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Nutritional Potentials and Nutrient Profile of Fenugreek (*Trigonella foenum-graecum* L.)

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A B S T R A C T

Fenugreek (*Trigonella foenum-graecum* L.) is an important seed spice crop and is largely grown in India. It grows well under diverse and a wide range of conditions; with moderate tolerance to drought and salinity. Fenugreek also has an exceptional nutritional and pharmaceutical profile. Fenugreek seeds contain a substantial amount of fiber, phospholipids, glycolipids, oleic acid, linolenic acid, linoleic acid, choline, vitamins A, B1, B2, C, nicotinic acid, niacin and many other elements. The micronutrients perform various essential roles in the body. It is, therefore, essential to ensure that the diet must include the recommended dietary allowance of the micronutrients. Commercially, it has high economic value as food, fodder and medicine. Its leaf and seed is used to prepare extract and powder for medicinal and cosmetic purpose. The knowledge about the nutrient diversity of different genotypes is very important for broaden the genetic base, heterotic pooling and reduction of genetic erosion. The review on nutritional potentials and nutrient profile will give insight into morphological parameters and source sink relationship to formulate sound breeding programme for qualitative and quantitative improvement of fenugreek.

Introduction

India is a major producer of fenugreek and also a major consumer of it for its culinary uses and medicinal application. Majority of the Indian population belongs to vegetarian class. In such a situation, fenugreek is of utmost importance due to its high nutritive value, medicinal importance and industrial uses. It is used in functional food, traditional food, nutraceuticals as well as in physiological utilization such as antibacterial, anticancer, antiulcer, antioxidant and anti-diabetic agent.

It is being commercially grown in India, Pakistan, Afghanistan, Iran, Nepal, Egypt, France, Spain, Turkey, Morocco, North Africa, Middle East and Argentina (Flammang *et al.*, 2004; Altuntas *et al.*, 2005). In India its cultivation is concentrated mainly in Rajasthan, which has share of 83 per cent of the total fenugreek production in the country (Anon, 2013). In India, during 2017-18 fenugreek was cultivated in an area of 220 thousand hectares with production of 311 thousand MT and productivity of 1.4 MT (Anon, 2018).

Fenugreek (*Trigonella foenum-graecum* L.) is an annual plant with leaves consisting of three small obovate to oblong leaflets. The species name "*foenum-graecum"* means "Greek-hay" indicated its use as a forage crop in the past (Petropoulos, 2002).

In India and other countries of the Mediterranean region, it is primarily used as a spice crop (Acharya *et al.,* 2008) to the flavour and nutritive value of food**.** Its fresh tender leaves and stems are consumed as curried vegetable. Commercially, it has high economic value as food, fodder and medicine. For medicinal and cosmetic purpose, its leaf and seed is used to prepare extract and powder. The leaves both fresh and dried are used in meat curries and several vegetable dishes.

Morphological description and origin

It is an annual herb belonging to the family fabaceae. It is a self-pollinated diploid species with chromosome number of 2n = 16 (Frayer, 1930). Fenugreek is a dicotyledonous crop with light green, pinnately trifoliate leaves (Srinivasan, 2006) and yellow-white papilionaceous flowers. It has two types of flowers-cleistogamous (closed type) and aneictogamous (open type). It blooms with white to yellowish white, axillary and sessile flowers that are hermaphrodite and insect pollinated.

Flowers have 5 petals referred as banner, wing and keel. The inflorescence is racemose and flowers are pedicellate, complete, bisexual and hypogynous. Fruits are legumes, long narrowed, curved, tapering with a slender point and containing small deep furrowed seeds. Fenugreek has two species of economic importance viz., *T. foenum graecum* (common methi) and *T. corniculata* (kasuri methi). Common methi has semi-erect, tall and moderately branched plants while kasuri methi has bushy green and medium sized plants. Common methi has white flowers with straight pods and is large seeded type while kasuri methi has yellow to orange flowers with sickle shaped pods and is small seeded type (Malhotra 2003). Fenugreek flower produces brownish to yellowish brown _15 cm long 2–8 pods. Each pod contains 10–20 seeds per pod; seeds are small (_5 mm long), hard, smooth, dull yellow to brownish yellow in color (Altuntas *et al.*, 2005; Moradi kor and Moradi, 2013).

It is considered to have originated in the Mediterranean Region of the "Old World" (Vavilov, 1926) or in part of Asia (De Candolle, 1964). It is a native of South Eastern Europe and Western Asia. It is extensively grown in the tropical and sub-tropical regions of India during winter season for its seeds, tender shoots and fresh leaves. Traditionally, it is consumed as fresh vegetable and as a spice to add flavor to the Indian cuisines. Fenugreek is gaining importance around the world due to its rare medicinal properties (Sharma *et al.*, 1990)

Climatic requirement and cultivation

Fenugreek has a wider adaptability and is grown under wide range of climatic conditions. It requires cool climate and can tolerate frost and freezing weather. During early stage the crop requires low temperature for its better vegetative growth, while for better ripening and high seed production it needs a dry and relatively high temperature. It can be grown on a wide range of soils but clay loam is relatively better. The optimum soil pH should be 6.0 to 7.0 for its better growth and development. Sowing in the plains is generally taken up in September to November while in the hills, it is grown from March. Approximately 20 to 25 kg of seed is required for one hectare. Line sowing is advocated in rows at 20 to 25 cm apart which

facilitates the intercultural operations. Fenugreek requires 5–10 days for germination while the first trifoliate leaf appears 5–8 days after germination. It is a fast growing plant and it requires a fair amount of sunlight. Fenugreek needs four to seven months to reach maturity (Petropoulos, 2002).

Nutritional and medicinal potentials

Fenugreek also has an exceptional nutritional and pharmaceutical profile. Fenugreek leaves and shoots are quite rich in protein, iron, calcium, carotene and ascorbic acid (Farooqi *et al.,* 2003) as well as minerals and vitamins (Rao and Sharma, 1987). Hundred gram of fenugreek seeds contain protein 6.3g, fat 9.5g, carbohydrates 42.3g, volatile oil 7g, vitamin A 1040 IU and calorific value of 370 cal. Fenugreek seed oil is golden yellow in colour having disagreeable odour, bitter taste and is insoluble in ether. Its seeds contain a substantial amount of fatty acids which consists largely of oleic, linoleic and linolenic acids. Dry seeds of fenugreek have been reported to contain 7.5% total lipids, 84.1% neutral lipids, 5.4% glycolipids and 10.5% phospholipids (Hemavathy and Prabhakar 1989). Its seed is also an important source of galactomannans which represents 50% of the seed weight (Raghuram *et al.,* 1994). The galactomannan is a polysaccharide having high water binding capacity and a soluble fraction of fiber (Srinivasan, 2006), which exhibit hypoglycemic activity. Also its seeds have commercial importance due to presence of saponins viz. diosgenin, tigogenin, yamogenin and gitogenin (Taylor *et al.,* 1997) and presence of 4 to 8% saponins along with 1% alkaloid i.e. *Trigonelline* led to bitter taste of the seeds (Fatima *et al.,* 2018)

Fenugreek seeds are a rich source of fiber (50–65 g/100 g) mainly non-starch polysaccharides (Table 1; Montgomery, 2009). Medicinally, fenugreek fiber is capable of moderating the human glucose metabolism. Moreover, mucilage, tannins, pectin and hemicellulose inhibit bile salt absorption in the colon and hence facilitate low density lipoprotein-cholesterol (LDL) reduction in blood. It binds the toxins of food and indirectly protects intestinal epithelial membrane from onset of cancer. Moreover, it helps to lower the blood glucose absorption and control sugar level, and thus facilitates the insulin action. Galactomannans constitute the major portion of soluble fiber in seeds that lower glucose absorption in body. Seed gum consists of mannose and galactose that gives high viscosity to an aqueous solution (Youssef *et al.,* 2009). Being rich in flavonoids and phenolic compounds fenugreek possesses anti-inflammatory, anti-carcinogenic, antioxidant, antiviral and hypotensive property (Moradi kor and Moradi, 2013).

Fenugreek seed is a rich source of vitamins viz. vitamin A, B1, B2, C, nicotinic acid and niacin (Table 2). Germinating seeds contain biotin, calcium pantothenate, pyridoxine, vitamin C and cyanocobalamine. However, exposure to b and c radiations significantly reduces the vitamin contents (Leela and Shafeekh, 2008). Its leaves also contain vitamins, but on boiling, steaming or frying, 7–11% of them may be lost.

Nutrient profile

Majority of the Indian population belongs to vegetarian class. In such a situation, a leafy vegetable, such as fenugreek, is of utmost importance due to its high nutritive value, medicinal importance, and industrial uses. Recent researches (Nasroallah and Moradi, 2013) have identified fenugreek as a valuable medicinal plant with a potential for multipurpose uses and also as a source for preparing raw materials of pharmaceutical industry, especially steroidal hormones.

Fenugreek seeds contain a fair amounts of steroidal sapogenin with diosgenin as major one which has great demand in pharmaceutical industry for production of steroidal drugs and sex hormones as well as in making oral contraceptives (Jayadev *et al.,* 2004). Its commercial preparations are quite popular in India. It has potential to fight against dandruff and can be used as hair conditioner (Table 2).

Fenugreek seeds contain fair amount of Sulfur, phosphorus (El Nasri and El Tinay, 2007) and calcium (Jani *et al.,* 2009) (Table 3).

The fenugreek extract has been investigated for its chemical composition and found that raw seeds of fenugreek contained higher amount of dietary fiber (46.50%) than soaked seeds (42.12%) and germinated seeds (32.50%). The level of dietary fiber, reducing sugars, non-reducing sugars and total soluble sugars decreased by soaking while improved protein content and starch digestibility and minerals availability improved. Further, it is observed that germinated seeds had significantly higher amount of protein and lysine than unprocessed seeds of fenugreek. However germination reduced the dietary fiber and starch content while improved the sugar level in fenugreek seeds (Hooda and Jood, 2003)

Jain *et al.,* (2007) investigated photosynthesis and nutrient composition of spinach and fenugreek grown under elevated carbon dioxide concentration and found that the content of iron in leaves of fenugreek varies from 2.39 to 3.59 µg/g, after exposure to CO_2 concentration at different intervals. Ca increased in the leaves of both the vegetables under ECO_2 (elevated carbon dioxide concentration) but the increase was more in fenugreek, *i.e.*, 48, 57 and 28.4 %, respectively at 40, 60 and 80 DAE as compared to spinach. The Fe content of the leaves significantly declined in the leaves of the plants grown under ECO_2 and such decline in the concentration of important micronutrient Fe in the leaves may affect the nutritional quality of the vegetables in the future high CO_2 world.

Shakuntala *et al.,* (2011) reported that the protein percentage of germinated endosperm, sprouts and ungerminated endosperm of fenugreek were 39.25%, 36.12% and 48.20%, respectively. However insoluble and total dietary fibres were recorded 55.80% and 86.96% in germinated seed coat, whereas 31.90% and 77.10% respectively in ungerminted seed coat. Further through Atomic Absorption Spectroscopy (AAS) analysis they observed that all the fractions showed overall differences in their mineral contents viz. Fe, Cu, Mn, Zn, Ca, Mg and K.

Al-Jasass and Al-Jasser (2012) conducted an experiment on chemical composition and fatty acid content of some spices and herbs viz. mustard, black cumin, cress seeds, clove, black pepper and fenugreek. They reported that mustard, black cumin, and cress seeds had high amount of fat and protein content than fenugreek. Crude fiber content varied from 6.36 to 23.6% while ash content ranged from 3.57 to 7.1%. Further they reported that seeds of all the spices and herbs showed high amount of potassium (383 to 823 mg/100g), calcium (75 to 270 mg/100g), magnesium (42 to 102 mg/100g) and iron (20.5 to 65 mg/100g) whereas low levels of zinc, manganese and copper. Singh *et al.,* (2013) in a study on variability in nutraceutical properties of fenugreek revealed that chemical constituents of seeds of various fenugreek genotypes viz. Saponin, protein, moisture %, ash, fiber, Zn, Fe, Mn, and Mg contents differed considerably and such variability should not be overlooked or underestimated in research trials. It suggested that the genetic

variability for such useful chemical components plays a significant role in enhancement of nutraceutical potential of fenugreek.

Table.1 Crude or proximate composition of fenugreek seeds and leaves

Particulars	Contents (g/100 g)	References
Carbohydrates	42.3	El Nasri and El Tinay (2007)
Gum (seeds)	20.9	Kakani *et al.*, (2009)
Ash (seeds)	3.38	Sowmya and Rajyalakshmi (1999)
Fiber (seeds)	50.0	Montgomery (2009)
Fiber (leaves) **Soluble** **Insoluble**	 0.7 4.2	 Altuntas *et al.*, (2005) Altuntas *et al.*, (2005)
Dietary fiber	48.0	Brummer *et al., (*2003)
Fats (seeds)	7.9	El Nasri and El Tinay (2007) Montgomery (2009)
Fats (leaves)	1.0	Montgomery (2009)
Protein (seeds)	25.4	El Nasri and El Tinay (2007)
Protein (leaves)	4.4	Montgomery (2009)
Moisture (seeds)	7.49	Sowmya and Rajyalakshmi (1999)
Moisture (leaves)	86.0	Sowmya and Rajyalakshmi (1999)

Table.2 Vitamins profile and their respective concentrations in fenugreek

Particulars	Plant part	Units	Value/100 g	References
Vitamin C	seed	Mg	12-43	Leela and Shafeekh (2008) Srinivasan (2006)
Vitamin C	Leaves	Mg	52.0	Srinivasan (2006)
Vitamin B1	seeds	Mg	0.41	Leela and Shafeekh (2008)
Vitamin B2	seeds	Mg	0.36	Leela and Shafeekh (2008)
Vitamin B6	seeds	Mg	0.600	USDA (2011)
Vitamin A,	seeds	IU	60-100	Leela and Shafeekh(2008) USDA (2011)
Niacin	seeds	Mg	6.0	Leela and Shafeekh (2008)
Nicotinic Acid	seeds	Mg	1.1	1 Leela and Shafeekh (2008)
Nicotinic Acid	Leaves	µg	800	Srinivasan (2006)
β-carotene	Leaves	mg	2.3	Srinivasan (2006)
β-carotene	seeds	µg	96	Srinivasan (2006)
Thiamine	Leaves	µg	40	Srinivasan (2006)
Thiamine	seeds	µg	340	Srinivasan (2006)
Riboflavin	Leaves	µg	310	Srinivasan (2006)
Riboflavin	Seeds	µg	290	Srinivasan (2006)
Folic acid	seeds	µg	84	Srinivasan (2006)

Table.3 Mineral contents (mg/100 g) of fenugreek seeds (Reported by Al Jasass and Al Jasser, 2012)

Minerals	mg/100 g of fenugreek seed extract
Potassium (K)	603.0± 15.0
Magnesium (Mg)	42.0± 5.0
Calcium (Ca)	75.0± 9.0
Zinc (Zn)	2.4± 0.2
Manganese (Mn)	0.9± 0.1
Cupper (Cu)	0.9± 0.1
Iron (Fe)	25.8± 1.2

Pathak and Agarwal (2014) studied 13 genotypes of fenugreek collected from different places in India. They observed significant differences in the content of iron, zinc and copper though the amount of magnesium and calcium was not significantly different between the genotypes ($p<0.05$). Mineral content was quantified by atomic absorption spectrophotometer. The iron content ranges from 5.89 ±. 01 µg /gm to 89.04 ± 0.07 µg /gm and zinc and copper content ranged from 25.4 ±. 02 µg /gm to 68.05 ±. 02 µg /gm and from 2.49 ± 1.42 µg /gm to 12.51 ±. 82 µg /gm, respectively. The lowest content of iron was found in cultivated genotype LFC 105 while highest content was reported in PRM 45. The lowest and highest copper content was found in UM 365 from Jobner, Rajasthan and LFC 105 from Pantnagar, Uttarakhand respectively. It was observed that the iron content was approximately more in the genotypes that were grown at Pantnagar as compared to those grown at Rajasthan. The results indicate that fenugreek genotypes cultivated at different locations exhibited variation in the content of mineral elements.

A research work on the dried samples of common methi leaves and kasuri methi for their potential for use as nutraceuticals was conducted. The common methi leaves and kasuri methi showed to be good sources of protein. While both the samples are excellent sources of Calcium, Magnesium, Potassium, Phosphorus and moderate sources of Zinc, kasuri methi has a slightly richer amount of iron as compared to common methi leaves. The samples revealed good amounts of alkaloids followed by moderate amounts of saponins. Total phenolics and flavonoids contents were obtained for methanolic and aqueous solvent extracts for each of the samples Antioxidant activity of the extracts was estimated using ABTS scavenging assay and FRAP assay (Pasricha and Gupta, 2014)

Agrawal *et al.*, (2015) conducted an experiment on physico-chemical properties of fenugreek seeds and revealed that raw seeds of fenugreek had 7 % fat, 23.30 % protein and 3 % ash content while germinated fenugreek seeds possessed 6.24 % fat, 24.12 % protein and 3.14 % ash. Hence raw seeds had comparatively higher fat content while germinated seeds have higher protein and ash content. Buba *et al.*, (2015) in an study on physico-chemical properties of fenugreek seeds found that the average value of ash and protein contents were 2.99±0.48% and 2.74±0.35% respectively while fat 6.33±0.52% and carbohydrate 77.04±0.63% in fenugreek seeds.

Gharneh and Davodalhosseini (2015) determined the nutrient content in seven fenugreek genotypes. Several minerals content like (P, K, Ca, Mg, Na, Fe, Mn, Zn

and Cu) were measured. Results showed that the levels of P ranged from 182 to 250 mg/100 gram fresh weight. The Gaz genotype had the highest content of Na and Fe while the highest content of Mg and Mn were observed in genotype Kashan (370.1 and 0.87 mg/100 gfw, respectively). The highest Zn and Cu content were identified in genotype Ardestan (4.1 and 2.5 mg/100 g, respectively).

Bhatnagar and Azhar (2016) studied ash content and other chemical composition such as water, iron, and total vitamin C content of 22 green leafy vegetables, collected from different places of Fatehpur district. The ash content of fenugreek leaves recorded 10.30 ± 0.3 g/100g of dry vegetable powder. Giridhar *et al.,* (2016) evaluated yield and diosgenin content in thirteen genotypes of fenugreek to identify the promising fenugreek genotypes and they observed that LFC-103 had highest yield followed by HM-348. They further reported that the diosgenin content in the studied genotypes varied significantly and UM-364 was recorded with highest diosgenin productivity followed by NDM-119.

Dilshad (2017) conducted an experiment on physicochemical properties of chemurgic-fenugreek herb of different origin and found that Yemen seed showed higher values of moisture (5.47 ± 0.66), oil (7.04 ± 0.21) and total phenolic (18.52 ± 1.80) content while Egyptian seed recorded with higher ash content along with sodium, iron and copper. Among the minerals, calcium and magnesium were the most abundant minerals followed by potassium and sodium in all the samples studied.

Nisha and Rao (2018) on the basis of their study on variability analysis in ten fenugreek varieties for mineral content reported that all the studied varieties had significant variation in micronutrient content. Also GM-2 had highest Iron (2.97±0.14 mg/g) and magnesium (17.68 ±0.15 mg/g) content while highest copper (10.13± 0.18 mg/g) content recorded in RMT-351 and zinc (2.85±0.16 mg/g) in RMT -303.

An experiment on nutritional potentials in twenty-eight genotypes of fenugreek was conducted and recorded significant variation among the investigated genotypes for protein, Saponin P, K, Fe, Mn, Zn and Cu content. Their research findings also revealed that PFG-35 had highest potassium (1207 mg/100g), PFG- 28 had highest zinc (4.43 mg/100g), PFG-26 had highest copper (1.97 mg/100g) content. However, PFG-20 was richest in phosphorus, iron and manganese content and for protein content (29.60 %), PFG-39 ranked first. They reported that the saponin content in fenugreek seeds varied from 0.38 g/100g to 1.31 g/100g (Naula *et al.,* 2018)

Pant *et al.,* (2018) evaluated micronutrient content in 25 fenugreek genotypes and reported that RMt-143 had highest iron (184.11±1.639 µg/g dry wt.), calcium (781.20±4.790 µg/g dry wt.) and manganese content (25.65±0.695 µg/g dry wt.). They further observed a significant positive correlation of iron content with other micronutrients viz., calcium, zinc and manganese. The research findings revealed significant variation among the investigated fenugreek genotypes. Among all the studied genotypes, Pant Ragini, Pusa Early Bunching, RMt-305, RMt-143, IC-066843, GM-2 and HM-355 found with higher micronutrients and dietary antioxidants and hence these can be used as potential source of dietary micronutrients to fight against micronutrient malnutrition.

In conclusions the fenugreek herb, seeds, powder, and extracts are known to possess several nutritional and medicinal properties.

Fenugreek nutritional potential and nutrient profile has been discussed in this review. From this review it can be concluded that Fenugreek seeds contain a substantial amount of fiber, phospholipids, glycolipids, oleic acid, linolenic acid, linoleic acid, choline, vitamins A, B1, B2, C, nicotinic acid, niacin and many other functional elements. Based on various past reported scientific findings, fenugreek can be recommended and must be taken as a part of our daily diet as its liberal use is safe and various health benefits can be drawn from this natural herb. The above-mentioned studies on fenugreek suggest that the nutritional characteristics of fenugreek can be exploited further in the development of healthy products and development of nutrient rich varieties through biofortification. Nutrient rich germplasm can be use in varietal development and more specifically in biotechnologically facilitated breeding.

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