Contents list available at Science Letters

Science Letters

journal homepage: http://www.scienceletters.org/

To study about the Taxonomic, Chemical Composition and Nutritional Value in Rice bean (*Vigna umbellate*)

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ARTICLE INFO

Article History
Received 2 January 2020
Revised 17 January 2020
Accepted 6 March 2020
Available Online 7 March 2020

Keywords:
Rice bean (Vigna umbellata)
Azukia umbellata (Thunb.)
OhwiDolichos umbellatus
ThunbPhaseolus calcaratus
Roxb. Vigna calcarata

ABSTRACT

Rice bean (Vigna umbellata (Thunb.) Ohwi and Ohashi) is a tropical to temperate grain legume primarily grown for food, especially in Asia. Rice bean seeds and vegetative parts are also used for fodder. Rice bean is a multipurpose legume, sometimes considered as neglected and underutilized. However, though less important than cowpea, adzuki bean and mung bean, rice bean is a locally important contributor to human nutrition in parts of India and South-East Asia. All parts of the rice bean plant are edible and used in culinary preparations. The dry seeds can be boiled and eaten with rice or they can replace rice in stews or soups. In Madagascar, they are ground to make nutritive flour included in the food for children. Unlike other pulses, rice beans are not easily processed into dhal, due to their fibrous mucilage that prevents hulling and separation of the cotyledons. Young pods, leaves and sprouted seeds are boiled and eaten as vegetables. Young pods are sometimes eaten raw. Rice bean is useful for livestock feeding. The vegetative parts can be fed fresh or made into hay and the seeds are used as fodder. The rice bean straw, the crop residue of the seed harvest, includes the stems, leafy portions, empty pods, and some seeds. Before feeding, the woody portions and soiled or mildewed parts of the straw should be removed. In the marginal hills of Indian, farmers consider rice bean both as a grain and fodder legume and look for dual-purpose landraces. Rice bean is grown for green manure, as a cover crop, and used as a living fence or biological barrier.

1. Introduction

Rice bean originated from Indochina and was probably domesticated in Thailand and neighbouring regions (Tomooka *et al.*, 2011). It is found naturally in India, central China and in the Indochinese Peninsula. It was introduced to Egypt, to the East Coast of Africa and to the islands of the Indian Ocean. It is now cultivated in tropical Asia, Fiji, Australia, tropical Africa, the Indian Ocean Islands as well as in the Americas (USA, Honduras, Brazil and Mexico) (Rajerison, 2006; van Oers, 1989; Khadka *et al.,* 2009). In the middle hills of Nepal, rice bean is cultivated along rice bunds and terrace-margins (Khadka *et al.,* 2009). Though it can thrive in the same conditions as cowpea and can better tolerate harsh conditions (including drought, waterlogging and acid soils), rice bean remains an underutilised legume and there is no breeding programme to improve this crop. Farmers must rely on landraces rather than on cultivars (Joshi *et al.,* 2008). Rice bean is a fast summer-growing legume found from sea level up to altitudes of 1500 m in Assam and 2000 m in the hills of the Himalayas (Khadka *et al.,* 2009). Rice bean requires a short day length to produce seeds. It is grown on a wide range of soils, including shallow, infertile or degraded soils. High soil fertility may hinder pod formation and reduce seed yield (Khadka *et al.,* 2009). *Vigna umbellata* is a versatile legume that can grow in humid subtropical to warm and cool temperate climates. It is suited to areas with annual rainfall ranging from 1000 to 1500 mm but it is also fairly tolerant of drought. It does better in areas where average temperatures range from 18 to 30°C, tolerates 10-40°C but does not withstand frost (Rajerison, 2006; Ecoport, 2014). It prefers full light and its growth can be hampered if it is intercropped with a tall companion. *Vigna umbellata* is a short-lived perennial legume usually grown as an annual. It has a very variable habit: it can be erect, semi-erect or twining. It is usually 30-100 cm in height, but can grow up to 200 cm (Ecoport, 2014). In India and Nepal, rice bean is sown in February and

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DOI: 10.46890/SL.2020.v01i02.005

March for harvest during summer and in July and August for harvest in December (Khanal *et al.,* 2009; Oommen *et al.,* 2002). It can be sown alone in small fields or along bunds of rice terraces. Rice bean benefits from being sown between rows of a tall cereal such as maize or sorghum that it can use for climbing. Rice bean is a hardy plant that is resistant to many pests and diseases, and it does not require fertilizer or special care during growth. In Nepal, farmers clip the tips of the plant to promote pod formation. Rice bean usually matures in 120-150 days after sowing but may need more time at higher altitudes. Seeds are harvested when 75% of the pods turn brown. Harvesting is best done in the morning or late afternoon to reduce the risk of heat-induced shattering. After the harvest, the vines and pods remain on the ground for 2-3 days after which the plants are threshed. The crop residues can then be used as fodder (Khanal *et al.,* 2009).

Common Names

Rice bean, red bean, ricebean, climbing mountain bean, mambi bean, oriental bean (in English); haricot riz (in French); feijao-arroz (in Portuguese); frijol mambe, frijol rojo, frijol de arroz (in Spanish); Reisbonhne (in German); kacang uci (in Indonesian); dau nho nhe (in Vietnamese)

Species

Vigna umbellata (Thunb.) Ohwi and Ohashi (Fabaceae)

Synonyms

Azukia umbellata (Thunb.) Ohwi, *Dolichos umbellatus* Thunb., *Phaseolus calcaratus* Roxb., *Vigna calcarata* (Roxb.) Kurz

Feed categories

1. Legume forages

2. Legume seeds and by-products

3. Plant products and by-products

Related feed(s)

1. Cowpea (*Vigna unguiculata*) seeds
2. Cowpea (*Vigna unguiculata*) forage

Description

Rice bean (*Vigna umbellata* (Thunb.) Ohwi and Ohashi) is a tropical to temperate grain legume primarily grown for food, especially in Asia. Rice bean seeds and vegetative parts are also used for fodder.

Morphology

Vigna umbellata is a short-lived perennial legume usually grown as an annual. It has a very variable habit: it can be erect, semi-erect or twining. It is usually 30-100 cm in height, but can grow up to 200 cm (Ecoport, 2014). It has an extensive root system with a taproot that can go as deep as 100-150 cm. The stems are branched and finely haired. The leaves are trifoliate with entire, 6-9 cm long leaflets. The flowers, born on 5-10 cm long axillary racemes, are papillonaceous and bright yellow. The fruits are cylindrical, 7.5-12.5 cm long pods that contain 6-10 oblong, 6-8 mm seeds with a concave hilum. Rice bean seeds are very variable in colour, from greenish-yellow to black through yellow, brown. Yellow-brownish types are reported to be the most nutritious. The red type gives its common name to the grain in several languages, for example in Chinese (red small bean) (Ecoport, 2014).

Utilisation

Rice bean is a multipurpose legume, sometimes considered as neglected and underutilised (Joshi *et al.,* 2008). However, though less important than cowpea (*Vigna unguiculata*), adzuki bean (*Vigna angularis*) and mung bean (*Vigna radiata*), rice bean is a locally important contributor to human nutrition in parts of India and South-East Asia (Joshi *et al.,* 2008; Tomooka *et al.,* 2011). All parts of the rice bean plant are edible and used in culinary preparations. The dry seeds can be boiled and eaten with rice or they can replace rice in stews or soups. In Madagascar, they are ground to make nutritive flour included in the food for children. Unlike other pulses, rice beans are not easily processed into dhal, due to their fibrous mucilage that prevents hulling and separation of the cotyledons (Rajerison, 2006; Ecoport, 2014; van Oers, 1989). Young pods, leaves and sprouted seeds are boiled and eaten as vegetables. Young pods are sometimes eaten raw (Rajerison, 2006). Rice bean is useful for livestock feeding. The vegetative parts can be fed fresh or made into hay and the seeds are used as fodder. Rice bean straw, the crop residue of the seed harvest, indudes the stems, leafy portions, empty pods, and some seeds (Chaudhuri *et al.,* 1981). Before feeding, the woody portions and soiled or mildewed parts of the straw should be removed (Göhl, 1982). In the marginal hills of Nepal, farmers consider rice bean both as a grain and fodder legume and look for dual-purpose landraces (Khanal *et al.,* 2009). Rice bean is grown for green manure, as a cover crop, and used as a living fence or biological barrier (Ecoport, 2014).

1.1 Forage Management

Establishment and Harvest

In India and Nepal, rice bean is sown in February and March for harvest during summer and in July and August for harvest in December (Khanal *et al.,* 2009; Oommen *et al.,* 2002). It can be sown alone in small fields or along bunds of rice terraces. Rice bean benefits from being sown between rows of a tall cereal such as maize or sorghum that it can use for climbing. Rice bean is a hardy plant that is resistant to many pests and diseases, and it does not require fertilizer or special care during growth. In Nepal, farmers clip the tips of the plant to promote pod formation. Rice bean usually matures in 120-150 days after sowing but may need more time at higher altitudes. Seeds are harvested when 75% of the pods turn brown. Harvesting is best done in the morning or late afternoon to reduce the risk of heat-induced shattering. After the harvest, the vines and pods remain on the ground for 2-3 days after which the plants are threshed.

The crop residues can then be used as fodder (Khanal *et al.,* 2009). In India, late maturing and photo-sensitive landraces of rice bean are cultivated as a fodder crop. They are sown during long-day periods in order to prevent the plant from flowering (Oommen *et al.,* 2002). Dual-purpose varieties may be cut when the pods are half-grown, but the hay should be handled as little as possible because the leaves drop easily (Göhl, 1982).

Seed Yield

The seed yield of rice bean is about 225 kg/ha worldwide (Duke, 1981). It can, however, vary from 200-300 kg/ha in West Bengal to 1300-2750 kg/ha in Zambia, Brazil and India (Chandel *et al.,* 1988; Chatterjee *et al.,* 1977).

Forage Yield

In Bengal (India), fodder yields were reported to range from 5-7 t DM/ha in May and June, to 8-9 t DM/ha in November and December (Chatterjee *et al.,* 1977). Lower values have been reported: 5-6 t DM/ha in Myanmar (Tin Maung Aye, 2001), and 2.9 t DM/ha in the sub-humid Pothwar plateau of Pakistan (Qamar *et al.,* 2014). In India, rice bean grown with Nigeria grass (*Pennisetum pedicellatum*) yielded 7.6 t DM/ha after the application of 20 kg N/ha (Chatterjee *et al.,* 1977). In Pakistan, rice bean grown with sorghum (50:50 mix) yielded up to 12 t DM/ha (Ayub *et al.,* 2004).

1.2 Environmental Impact

Green Manure and Cover Crop

Rice bean is an N-fixing legume that improves the N status of the soil, thus providing N to the following crop. Its taproot has a beneficial effect on soil structure and, when ploughed in, returns organic matter and N to the soil. Rice bean grown before or after a rice or maize crop is beneficial. In Thailand, it is profitably sown between the rows of maize once the crop has reached maturity, but before harvest so that rice bean covers enough soil at harvest. It is then possible to harvest the rice bean, thresh to obtain the seeds and bring the dry plants back to the field where they provide soil cover for the dry season (Echo AIC, 2012). In the Thai highlands, rice bean is a valuable green manure, which outcompetes other legumes such as *Canavalia ensiformis*, *Lablab purpureus* and *Mimosa diplotricha* in their ability to improve rice yields (Chaiwong *et al.,* 2012). In China, rice bean used as green manure in tangerine orchards resulted in higher fruit yields than soybean (*Glycine max*), mung bean (*Vigna radiata*) and cowpea (*Vigna unguiculata*) (Wen MingXia *et al.,* 2011).

1.3 Nutritional Attributes

Rice Bean Forage

Data on the composition of rice bean forage is scarce. Like other legume forages, fresh rice bean forage is relatively rich in protein, though its concentration is extremely variable (17-23% DM). Rice bean hay and straw are slightly less nutritious (16 and 14% protein in the DM, respectively). Rice bean forage is also rich in minerals (10% of the DM in the fresh forage), and particularly in calcium (up to 2% in the fresh forage). Rice bean straw contains large amounts of mineral matter (more than 20% of DM) though it is highly variable.

Rice Bean Seeds

Rice bean seeds are rich in protein (18-26% DM), though generally less than pea (*Pisum sativum*) or cowpea (*Vigna unguiculata*). They contain limited amounts of fibre and fat (about 4 and 2%, respectively). The amino acid profile is comparable to that of other grain legumes: it is relatively rich in lysine (more than 6% of the protein) but poor in sulphur-containing amino acids. Rice beans have a high starch concentration, with reported values ranging from 52 to 57% of the DM (Kaur *et al.,* 1990; Chavan *et al.,* 2009). The amylose content of the starch is extremely variable, from 20 to 60% (Kaur *et al.,* 2013).

1.4 Potential Constraints

Rice Bean Forage

Rice bean forage contains variable amounts of condensed tannins (0.1-2.8% DM) (Wanapat *et al.,* 2012; Chanthakhoun *et al.,* 2010).

Rice Bean Seeds

Like many grain legumes, rice bean seeds contain antinutritional factors. Antitrypsin activity is notable though comparable to that of cowpea (*Vigna unguiculata*) and black gram (*Vigna mungo*). Hemagglutinin activity was found to be lower than that of the two latter legumes (Malhotra *et al.,* 1988). Relatively low levels of phenols and phytic phosphorus have been reported (Gupta *et al.,* 1992).

Ruminants

Rice bean fodder (fresh, hay and straw) and rice bean seeds can be fed to ruminants.

Palatability

Rice bean forage at the pre-flowering stage is palatable to sheep (Chandel *et al.,* 1988). In Nepal, farmers have emphasized the softness and palatability of rice bean fodder for livestock (Joshi *et al.,* 2008). In an experiment with rice bean hay in India, bullocks consumed it hesitantly at first, but within a few days the animals grew accustomed to it and DM consumption increased, indicating that the hay was palatable (Gupta *et al.,* 1981). Rice bean straw was reported to be relished by cattle (Gohl, 1982).

Fresh Rice Bean forage

In India, 22 month-old calves fed a mixture of fresh Sudan grass (*Sorghum × drummondii*) and rice bean forage (54:46 fresh basis) for 64 days had a DM intake of 1.90 kg DM/100 kg LW and a daily weight gain of 456 g/d (Singh *et al.,* 2000). In India, 22 month-old calves fed a mixture of fresh Sudan grass (*Sorghum × drummondii*) and rice bean forage (54:46 fresh basis) for 64 days had a DM intake of 1.90 kg DM/100

kg LW and a daily weight gain of 456 g/d (Singh *et al.,* 2000).

Rice bean hay

Rice bean hay is generally used as a protein source to supplement poor quality roughage-based diets in ruminants.

Dairy cows

In Thailand, rice bean hay supplementing a Congo grass (*Brachiaria ruziziensis*)-based dairy cow diet increased milk yield and decreased feed cost, resulting in higher farmer income. Rice bean hay supplementation did not alter rumen volatile fatty acid (VFA) production, or increase diet digestibility and intake (Wanapat *et al.,* 2012).

Other cattle

In India, a trial with bulls showed that rice bean hay had a moderate OM digestibility (50%) but that it contained nitrogen, calcium and phosphorus in adequate amounts to meet the maintenance needs of adult cattle (Gupta *et al.,* 1981). In Vietnam, a mixture of cassava hay and rice bean hay (3:1 ratio) replaced 60% of concentrate in a forage-based diet (*Pennisetum purpureum* + urea-treated rice straw) offered to growing crossbred heifers, resulting in higher daily weight gain (609 g/d), better feed efficiency and reduced feed costs (Thang *et al.,* 2008).

Buffalo

In Thailand, rice bean hay included at 600 g/d to supplement rice straw in diets for swamp buffalo increased DM intake, digestible protein and N retention. It had a positive effect on rumen microflora, resulting in increased VFA production and lower CH_4 emissions (Chanthakhoun *et al.,* 2011). Adding rice bean hay was reported to increase cellulolytic rumen bacteria, thus improving the utilization of high fibrous feeds in buffalo diets (Chanthakhoun *et al.,* 2010).

Goats

In India, supplementing local goats fed grass with rice bean hay (15% of diet DM) did not increase grass intake, but total DM intake and nutrient digestibility were increased. Increasing the level of rice bean level above 15% had no further effect on digestibility (Das, 2002).

Rice bean straw

In India, a trial with bullocks showed that rice bean straw had a low OM digestibility (31-47%) and it was recommended to supplement a rice straw-based diet with energy-rich feed materials, such as cereal grains or bran (Chaudhuri *et al.,* 1981).

Rice bean seeds

In India, rice bean seeds are fed to buffalo calves and sheep to provide energy. Rice beans replaced half the cereals and half the deoiled cake present in the concentrate offered to buffalo calves (Ahuja *et al.,* 2001). In sheep, replacing 50% of the metabolizable energy from oat hay by rice bean seeds had no deleterious effect on sheep N balance, which remained positive (Krishna *et al.,* 1989).

Poultry

Rice beans are rich in protein but contain trypsin inhibitors and other anti-nutritional factors that limit their use in poultry feeding. Raw rice beans fed to broilers at 20 or 40% of the diet exhibited adverse effects on growth. Roasted rice beans gave better results and were included at 40% without hampering performance, but weight gain was lower than with the control diet (Gupta *et al.,* 1992).

1.5 Rabbits

Rice bean forage

Several experiments in India have compared rice bean forage favourably with other locally available fodders. A comparison of rice bean forage, pea forage and stylo (*Stylosanthes hamata*) fed *ad libitum* to adult rabbits concluded that rice bean forage could be fed at up to 25% (DM basis) of the diet (Gupta *et al.,* 1993). A comparison of rice bean forage with leaves of two Indian trees, amliso (*Thysanolaena latifolia*) and nevaro (*Ficus* spp.), included at 30% (DM) in the diet of growing rabbits resulted in higher growth from the rice bean (Bharat Bushan *et al.,* 1997). In a comparison of rice bean forage, Congo grass (*Brachiaria ruziziensis*) and groundnut leaves fed at 300 g/d to growing rabbits for 6 weeks, all production and feeding measurements were best in the group fed rice bean forage (Das *et al.,* 2004).

Tables of chemical composition and nutritional value

1. Rice bean (*Vigna umbellata*), aerial part, fresh

2. Rice bean (*Vigna umbellata*), hay

3. Rice bean (*Vigna umbellata*), straw

4. Rice bean (*Vigna umbellata*), seeds

Tables-1 Rice bean (*Vigna umbellata*) aerial part fresh

S. No.	**Characters**	**Quantity**
Main analysis		
1	Dry matter	21.4% as fed
2	Crude protein	19.0% DM
3	Crude fibre	30.8% DM
4	NDF	59.7% DM
5	ADF	38.9% DM
6	Ether extract	1.8% DM
7	Ash	10.4% DM
8	Gross energy	18.3 MJ/kg DM
Minerals		
9	Calcium	15.2 g/kg DM
10	Phosphorus	3.5 g/kg DM

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11	Magnesium	3.6 g/kg DM
12	Zinc	88 mg/kg DM
13	Copper	30 mg/kg DM
14	Iron	1523 mg/kg DM
Secondary metabolites		
15	Tannins, condensed (eq. catechin)	0.9 g/kg DM
Ruminant nutritive values		
16	OM digestibility, ruminants	64.4%
17	Energy digestibility, ruminants	61.6%
18	DE ruminants	11.3 MJ/kg DM
19	ME ruminants	8.9 MJ/kg DM

Sucrose: Chandel *et al.,* 1988; Gowda *et al.,* 2004; Gupta *et al.,* 1996; Lim Han Kuo, 1967; Qamar *et al.,* 2014 and Wanapat *et al.,* 2012

Tables-2 Rice bean (*Vigna umbellata*), hay

S. No.	**Characters**	**Quantity**
Main analysis		
1	Crude protein	15.6% DM
2	Crude fibre	30.2% DM
3	NDF	51.2% DM
4	ADF	30.7% DM
5	Ether extract	4.6% DM
6	Ash	9.9% DM
7	Gross energy	18.8 MJ/kg DM
Minerals		
8	Calcium	13.1 g/kg DM
9	Phosphorus	2.6 g/kg DM
Secondary metabolites		
10	Tannins, condensed (eq. catechin)	28.0 g/kg DM
Ruminant nutritive values		
11	OM digestibility, ruminants	50.7%
12	Energy digestibility, ruminants	47.4%
13	DE ruminants	8.9 MJ/kg DM
14	ME ruminants	7.1 MJ/kg DM
15	Nitrogen digestibility, ruminants	65.2%

Sucrose: Chanthakhoun *et al.,* 2010 and Gupta *et al.,* 1981

Tables-3 Rice bean (*Vigna umbellata*), straw

S. No.	**Characters**	**Quantity**
Main analysis		
1	Crude protein	13.6% DM
2	Crude fibre	26.3% DM
3	Ether extract	1.4% DM
4	Ash	22.2% DM
5	Gross energy	15.5 MJ/kg DM
Minerals		
6	Calcium	29.1 g/kg DM
7	Phosphorus	1.2 g/kg DM
Ruminant nutritive values		
8	OM digestibility, ruminants	38.7%
9	Energy digestibility, ruminants	35.5%
10	DE ruminants	5.5 MJ/kg DM
11	ME ruminants	4.4 MJ/kg DM
12	Nitrogen digestibility, ruminants	50.8%

Sucrose: Chaudhuri *et al.,* 1981

Tables-4 Rice bean (*Vigna umbellata*) seeds

S. No.	**Characters**	**Quantity**
Main analysis		
1	Dry matter	91.1% as fed
2	Crude protein	21.0% DM
3	Crude fibre	4.0% DM
4	NDF	23.5% DM
5	Ether extract	2.3% DM
6	Ash	4.3% DM
7	Starch (enzymatic)	54.2% DM
8	Gross energy	18.5 MJ/kg DM
Minerals		
9	Calcium	
10	Phosphorus	4.1 g/kg DM
11	Potassium	3.4 g/kg DM
12	Sodium	23.4 g/kg DM
13	Magnesium	0.7 g/kg DM
14	Manganese	2.4 g/kg DM
15	Zinc	11 mg/kg DM
16	Copper	8 mg/kg DM
17	Iron	5 mg/kg DM
18	22 mg/kg DM	

continue...

Amino acids		
19	Alanine	4.6% protein
20	Arginine	5.5% protein
21	Aspartic acid	11.9% protein
22	Cystine	1.0% protein
23	Glutamic acid	15.7% protein
24	Glycine	4.0% protein
25	Histidine	2.9% protein
26	Isoleucine	4.4% protein
27	Leucine	7.3% protein
28	Lysine	6.8% protein
29	Methionine	1.0% protein
30	Phenylalanine	5.7% protein
31	Proline	4.0% protein
32	Serine	4.4% protein
33	Threonine	4.0% protein
34	Tryptophan	0.9% protein
35	Tyrosine	3.2% protein
36	Valine	4.5% protein
Secondary metabolites		
37	Tannins (eq. tannic acid)	7.1 g/kg DM
38	Tannins, condensed (eq. catechin)	9.8 g/kg DM
Ruminant nutritive values		
39	OM digestibility, ruminants	59.9%
40	Energy digestibility, ruminants	58.0%
41	DE ruminants	10.7 MJ/kg DM
42	ME ruminants	8.7 MJ/kg DM
43	Nitrogen digestibility, ruminants	68.9%
Poultry nutritive values		
44	TME poultry	8.7 MJ/kg DM
45	TMEn poultry	7.7 MJ/kg DM

Sucrose: Yamazaki *et al.,* 1988, Tiwari *et al.,* 2006, Kalidass *et al.,* 2012 and Katoch *et al.,* 2013.

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