Contents list available at Science Letters

Science Letters

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To study the Taxonomic and Nutritional Composition in Mungbean (*Vigna radiata* (L.) R. Wilczek)

Lokesh Verma and Pushpa C. Tomar*

Department of Biotechnology, Faculty of Engineering and Technology, Manav Rachna International Institute of Research and Studies, Faridabad, Haryana, India

ARTICLE INFO

Article History
Received 2 February 2020
Revised 19 March 2020
Accepted 20 March 2020
Available Online 7 March 2020

Keywords:
Taxonomic,
Vigna radiata,
Nutritional Composition,
papilionaceous,
vermicelli

ABSTRACT

The mungbean (Vigna radiata (L.) R. Wilczek) is a legume cultivated for its edible seeds and sprouts across Asia. There are three subgroups of Vigna radiata: one is developed (Vigna radiata subsp. radiata), and two are wild (Vigna radiata subsp. sublobata and Vigna radiata subsp. glabra). The mung bean plant is an annual, erect or semi-erect, reaching a height of 0.15-1.25 m. It is slightly hairy with a well-developed root system. Wild types tend to be prostrate, while cultivated varieties are more erect. The stems are many-branched, sometimes twining at the tips. The leaves are alternate, trifoliolate with elliptical to ovate leaflets, 5-18 cm long x 3-15 cm broad. The flowers (4-30) are papilionaceous, pale yellow, or greenish. The pods are long, cylindrical, hairy, and pending. They contain 7 to 20 tiny, ellipsoid or cube-shaped seeds. The seeds are variable in color; they are usually green and yellow, olive, brown, purplish brown or black, mottled and ridged. Seed colors and the presence or absence of a rough layer are used to distinguish different types of mungbean. Several mungbean products are helpful for livestock feeding; Mungbeans, raw or processed, and split or weathered seeds. By-products of mungbean processing: mungbean bran (called chuni in India), which is the by-product of dehulling for making dhal, and the by-product of the manufacture of mungbean vermicelli. Mungbean is sometimes grown for fodder as hay, straw, or silage. It is particularly valued as early forage as it outcompetes other summer growing legumes such as cowpea or velvet bean in their early stages. The mungbean plant makes valuable green manure and can be used as a cover crop.

1. Introduction

The mung bean (*Vigna radiata* (L.) R. Wilczek) is a legume cultivated for its edible seeds and sprouts across Asia. There are 3 subgroups of *Vigna radiata*: one is developed (*Vigna radiata* subsp. *radiata*), and two are wild (*Vigna radiata* subsp. *sublobata* and *Vigna radiata* subsp. *glabra*). The mung bean plant is an annual, erect or semi-erect, reaching a height of 0.15-1.25 m (FAO, 2012; Lambrides *et al.*, 2006; Mogotsi, 2006). It is slightly hairy with a well-developed root system. Wild types tend to be prostrate, while cultivated varieties are more erect (Lambrides *et al.*, 2006). The stems are many-branched, sometimes twining at the tips (Mogotsi, 2006). The leaves are alternate, trifoliolate with elliptical to ovate leaflets, 5-18 cm long x 3-15 cm broad. The flowers (4-30) are papilionaceous, pale yellow, or greenish. The pods are long, cylindrical, hairy, and pending. They contain 7 to 20 tiny, ellipsoid or cube-shaped seeds. The seeds are variable in color: green and yellow, olive, brown, purplish brown or black, mottled and ridged. Seed colors and the presence or absence of a rough layer are used to distinguish different types of mung bean (Lambrides *et al.*, 2006; Mogotsi, 2006). Cultivated varieties are generally green or golden and can be shiny or dull depending on the presence of a texture layer (Lambrides *et al.*, 2006). Golden gram, which has yellow seeds, low seed yield, and pods that shatter at maturity, is often grown for forage or green manure. Green gram has bright green sources, is more prolific, and ripens more uniformly, with a lower tendency for pods to shatter. In India, two other types of mung beans exist, one with black seeds and one with brown seeds (Mogotsi, 2006). The mung bean resembles the black gram (*Vigna mungo* (L.) with two main differences: the corolla of *Vigna mungo* is bright yellow while *Vigna radiata* is pale yellow; mung bean pods are pendulous whereas they are erect in black gram. Mung bean is slightly less hairy than a

*Corresponding Author: Pushpa C. Tomar
E-mail Address: pushpa.fet@mriu.edu.in
DOI: 10.46890/SL.2020.v01i03.004

black gram. Mung bean is sown on lighter soils than a black gram (Göhl, 1982).

The mung bean is a primary edible legume seed in Asia (India, South East-Asia, and East Asia) and is also eaten in Southern Europe and the Southern USA. The mature seeds provide an invaluable source of digestible protein for humans in places where meat lacks or where people are mostly vegetarian (AVRDC, 2012). Mung beans are cooked fresh or dry. They can be eaten whole or made into flour, soups, porridge, snacks, bread, noodles and ice-cream. Split seeds can be transformed into dhal in the same way as black gram or lentils. Mung beans can be processed to make starch noodles (vermicelli, bean thread noodles, cellophane noodles) or soap. The sprouted seeds ("bean sprouts" in English and incorrectly called "germes de soja" or "pousses de soja" in French) are relished raw or cooked throughout the world. The immature pods and young leaves are eaten as a vegetable (Mogotsi, 2006).

Common Names

Mung bean, mungbean, moong bean, golden gram, green gram, celera bean, Jerusalem pea (in English); amberique verte, haricot mungo (in French); frijol mungo, judia mungo, poroto chino (in Spanish); feijao-da-china, feijao-mungo (in Portuguese); mungboon (in Dutch); Mungbohne, Jerusalembohne (German); kacang hijau (in Indonesian); kacang ijo (in Javanese); fagiolo indiano verde, fagiolo mungo verde (in Italian); monggo, munggo (in Tagalog); Dau xanh Mung (in Hindi).

Species

Vigna radiata (L.) R. Wilczek (Fabaceae)

Synonyms

Phaseolus aureus Roxb., *Phaseolus radiatus* L., *Phaseolus setulosus* Dalzell, *Phaseolus sublobatus* Roxb., *Phaseolus sublobatus* var. *grandiflora* Prain, *Phaseolus trinervius* Wight & Arn., *Vigna radiata* var. *setulosa* (Dalzell) Ohwi & H. Ohashi, *Vigna sublobata* (Roxb.) Bairig. *et al.,*

Taxonomic information

Mungbean (*Vigna radiata*) used to be known as *Phaseolus aureus* Roxb. before many *Phaseolus* species were moved to the *Vigna* genus (Lambrides *et al*., 2006). In spite of its usual vernacular name of mung bean, *Vigna radiata* is a different species from *Vigna mungo*, which is usually called black gram or urdbean. Both species have a similar morphology (Tiwari *et al.,* 2017).

Feed categories

1. Legume forages
2. Legume seeds and by-products
3. Plant products and by-products
4. Bambara groundnut (Vigna subterranea) seeds
5. Black gram (Vigna mungo)
6. Cowpea (Vigna unguiculata) seeds

Several mung bean products are useful for livestock feeding:

1. Mung beans, raw or processed, as well as split or weathered seeds (Vaidya, 2001).

2. By-products of mung bean processing: mung bean bran (called chuni in India), which is the by-product of dehulling for making dhal, and the by-product of the manufacture of mung bean vermicelli.

3. Mung bean is sometimes grown for fodder as hay, straw or silage (Mogotsi, 2006). It is particularly valued as early forage as it outcompetes other summer growing legumes such as cowpea or velvet bean in their early stages (Lambrides *et al.,* 2006).

The mung bean crop makes valuable green manure and can be used as a cover crop (Mogotsi, 2006).

Distribution

The mung bean is thought to have originated from the Indian subcontinent where it was domesticated as early as 1500 BC. Cultivated mung beans were introduced to southern and eastern Asia, Africa, Austronesia, the Americas and the West Indies. It is now widespread throughout the Tropics and is found from sea level up to an altitude of 1850 m in the Himalayas (Lambrides *et al.,* 2006; Mogotsi, 2006).

The mung bean is a fast-growing, warm-season legume. It reaches maturity very quickly under tropical and subtropical conditions where optimal temperatures are about 28-30°C and always above 15°C. It can be sown during summer and autumn. It does not require large amounts of water (600-1000 mm rainfall/year) and is tolerant of drought. It is sensitive to waterlogging. High moisture at maturity tends to spoil the seeds that may sprout before being harvested. The mung bean grows on a wide range of soils but prefers well-drained loams or sandy loams, with a pH ranging from 5 to 8. It is somewhat tolerant to saline soils (Mogotsi, 2006). Mung bean production is mainly (90%) situated in Asia: India is the largest producer with more than 50% of world production but consumes almost its entire production. China produces large amounts of mung beans, which represents 19% of its legume production. Thailand is the main exporter and its production increased by 22% per year between 1980 and 2000 (Lambrides *et al.,* 2006). Though it is produced in many African countries, the mung bean is not a major crop there (Mogotsi, 2006).

1.1 Processes

Seed harvest

Mung bean crops grown for seeds are generally harvested when pods begin to darken. They are mostly hand-picked at weekly intervals. In newer varieties in which the plants mature uniformly, the whole plants are harvested and sun-dried before being threshed. Once pods have dried, the seeds are removed by beating or trampling (Mogotsi, 2006).

Forage harvest

The mung bean can be grazed six weeks after planting and two grazings are usually obtained (FAO, 2012). It can be used to make hay, when it should be cut as it begins to flower and then quickly dried for storage. It is possible to make hay without compromising seed harvest.

Forage management

Mung bean seed yields are about 0.4 t/ha but yields as high as 2.5 t/ha can be reached with selected varieties in Asia (AVRDC, 2012). Mung beans can be sown alone or intercropped with other crops, such as other legumes, sugarcane, maize, sorghum, fodder grasses or trees (Göhl, 1982). Intercropping can be done on a temporal basis: modern varieties ripen within 60-75 days and there is enough time to harvest another crop during the growing season. For instance, in monsoonal areas, it is possible to sow mung bean and harvest it before the monsoon season when rice is planted. It is also possible to grow mung bean on residual moisture after harvesting the rice (Mogotsi, 2006). Forage yields range from 0.64 t/ha of green matter under unfertilized conditions to about 1.8 t/ha with the addition of fertilizer (FAO, 2012)

1.2 Environmental impact

Cover crop and soil improver

The mung bean can be used as a cover crop before or after cereal crops. It makes good green manure. The mung bean is a N-fixing legume that can provide large amounts of biomass (7.16 t biomass/ha) and N to the soil (ranging from 30 to 251 kg/ha) (Hoorman *et al.,* 2009; George *et al.,* 1995 cited by Devendra *et al.,* 2001; Meelu *et al.,* 1992). Green manure should be ploughed in when the plant is in full flower (FAO, 2012).

1.3 Nutritional attributes

Seeds

Mung beans are rich in protein (20-30% DM) and starch (over 45% DM) with a low lipid content (less than 2% DM), and variable but generally low amounts of fibre (crude fibre 6.5% DM on average). The amino acid profile of mung beans is similar to that of soybean.

Mung bean by-products

The by-product of mung bean vermicelli processing contains 11-23% crude protein, 0.4-1.8% ether extract, 13-36% crude fibre, 0.30-0.68% calcium and 0.17-0.39% phosphorus depending on the mung bean material (Sitthigripong *et al.,* 1998).

Forage

Fresh mung bean forage has a moderate (13%) to high (21% DM) protein content. Like other legume straws, mung bean straw is higher in protein (9-12%) than cereal straws.

1.4 Potential constraints

Antinutritional factors

Mung beans contain several antinutritional factors (trypsin inhibitors, chymotrypsin inhibitor, tannins and lectins) (Wiryawan *et al.,* 1997). The amounts of antinutritional factors vary greatly among mung bean types and can be reduced through processing methods such as soaking, cooking or extruding (Lambrides *et al.,* 2006; Mogotsi, 2006; Wiryawan *et al.,* 1997). However, in some cases, these metabolites were found to have no negative effects (Creswell, 1981).

1.4 Ruminants

Seeds

Information on the use of mung beans in ruminants is limited. Mung beans are highly fermentable in the rumen and compare favourably with coconut meal, palm meal (mechanically or solvent extracted) and dried brewer's grains (Chumpawadee *et al.,* 2005). In a comparison of several legume seeds in the Southern Great Plains of the USA, the protein and *in vitro* digestible DM of mung beans indicated that they could be efficient replacements for maize or cottonseed meal in livestock diets, assuming that mung bean could generate enough grain biomass to be cost-effective. Though not as effective as soybean, the mung bean was capable of accumulating useful levels of protein and digestible dry matter under the variable growing conditions of the study (Rao *et al.,* 2009).

Mung bean bran (chuni)

Mung bean chuni was included at 50% of the concentrates offered to buffaloes fed on a rice straw diet. It met maintenance requirements without any adverse effect on nutrient utilization (Krishna *et al.,* 2002).

Forage

Mung bean forage sustained sheep maintenance without adverse effects (Garg *et al.,* 2004). Mung bean straw (haulms) can be used in the same way as other cereal and legume straws. In the highlands of Afghanistan, they are mixed with rice straw and wheat straw to make a bulky component in sheep and goat diets (Fitzherbert, 2007). In a comparison of sheep and goat feeding, mung bean straw was found to be palatable to both species with no deleterious effects on animal health. Reported OM digestibilities were moderate, 56 and 61% in sheep and goats respectively (Khatik *et al.,* 2007). DM digestibility of mung bean straw (64%) fed to ewes *ad libitum* was similar to that of the straws of groundnut, alfalfa and cowpea and higher than that of cajan pea straw (54%). Feeding ewes with mung bean straw increased overall DM intake from 12.6 to 18.9 g/kg LW/day (McMeniman *et al.,* 1988).

Growing pigs

Mung beans are rich in protein, with a high lysine content, but the raw seeds contain antinutritional factors that may limit their use in pigs (Maxwell *et al.,* 1989). Processed seeds have a higher digestibility in growing pigs: extrusion proved to be more effective than cooking or roasting (Canizales *et al.,* 2009). Mung beans used as a supplementary source of lysine could be included at up to 10% in the diets of growing pigs, with weight gains similar to that obtained with maize-soybean-based diets (Maxwell *et al.,* 1989). Inclusion levels were increased up to 30% with specific cultivars (Wiryawan *et al.,* 1997). In finishing pigs, proposed inclusion levels have been lower (6 to 9%) (Maxwell *et al.*, 1986a), though higher rates (up to 16%) were shown to have a little adverse effect on performance (Maxwell *et al.,* 1989).

Sows

Gestating sows were fed up to 16% mung beans without adverse effects on animal performance or litter size (Luce *et al.,* 1988). A 19% dietary inclusion had negative impact on gestating sows, notably a lower weight gain during pregnancy and lower milk production (Maxwell *et al.,* 1986b).

Mung bean by-products

The mung bean meal, a by-product of vermicelli manufacturing, has been tested in pig diets with satisfactory results due to its bulk and fiber content. It could replace up to 75% of the rice bran in pig diets, with older pigs benefiting the most. Higher inclusion rates resulted in higher intakes but were detrimental to the feed conversion ratio (Sitthigripong, 1996). Amino acid supplementation failed to make diets based on this product as efficient as a maize-soybean meal-based diet (Sitthigripong *et al.,* 1998). Mung bean bran (chuni) was included at a 15% level in the rations of finisher crossbred pigs (Ravi *et al.,* 2005).

Forage

Mung bean forage has been assessed with eight other tropical legumes as a potential alternative protein feed for pigs and ranked among the more suitable ones (Bui Huy Nhu Phuc, 2000).

Poultry

Mung bean has a higher energy value than many other legume seeds (Wiryawan *et al.,* 1995). It is a high-value resource for poultry feeds.

Broilers

High levels of mung beans have been tested in young broilers without loss of growth or feed efficiency: up to 40% of mung beans in the diet gave the same performance as the maize-soybean meal-based control diet. Feed efficiency was affected only when the energy level of the diet was not adjusted. There was no effect of raw mung bean on pancreas weight, and boiling mung bean did not increase performance. It can be concluded that no harmful antinutritional factors were present (Creswell, 1981).

Layers

Raw mung beans introduced at 15% or 30% in the diet did not result in reduced egg production or feed efficiency. However, egg production was significantly depressed at a 45% inclusion level. Pelleting diets did not affect the 15% or 30% inclusion rate but positively affected production at the 45% level (Robinson *et al.,* 2001). In all cases, body weight was slightly depressed by the inclusion of mung beans in the diet. The general recommendation is to use mung beans at levels up to 30% in layer diets, provided that the diet is appropriately balanced, especially with amino acids.

Rabbits

Little information is available in the international literature on mung bean utilization in rabbits. In a study where mung beans replaced soybean meal in complete feeds for growing rabbits, mung beans were introduced at up to 24% in the diet without impairing performance. The 10% reduction in growth rate observed at the 32% inclusion rate may be related to the lower protein digestibility attributed to mung beans compared to soybean meal (73 *vs.* 85%) (Amber, 2000).

1.5 Fish

Asian sea bass (*Lates calcarifer*)

Mung beans can be used as a protein source at up to 18% in the diet of Asian sea bass without affecting growth (Eusebio *et al.,* 2000).

Nile tilapia (*Oreochromis niloticus*)

Nile tilapia fry was fed on mung beans as a partial replacer of fish meal. Best results were obtained at 25% fish meal replacement (de Silva *et al.,* 1989).

1.6 Crustaceans

India prawn (*Fenneropenaeus indicus*)

Indian prawns (*Fenneropenaeus indicus*) fed a soybean meal-based diet, where mung beans replaced 9% of the protein, had a significantly lower weight gain, growth rate, and survival rate than those fed the control diet (Eusebio *et al.,* 1998).

Tables of chemical composition and nutritional value

1. Mung bean (Vigna radiata), aerial part, fresh

2. Mung bean (Vigna radiata), straw

3. Mung bean (Vigna radiata), seeds

Tables-1 Mung bean (Vigna radiata), aerial part, fresh

S. No.	Characters	Quantity
	Main analysis	
1	Dry matter	26.9%
2	Crude protein	17.1%
3	Crude fibre	22.5%
4	NDF	28.4%
5	Ether extract	3.0%
6	Ash	11.4%

continue...

7	Gross energy	18.0%
Minerals		
8	Calcium	24.7 g/kg DM
9	Phosphorus	3.4 g/kg DM
Amino acids		
10	Arginine	7.7% protein
11	Histidine	2.1% protein
12	Isoleucine	4.1% protein
13	Leucine	7.7% protein
14	Lysine	4.1% protein
15	Methionine	1.1% protein
16	Phenylalanine	5.2% protein
17	Threonine	4.3% protein
18	Tyrosine	3.6% protein
19	Valine	5.4% protein
Ruminant nutritive values		
20	OM digestibility, ruminants	72.8
21	Energy digestibility, ruminants	69.6
22	DE ruminants	12.5
23	ME ruminants	10.0
Pig nutritive values		
24	Energy digestibility, growing pig	54.9
25	DE growing pig	9.9
26	Nitrogen digestibility, growing pig	59.0

Tables-2 Mung bean (Vigna radiata), straw

S. No.	Characters	Quantity
Main analysis		
1	Dry matter	88.2% as fed
2	Crude protein	9.8% DM
3	Crude fibre	28.2% DM
4	NDF	63.5% DM
5	ADF	39.6% DM
6	Lignin	4.8% DM
7	Ether extract	2.3% DM
8	Ash	9.9% DM
9	Gross energy	17.7 MJ/kg DM
Minerals		
10	Calcium	27.1 g/kg DM
11	Phosphorus	2.0 g/kg DM
Ruminant nutritive values		
12	OM digestibility, ruminants	67.0%
13	Energy digestibility, ruminants	63.4%
14	DE ruminants	11.2 MJ/kg DM
15	ME ruminants	9.1 MJ/kg DM
16	Nitrogen digestibility, ruminants	65.3%

Tables-3 Mung bean (Vigna radiata), seeds

S. No.	Characters	Quantity
Main analysis		
1	Dry matter	90.0% as fed
2	Crude protein	25.8% DM
3	Crude fibre	6.3% DM
4	NDF	15.6% DM
5	ADF	8.5% DM
6	Ether extract	1.9% DM
7	Ash	4.6% DM
8	Starch (polarimetry)	47.0% DM
9	Gross energy	18.7MJ/kg DM
Minerals		
10	Calcium	1.6 g/kg DM
11	Phosphorus	4.5 g/kg DM
12	Potassium	9.6 g/kg DM
13	Magnesium	2.2 g/kg DM
14	Zinc	35 g/kg DM
15	Copper	8 g/kg DM
16	Iron	537 g/kg DM
Amino acids		
17	Alanine	3.6% protein
18	Arginine	5.9% protein
19	Aspartic acid	9.3% protein
20	Cystine	0.8% protein
21	Glutamic acid	13.3% protein
22	Glycine	2.9% protein
23	Histidine	2.5% protein
24	Isoleucine	3.7% protein
25	Leucine	6.8% protein
26	Lysine	6.9% protein
27	Methionine	1.3% protein
28	Phenylalanine	5.3% protein
29	Proline	5.2% protein
30	Serine	4.1% protein
31	Threonine	2.7% protein

continue...

32	Tryptophan	1.3% protein
33	Tyrosine	2.4% protein
34	Valine	4.4% protein
Secondary metabolites		
35	Tannins (eq. tannic acid)	2.3 g/kg DM
36	Tannins, condensed (eq. catechin)	2.3 g/kg DM
Ruminant nutritive values		
37	OM digestibility, ruminants	92.0%
38	Energy digestibility, ruminants	90.2%
39	DE ruminants	16.9 MJ/kg DM
40	ME ruminants	13.6 MJ/kg DM
41	a (N)	62.3%
42	b (N)	17.9%
43	c (N)	0.030 h-1
44	Nitrogen degradability (effective, k=4%)	70%
45	Nitrogen degradability (effective, k=6%)	68%
Poultry nutritive values		
46	AME poultry	13.4 MJ/kg DM
47	TME poultry	14.7 MJ/kg DM

Sucrose: AFZ, 2011; Amber, 2000; Bagchi *et al.,* 1955; Creswell, 1981; Friesecke, 1970; Garg *et al.,* 2002; Gowda *et al.,* 2004; Harmuth-Hoene *et al.,* 1987; Holm, 1971; Lim Han Kuo, 1967; Min Wang *et al.*, 2008; Ranaweera *et al.,* 1981; Ravindran *et al.,* 1994; Robinson *et al.,* 2001; Wiryawan, 1997; Yin *et al.,* 1993

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