

Review Article

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Usefulness of Three under Exploited Vegetable Legumes - A Review

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ABSTRACT

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Vegetables form an important portion of human diet and are more important for the vegetarian population. Family *Leguminosae* is one of the highly diverse families of vegetables. In addition, vegetables belonging to this family are exceptionally rich in proteins, vitamins, minerals, and nutraceuticals. However, the vegetables belonging to this group were never exploited to the immense value they warrant. In this review, we highlight the usefulness of cultivating three underexploited vegetable legumes such as cluster bean, velvet bean and winged bean by discussing their botanical characters and health-related benefits.

Introduction

Leguminosae, also named as *Fabaceae*, is a big family of the dicotyledons flowering plants, with more than 18000 species further divided into 650 different genera. This family has tremendous potential for use of its members in numerous forms based on plant type, but still, the family is not well utilized (Young and Bharti, 2012; Varshney and Kudapa, 2013).

Most of the members of this family are annuals and cultivated for their fresh pods, foliage, tender shoots and roots, although they

can be dried or processed for increasing their year-round availability (Rubatzky *et al.*, 1997; Ntasi *et al.*, 2018). While some vegetable legumes like Pea and Phaseolus are popular and extensively cultivated in the world, others like Velvet Bean remain underexploited. This is based on the fact of their limited diversity, confinement to certain regions, (i.e. mostly to developing world), along with limited exploitation of their available resources on various scales to show the potential benefits of their use to the modern consumers (Fantz *et al.*, 1991; O'Brian and Vance, 2007; Wyk and Boatwright, 2013). Nonetheless, vegetable legumes are highly rich in

carbohydrates, oils, proteins, minerals, vitamins, micronutrients along with other important phytochemicals and bioactive compounds essentials for healthy life in order to overcome various cardiovascular and chronic diseases like cancer (Sandberg, 2002; Trinidad *et al.*, 2009; Kaushik *et al.*, 2015; Papandreou *et al.*, 2018). In addition, these legumes are also acknowledged to have anti-nutritional factors harmful to human health like trypsin inhibitors, phytic acid etc, which further reduces their possible use as food and fodder. By employing different techniques like irradiation and fermentation, these toxins can be readily eliminated (D'Mello, 1992).

Although today's agriculture is dealing with the serious threat of climate change, vegetable legumes can reduce its harmful impact and provide global food security (Abelson, 1992; Smit *et al.*, 1996). These underutilized vegetables are well adapted to climatic extremes and have a high tolerance of different stresses like drought and mineral deficiency; they have a broad genetic base due to the absence of human interference (Nagarajan and Nagarajan, 2010). Also, legumes are well known for their nodules, which can support nitrogen fixation and protect the soil from the harmful effect of erosion (Ampomah *et al.*, 2012).

In this review, botanical, nutritional and breeding aspects of three vegetable legumes *viz.*, cluster bean, velvet bean and the winged bean are examined for their numerous medicinal properties, which allow for multiple uses that research can discover.

Botany

Genus *Cyamopsis* include 3 species that are well distributed in Asia and Africa. These species are drought resistant and can sustain plant growth under extremely harsh climatic conditions. *C. tetragonoloba* (L.) Tabu. or

Guar bean ($2n = 14$) is a self-pollinated plant in nature and it is cultivated chiefly for its young pods; these can be cooked and dried to make industrial gum. Moreover, its seeds can also be used as fodder in both farms with or without pods (Patil, 2004; Purohit *et al.*, 2011). *C. tetragonoloba* is an annual plant whose height ranges from 50–150 cm tall. Its other features include a taproot system, well-developed laterals, and rhizobium nodules. Its name comes from its pod's tendency to cluster together. The pod length varies from 32 to 110 mm with an average of around 58 mm in most of the refined varieties (Morris, 2010).

The species of genus *Mucuna* are identified to be trifoliolate climbers. Pollination is carried out by bats and birds and as a result, they are known as zoophilous. With more than 100 species spread over various tropical and subtropical regions of the world, *Muncua* is divided into two subgenera, *Mucuna* and *Stizolobium*. While *Mucuna pruriens* (velvet bean) with $2n=22$ fits into subgenus *Stizolobium*, it can be clearly distinguished from other species within this genus based on the visual descriptors related to its seeds, fruit and corolla (Wilmot-Dear, 1991a, 1991b, 1993; Tozzi *et al.*, 2005). *Mucuna* is a dual-purpose vegetable with pods consumed by humans and its tender leaves used as fodder for farm animals. Cultivated in some countries in the continents of Asia, America, and Africa, it has a tolerance to abiotic stresses like drought and high temperature. In contrast, it is susceptible to cold and frost. Morphologically the plant possesses dark brown pods covered with hairs and is typically around 10 cm long, with an average of four to six seeds inside (Lampariello *et al.*, 2012).

Genus *Psophocarpus* Neck. ex DC consists of 10 species and grows wild in nature. This excludes *P. tetragonolobus* (winged bean), which is distributed in the tropics and

popularly grown in some Asian countries (Klu, 2000). Although winged bean is a perennial plant with tuberous roots, it is generally cultivated as an annual. Every different part of its plant, (i.e., leaves, pods, seeds and tubers), is edible at every stage of its growth. Winged bean is also found to be resistant to soil acidity and salinity; thus, it can function as an excellent soil cover under those situations (Anugroho *et al.*, 2015). It generally has four-cornered pods with wings of varying length and seed count on each corner (Nwokolo, 1996). Moreover, owing to its multipurpose nature as a plant, winged bean was introduced to eighty different countries, although it has been recently discovered that the cultivated winged bean has limited genetic diversity within popular varieties as the introduction of same common popular varieties (Chen *et al.*, 2015).

Nutritional importance

Cluster bean

Cluster bean, when raised as a vegetable, is appreciable for its nutritional value, which consists of proteins, fat, carbohydrate, Vitamin A, Vitamin C, calcium and iron (Zanoni *et al.*, 1980). However, it is also processed for its various commercial uses, such as the natural vegetable gum extracted from its endosperm. Originally it was grown as a green manure crop (Mudgil *et al.*, 2011; Bhatt *et al.*, 2016). Since its seed endosperm contains galactomannan, it is also known as an endosperm legume and is preferred as a food additive (Manjunath *et al.*, 2016). Different natural compounds are present in the seeds of the cluster bean in the form of flavonoids like quercetin, kaempferol, phenolic compounds and tannins (Heyne and Whistler, 1948; Padalino *et al.*, 2015).

In contrast, several unfavourable features were also reported in guar bean such as

trypsin inhibitor (Hooper and Couch 1971), hemagglutinins (Arora and Joshi 1980), saponins (Curl *et al.*, 1986), polyphenols (Kaushal and Bhatia 1982) and tannins. However, these components can be separated by various treatments via cooking or processing. Furthermore, health benefits of Guar bean consumption are numerous: low serum cholesterol levels, antidiabetic properties, and prevention of cardiovascular and cancerous diseases (Jenkins *et al.*, 1975; Nishimura *et al.*, 1997; Yellela *et al.*, 2009; Kaczmarczyk *et al.*, 2012). Moreover, the biopolymer obtained from the guar gum can be utilized as for the removal of dissolved lead from the turbid industrial wastewater systems (Mukherjee *et al.*, 2018).

Velvet bean

Velvet bean is a prominent source of different essential nutrients such as vitamins and minerals. As a result, it can be readily utilized as food and animal feed. It contains a high level of protein and serves as a supplement for humans (Pugalenthi *et al.*, 2005; Bhat *et al.*, 2008; Chikagwa-Malunga *et al.*, 2009; Vadivel and Pugalenthi, 2010; Vadivel *et al.*, 2011). Velvet bean possesses a phytochemical known as L-Dopa, which is a non-protein amino acid present in a higher concentration within its seed; it is used to treat Parkinson's disease (Kaizzi *et al.*, 2006; Mannangatti and Naidu, 2016). Likewise, it is also found to be anti-cholesterol, antidiabetic, antitumor, aphrodisiac, anti-venom and antimicrobial in nature (Pugalenthi *et al.*, 2005; Bhat *et al.*, 2008; Chikagwa-Malunga *et al.*, 2009; Vadivel and Pugalenthi, 2010b; Vadivel *et al.*, 2011). However, one of the reasons that it is not a popular vegetable is that it is known to contain several toxins such as tannins, lectins, phytic acid and trypsin inhibitors. Fortunately, these may vary in amount in each plant and they can be easily removed. Processes such as hydrothermal treatments, fermentation and

ionising radiation-based processing can be used to remove the harmful compounds (Siddhuraju *et al.*, 1996, 2000). Although in general, the constitution of these compounds is dependent on location, harvest processing and climate, along with many other factors (Pugalenthi *et al.*, 2005).

Winged bean

Winged bean is identified to exhibit very high protein content as well as carbohydrates, fat and minerals. Subsequently, it can perhaps be recommended as infant food, for its dried seeds generally contains more than 30 percent protein while tuber contains up to 20 percent protein (Kadam and Salunkhe, 1984; Kantha and Erdman, 1984; Smith *et al.*, 1984; Anugroho *et al.*, 2015). Winged bean root tubers can also be cooked like potatoes. It is a surprisingly high yielder and can outperform many vegetables. Moreover, it is also one of the more heavily nodulated than some popular legumes (Nwokolo, 1996). Several studies have shown the Winged bean to be a powerful source of antioxidants, due to its phenolic content (Ismail *et al.*, 2009; Khalili *et al.*, 2013).

Winged bean also possesses antimicrobial properties against several human pathogenic microbes, which resulted in its use within traditional medicine in various parts of the world (Latha *et al.*, 2006, 2008; Sasidharan *et al.*, 2008a, 2008b). In contrast, there are several contaminants still present in winged bean namely; behenic acid, parinaric acid, trypsin inhibitors, phytic acid, tannin and lectin (de Lumen and Chan, 1986; Fernando and Bean, 1986; Kotaru *et al.*, 1987). Yet, the trypsin inhibitors present in the winged bean are heat tolerant and require alternative methods for treatment like fermentation (Tan *et al.*, 1983, 1984a, 1984b). Moreover, these anti-nutritional factors differ depending on different cultivars making it feasible to select

beans with a lower content of these anti-nutritional factors (Fernando and Bean, 1985).

Breeding aspects

As self-pollination is a natural phenomenon in family Leguminosae, the cross-pollination is cumbersome. Furthermore, the specialised structures like a keel, small flowers and excessive flower drops also limit the chance of cross-pollination (Yang *et al.*, 1990). The locally grown landraces can be integrated into the breeding programs for these vegetable legumes as they can contribute towards many desirable traits (Viswanatha *et al.*, 2016). Wild relatives are more likely to assist in the genetic improvement of these legumes, but sometimes different kinds of genetic barriers limit their ability to achieve viable crosses (Tiffin *et al.*, 2001). However, these genetic barriers can be overcome by specialized techniques like embryo rescue (Sharma, 1995; Sharma *et al.*, 1996). Nevertheless, rapid plant regeneration protocols are also well studied and devised in these crops which can increase production time (Ahmad and Anis, 2015).

For these legumes the genetic variability is undoubtedly being of immense value for breeding and targeting several aspects like disease resistance and yield; as seen in their sister legumes that genetic variability facilitated to create germplasm for several uses and increased the adaptability of the plant to different environmental conditions (Harder, 1991). Moreover, there is the presence of an exceptional amount of diversity in these underexploited vegetable legumes for various plant morphological characters and biochemical parameters (Janardhanan *et al.*, 2003). Knowledge of the inheritance patterns of these characters is a key for their successful genetic improvement and was also employed to revise them for various purposes. For example, in cluster

bean, seven seed related quantitative characters were estimated among forty different genotypes and it was concluded that genetic variation was due to high additive effect and all the genotypes were grouped into seven different clusters irrespective of their place of collection (Pathak *et al.*, 2011). Whereas, in winged bean one hundred twenty-one pure lines were isolated from the highlands of Papua New Guinea (Khan, 1976). Also, there is a wide intraspecific diversity present for various biochemical parameters pod parameters of velvet beans as studied in six distinct species (Adebowale *et al.*, 2005).

Furthermore, various kinds of molecular markers were also employed to estimate diversity in Cluster bean, Velvet bean and Winged bean and shown a very high level of diversity even among morphologically similar lines (Capo-chichi *et al.*, 2001; Chen *et al.*, 2015; Kumar *et al.*, 2015).

Mutation is known as a sudden heritable change in the genetic architecture of individual it can either be incorporated in the seeds or other vegetative plant parts (winged bean tubers) for these legumes mentioned in this review. Mutation can be induced by diverse means mainly by employing physical and chemical mutagen. However successful mutation should be free from undesirable changes and only have a target that is a trait of our interest (Donini and Sonnino, 1998). One of the traits of importance is the removal of undesirable phytochemicals like trypsin inhibitors e.g. in Winged bean using gamma rays and EMS (ethyl methane sulfonate) mutants were identified, lower in trypsin, chymotrypsin inhibitors and with low in tannins (Kothekar *et al.*, 1996).

With the tremendous promises of the modern so-called genomic tools, it looks easier to perform breeding activities than to do the

same by conventional breeding approaches. Likewise, with the rapid progress and cheap availability of sequencing technology, it can also establish as an important milestone for these underexploited legumes (Bohra *et al.*, 2014). In fact, this technology has benefited various other legumes like chickpea, groundnut and pigeon pea. The draft genome sequence is helpful for accelerating plant breeding by pointing out easily the genes responsible for economically important traits. The transcriptomics, proteomics, metabolomics, and epigenomics have encouraged in various other crops and need a further detailed exploration to be applied to these underexploited vegetable legumes (Smýkal *et al.*, 2014; Pandey *et al.*, 2016). Traditional breeding methods to improve these crops can be complemented with genetic manipulation techniques to introduce genetic traits or event of interest e.g. Disease resistance, salt tolerance, insect pest resistance and biochemical compounds of interest at a very fast rate (Gosal *et al.*, 2010).

These edible legumes are rich in essential fatty acids, proteins, vitamin and minerals but the overall production scenario of these legumes still lags. There is the continuous growing demand for plant-based proteins for humans and as well as livestock. Undoubtedly, these legumes can play a crucial role in diversifying agriculture and improving human health. However more far-reaching research is needed to search for the possibilities of employing these under-utilized legumes as an integrated part of modern agricultural systems. Increased genetic resources both by indigenous and exotic resources are emphasized for increased and sustainable crop production of these three unexploited vegetable legumes. Moreover, these legumes can act as intercrop in our present horticultural system to combat insect pest infestation thereby increasing agricultural production and improving soil health.

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