is a rich source of antioxidant activities which are concentrated more in the seed coat of the seeds and consumption of food items prepared with unprocessed raw horsegram seeds may have more health benefits for hyperglycaemic individuals (Tiwari et al., 2013). Horsegram seed proteins exhibit free radical scavenging capacities which can be used as a food supplement, natural antioxidant and useful as therapeutics for health benefits of human (Petchiammal and Hopper, 2014). The seeds and sprouts of horsegram are excellent examples of ‘functional food’ as it has role in lowering the risk of various diseases and exerting health promoting effects in addition to its nutritive value (Ramesh et al., 2011). However, the metabolic changes during sprouting affect the bioavailability, palatability and digestibility of essential nutrients (Masood et al., 2014). In some parts of India, leaves of horsegram are also used as vegetable (Mandle et al., 2012) and leaves contain additional health enhancing traits such as anthocyanins which are potent antioxidants by acting as free radical scavengers and shown to be anti-inflammatory (Morris, 2008). Non-toxic extracts from aerial parts of horsegram justifying its ethnomedical use (Kawser et al., 2008). Horsegram is low cost pulse with high protein and acceptable cooking quality and has the potential to formulate products (Hiramath et al., 2001). In addition, horsegram flour has good functional properties with swelling capacity (1.43±0.01 ml), water solubility index (7.56±0.10 %), oil absorption capacity (80.76±0.03 %), water absorption capacity (142.14±0.10 g/100g) and swelling index (0.46±0.15 %), hence can be used as functional foods for nutrition and food formulation (Marimuthu and Krishnamoorthi, 2013). Horsegram flour is rich in protein, calcium and dietary fibre, after simple processing like soaking and drying or roasting eliminates the antinutritional content hence suitably processed horsegram flour could be used in the preparation of various food products (Thirukkanmar and Sindumathi, 2014). Horsegram flour found to have favourable functional properties like higher water absorption capacity (148.1±3.4mg/100g), emulsion activity (58.1±0.5%) and emulsion stability (52.0±1.6%) as compared to chickpea flour which suggest its scope to be exploited in the preparation and development of food products such as bakery products, soups and snacks as well as may be used to produce composite flours as partial substitutes of chickpea flour in snacks, confectionery and other traditional food products (Sreerama et al., 2012).

The whole seeds of horsegram are generally utilized as cattle feed and are usually given after boiling (Reddy et al., 2008; Kadam and Salunkhe, 1985). Non shattering pods has shown the potential of stand over dry season livestock feed in Northern Australia while in India as annual pulse and forage crop in areas receiving less than 875mm average annual rainfall (Blumenthal and Staplesz, 1993). Horsegram seed can also be utilized in
chick and grower ration without any deleterious effect as better feed efficiency observed in the diets of egg-type chicks and growers with 10% raw horsegram seeds without mortality (Ravindran and Bino Sundar, 2009). Sheep appeared to prosper best when fed hay containing 70% *M. uniflorum* than hay consisting of 70% *Stylosanthes hamata*, *Vigna unguiculata*, and *Crotalaria juncea* (Murthy and Prasad, 2005). Horsegram seed meal is non-toxic in nature, safe for edible use and has a better promise as a source of food supplement and likely to be satisfactory in supporting growth and maintenance in animal feeding (Sreelekshmi et al., 2011). It possess high nutritional value and remedial properties. Moreover, it has the potential for further utilization as nutraceutical, food and forage for malnourished and drought-prone areas of the world (Morris, 2008). There are great possibilities exist for horsegram to be explored further for various undiscovered phytochemicals, therapeutics usage as well as development of low cost functional and medicinal food.

**Conclusion:** Horsegram is an important food and feed crop traditionally grown in arid regions of the developing world and often considered as minor/neglected/underexploited/poor man’s pulse. Its innate climate resilience suggests its scope as a suitable alternative in the present climate change era. It is a treasure house of various therapeutic, bioactive compounds along with excellent nutritional quality makes it a wholesome food that should be added to diet on a regular basis. The health benefits of horse gram are being recognized in the western world recently, but have been known for its ability to prevent and cure various diseases by Indian “Ayurvedic” system since centuries. Furthermore, there are still great possibilities exist for this legume to be explored for its chemoprofile, pharmacology, biological evaluation, toxicological consequences, innate health-promoting aspects and many undiscovered phytochemicals as well as there is need to promote and support the initiatives that make the most use of this indigenous underutilized legume to address food and nutritional security issues.

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