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Nutritional potentials of fenugreek (*Trigonella foenum-graecum* L.) Genotypes: Chemical characterization

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Abstract
Fenugreek (*Trigonella foenum-graecum* L.) is known for its medicinal, aromatic, antibacterial and nutritional qualities. Nutrient content of seeds varied among genotypes but not with fertility practices, suggesting that germplasm selection could lead to production of nutrient-rich varieties. The crop was raised at Pantnagar Centre for Plant Genetic Resources, during rabi season 2015-16. The nutrient, protein and Saponin content of twenty-eight genotypes of fenugreek were determined. Nutrient content namely P, K, Fe, Mn, Zn and Cu, protein and Saponin varied significantly among different genotypes. Maximum potassium content was observed in PFG-35(1207 mg/100g). PFG-37and PFG-20 was richest in phosphorus, iron and manganese content among all genotypes. The lowest zinc content was found in PFG-26 (1.19 mg/100g), while the maximum zinc content was observed in PFG- 28 (4.43 mg/100g). Highest content of copper was found in PFG-26 (1.97 mg/100g). PFG-39 has the highest protein content (29.60 %). Saponin content ranged from 0.38 g/100g to 1.31 g/100g.

Keywords: fenugreek, genotypes, macronutrients, micronutrient, protein and seed

Introduction

Among vegetables, leafy vegetables represent inexpensive but high quality nutritional sources, for the poor segment of the population especially where malnutrition is wide spread as in India. Fenugreek is becoming popular around the world with its medicinal and nutraceutical properties. Fenugreek (*Trigonella foenum-graecum* L.) is an annual herb belonging to the legume family. The tender green leaves of fenugreek are consumed as a vegetable while the seed are used as spice. Fenugreek originated from the Mediterranean areas and is widely cultivated in Asia and Africa and occasionally in Europe. Recent researchers 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.

Protein, macro and microelements influence biochemical processes in the human organism (Bronus and Vermeer, 2000) [6]. Minerals are also an important part of a balanced diet. It is, therefore, essential to ensure that the diet must include the recommended dietary allowance of the micronutrients. Collection and Characterization of genotypes is crucial to variety release programme and in the coming times of WTO regime for the registration of the genotypes/cultivars. Until a collection has been properly evaluated, it has little practical use. (Chang, 1976) [7].

Characterization should eventually lead to a system of recording and storing useful data that can be readily retrieved and made available to others and help in planning breeding programme. Practically a variety must be distinct, uniform and stable in the characters that are adopted for use in varietal characterization and identification. The fenugreek is tremendous diverse in respect to nutrient content. Gene banks posses' scanty germplasm and very little background information regarding its genetic variability that has hampered its improvement.

Due to the lack of information about the nutritional values of fenugreek genotypes, this study was conducted to determine the nutrients and Saponin content of twenty eight fenugreek genotypes. The ultimate goal of research would be to enhance better food selection and consequently improve the nutritional status of both the rural and urban dweller.

Material and Methods

Twenty-eight genotypes of fenugreek, collected from different parts of India (table1), were grown under *tarai* conditions during winter season of 2015-16. The crop was raised in the field in Randomized Block Design with two checks in three replications. The suggested package of practices was followed to grow a fenugreek crop. The seeds of fenugreek genotypes were collected after harvest and stored for further analysis. Research was carried out at G. B. Pant University of Agriculture & Technology, Pantnagar (Uttarakhand). The climate of the area is humid and subtropical with maximum temperature ranging from 32^0 to 43^0C in summer and minimum temperature ranging from 4.8^0 to 13.6^0C in winter. To estimate macronutrient and micronutrient content, the nitric acid and hydrogen peroxide used were of analytical grade.

Analysis of Micronutrients: take seeds and dry them at 60^0C and then at 75^0C till weight becomes constant. Grind the seed sample in a Wiley Mill. Take one gram of finely ground powdered seed into150 ml conical flask and add 10 ml concentrated HNO3 to each flask and keep overnight while covering the mouth then heat the flask for 30 min on hot plate. After cooling add 10 ml 4: 1 of nitric and perchorlic acids and digest at 40^0C till completion of digestion. First brown fumes of nitric acids evolve and towards end of digestion white fumes of perchorlic acids evolve. A semi-solid viscous material of light brownish colour bottom towards the end of digestion. It usually takes 1-2 h for completion of digestion. In no case full drying should be allowed as there may be chance of volatilization loss of some nutrients. If the samples are likely to be charred then add another 10 ml of HNO3 and digest it again. When the digestion is successfully over, remove the conical flask from hot plate and cool it and adds 5 ml of 6 N HCL along with few ml of water. Gently boil the contents and transfer them to 100 ml volumetric flask and make up the volume. The diluted samples were filtered and stored for further analysis. The quantitative estimation of macronutrient i.e. P and K was done by using spectrophotometer and flame photometer and micronutrients was done using atomic absorption spectrophotometer. Protein content was estimated by instrument Rapid N Cube Analyser which provides directly the information amount of protein in per cent. The quantity of Diosgenin in samples was determined as described by Baccou *et al*. (1977) [3] and Uematsu *et al*. (2000) [15]. The statistical analysis has been done. The mean values of micronutrients of each genotype were compared using ANOVA to find the presence or absence of significant difference in the nutrient content.

Result and Discussion

The analysis of variance for various characters is presented in table 2. Highly significant differences among the genotypes were obtained for all the characters namely, P content, K content, Fe content, Mn content, Zn content and Cu content, protein content and diosgenin content. The result of the analysis of the fenugreek genotypes is presented Figure 1.It showed that these genotypes are potentially endowed with essential nutrients required for maintenance of good human health.

Phosphorus is the second most abundant mineral in the body, after calcium. Phosphorus is an essential mineral primarily used for growth and repair of body cells and tissues. There was a significant difference among all the genotypes for phosphorus content. Phosphorus content ranged from 133 to 1500 mg/100g. PFG-37 (*Trigonella corniculata* L.) has the highest phosphorus content (1500 mg/100g) followed by Pant Ragini (1200 mg/100g) and PFG-29, PFG-32 (1100 mg/100g) whereas minimum phosphorus content was found in Pusa Early Bunching (133 mg/100g). Rest genotype showed intermediate phosphorus content (table 3). The results were in partial agreement with Ali *et al*. (2012) [2].

Potassium is pivotal to heart function and plays a major part in skeletal and smooth muscle contraction, making it crucial for normal digestive and muscular function. Potassium content ranged from 149 to 1207 mg/100g (table 3). PFG-35 has the highest potassium content (1207 mg/100g) followed by PFG-15(1189 mg/100g) and PFG-33 (1182 mg/100g) whereas minimum potassium content was found in PFG-39 (149 mg/100g). Rest genotype showed intermediate potassium content. The similar results were also observed by Ali *et al*. (2012) [2]. The results were in partial agreement with findings of Jasass *et al.* (2012) [10].

Iron is an important mineral as it performs several important functions such as being a component of enzymes involved in energy production, metabolism of proteins, nucleotides as well as in synthesis of proteins and neurotransmitters. Data revealed that iron content ranges from 24.58 to 07.66 mg/100g (table 3). Highly significant differences among the genotypes for iron content were observed. PFG-37 (*Trigonella corniculata* L.) has highest content of iron (24.58 mg/100g) followed by PFG-20 (*Trigonella corniculata* L.) (22.82 mg/100g), whereas minimum iron content was found in PFG-1 (07.66 mg/100g) followed by PFG-15 (07.81 mg/100g). Rest genotypes showed intermediate iron content. It has been found that vitamin C enhance the potential of iron for mucosal uptake. The recommended dietary allowance of iron was 18 mg. Iron deficiency was a commonly encountered problem prevalent in female population. To alleviate the iron deficiency, the supplementation with iron capsules was not enough as the absorption of iron was also a major factor. Fenugreek is also rich in vitamin C (12mg/100g).Therefore consumption of fenugreek can be a good remedy for iron deficiency control as it will promote bioavailability. The findings are in accordance with the findings of Bhatt and Singh (2015) [5]. The results are also in partial agreement with Gharneh *et al*. (2015) [8].

Manganese plays a role in fat and carbohydrate metabolism, calcium absorption and blood regulation. Manganese is also necessary for normal brain and nerve function. Manganese is an essential mineral nutrient for lignin, amino acid biosynthesis, CO2 assimilation and nitrogen metabolism (Jhanji *et al.*, 2014) [11]. The Manganese content ranged from 0.30 to 14.05 mg/100g (table 3). PFG- 37 (*Trigonella corniculata* L.) has highest content of manganese (14.05 mg/100g) followed by PFG- 20 (*Trigonella corniculata* L.) (13.10 mg/100g). The minimum manganese content was found in PFG-22(0.30 mg/100g) followed by PFG-15 (1.73 mg/100g). Rest genotypes showed intermediate manganese content. The results are in consonance with Bhatt and Singh (2015) [5]. The findings are in accordance with the findings of Pathak and Agrawal (2014) [12].

Zinc content ranged from 1.19 to 4.43 mg/100g (table 3). Highest content of zinc was found in PFG- 28 (4.43 mg/100g) followed by PFG- 27 (4.40 mg/100g). Whereas minimum zinc content was in PFG-26 (1.19 mg/100g) followed by Pusa Early Bunching (1.77 mg/100g). Rest genotypes showed intermediate zinc content. Zinc is vital for the immune system. Zinc also prevents night blindness and prevents

development of cataract. Singh *et al*. (2013) [13], Bhatt and Singh (2015) [5] and Gharneh *et al*. (2015) [8] also have the similar results for zinc content.

Variation in copper content ranged from 1.97 to 0.32 mg/100g (table 3). PFG-26 exhibited highest content of copper (1.97 mg/100g) followed by PFG-25 (1.85 mg/100g). Pant Ragini has minimum copper content (0.32 mg/100g) followed by PFG-24 (0.33 mg/100g). It is involved in the formation of the cells of the immune system and it also maintains proper structure and function of circulating blood vessels. Similar results have been reported by Bhatt and Singh (2015) [5] and with the Gharneh *et al*. (2015) [8] the results were in partial agreement for copper content.

Proteins are one of the building blocks of body tissue, and can also serve as a fuel source. Protein can be found in all cells of the body and is the major structural component of all cells in the body, especially muscle. Fenugreek seed was reported to be rich in protein with a well balanced amino acid pattern. Highly significant differences among all the genotypes were observed for protein content. PFG-39 has the highest protein content (29.60 %) followed by PFG-30 (29.51%) and Pusa Early Bunching (28.49 %) whereas minimum protein content was found in PFG- 25(20.20 %). Rest genotype showed intermediate protein content (table 3). The results are in accordance with Balai *et al*. (2006) [4], Singh *et al*. (2007) [14], Hora *et al*. (2013) [9]. The results are also in partial findings of Singh *et al*. (2013) [13].

Highly significant differences were observed for Saponin content among all the genotypes of fenugreek (table 3). The Saponin content varied from 0.38 g/100g to 1.31 g/100g. PFG-36 has the highest content of diosgenin (1.31g/100g) followed by PFG-17 (1.28g/100g) whereas minimum Saponin content was found in PFG-32 (0.38g/100g) then PFG-24 (0.40g/100g). Rest genotypes showed intermediate Saponin content. Similar results observed in fenugreek by, Arivalagan *et al.* (2013) [1].

From this study, the fenugreek genotypes were highly variable for several nutritional traits, indicating the possibilities for genetic improvement of the fenugreek via selection and cross breeding. The varying traits of the superior genotypes have implications for further breeding work. Thus, the variation for the different traits found in fenugreek genotypes included in this investigation could be exploited and used in fenugreek breeding programs. However, regarding all of the measured traits, genotype PFG-37, PFG-20, PFG-26, PFG-28 and PFG-35 were the most favourable genotypes considering mineral elements. There are clear implications from the variations among the most favourable genotypes in this study that will provide a basis for a genetically diverse breeding program and provide diversity. Crossing these favourable genotypes in a breeding program should result in segregating populations which could be useful for selecting good nutritional genotypes and could be useful for selecting specific cultivars for special purposes.

Table 1: List of genotypes of fenugreek

S. No.	Genotypes	Source	S. No.	Genotypes	Source
1.	PFG-1	PCPGR, Pantnagar	15.	PFG-28	Rudrapur, Uttarakhand
2.	PFG-11	PCPGR, Pantnagar	16.	PFG-29	Dineshpur, Uttarakhand
3.	PFG-12	PCPGR, Pantnagar	17.	PFG-30	Bareilly, Uttar Pradesh
4.	PFG-15	PCPGR, Pantnagar	18.	PFG-31	Lucknow, Uttar Pradesh
5.	PFG-17	PCPGR, Pantnagar	19.	PFG-32	Allahabad, Uttar Pradesh
6.	PFG-18	PCPGR, Pantnagar	20.	PFG-33	Allahabad, Uttar Pradesh
7.	PFG-20 *kasuri methi*	PCPGR, Pantnagar	21.	PFG-34	Gaya, Bihar
8.	PFG-21	PCPGR, Pantnagar	22	PFG-35	Gaya, Bihar
9.	PFG-22	Golapar, Uttarakhand	23.	PFG-36	Gaya, Bihar
10.	PFG-23	Sitarganj, Uttarakhand	24.	PFG-37	Gaya, Bihar
11.	PFG-24	Kotabagh, Uttarakhand	25.	PFG-38	Uttarkashi, Uttarakhand
12.	PFG-25	Kiccha, Uttarakhand	26.	PFG-39	Dehradun, Uttarakhand
13.	PFG-26	Nainital, Uttarakhand	27.	Pant Ragini*	G.B.P.U.A.T, Pantnagar
14.	PFG-27	Ramnagar, Uttarakhand	28.	Pusa Early* Bunching	New Delhi

*checks

Table 2: Analysis of variance (ANOVA) for different characters in fenugreek genotypes

Source	d.f	P (mg/100g)	K (mg/100g)	Protein (%)	Fe (mg/100g)	Mn (mg/100g)	Zn (mg/100g)	Cu (mg/100g)	Protein (%)	Saponin content(g/100g)
Replication	2	157975.7	470.00	0.39	0.056	0.02	0.73	0.04	0.39	0.016
Treatment	27	314920.6**	391056.4**	18.55**	66.41**	26.04**	2.55**	0.79**	18.55**	0.21**
Error	54	9457.69	177.18	0.26	0.20	0.03	0.35	0.22	0.26	0.0076

** Significant at 1% level

Table 3: Nutrient and Saponin content in different genotypes of fenugreek

Genotypes	Protein (%)	P (mg/100g)	K (mg/100g)	Fe (mg/100g)	Mn (mg/100g)	Zn (mg/100g)	Cu (mg/100g)	Saponin (g/100g)
PFG-22	22.76 ± 0.17	500 ± 0.001	476 ± 0.07	14.70 ± 0.26	0.30 ± 0.02	3.10 ± 0.05	1.15 ± 0.001	0.46 ± 0.0
PFG-23	25.33 ± 0.57	566 ± 0.001	513 ± 0.02	9.06 ± 0.02	3.93 ± 0.04	2.70 ± 0.04	0.63 ± 0.006	0.59 ± 0.06
PFG-24	24.25 ± 0.31	500 ± 0.001	270 ± 0.05	14.66 ± 0.02	7.78 ± 0.01	4.30 ± 0.18	0.33 ± 0.009	0.40 ± 0.03
PFG-25	20.20 ± 0.01	433 ± 0.001	609 ± 0.06	19.21 ± 0.28	2.60 ± 0.02	1.85± 0.02	1.85 ± 0.006	0.48 ± 0.04
PFG-26	26.25 ± 0.07	333 ± 0.001	378 ± 0.02	17.41 ± 0.27	3.14 ± 0.02	1.19± 0.02	1.97 ± 0.012	0.48 ± 0.04
PFG-27	25.53 ± 0.42	633 ± 0.001	1089 ± 0.02	15.90 ± 0.11	3.07 ± 0.01	4.40 ± 0.18	1.23 ± 0.019	0.73 ± 0.03
PFG-28	24.46 ± 0.26	900 ± 0.001	1110 ± 0.17	21.74 ± 0.46	5.13 ± 0.06	4.43 ± 0.12	1.35 ± 0.015	0.72 ± 0.02
PFG-29	27.55 ± 0.14	1100 ± 0.001	1120 ± 0.08	18.31 ± 0.63	5.26 ± 0.06	4.28± 0.04	1.34 ± 0.015	0.54 ± 0.03
PFG-30	29.51 ± 0.42	800 ± 0.001	1167 ± 0.05	21.08 ± 0.34	5.33 ± 0.06	4.29 ± 0.31	1.72 ± 0.023	0.42 ± 0.02

PFG-31	24.41 ± 0.29	600 ± 0.001	1157 ± 0.11	19.59 ± 0.16	3.61 ± 0.08	3.90± 0.10	1.14 ± 0.015	0.42 ± 0.01
PFG-32	26.22 ± 0.32	1100 ± 0.001	1181 ± 0.10	20.69 ± 0.03	4.41 ± 0.02	4.22 ± 0.16	1.83 ± 0.009	0.38 ± 0.03
PFG-33	26.51 ± 0.16	766 ± 0.001	1182 ± 0.11	21.18 ± 0.06	3.82 ± 0.04	3.39 ± 0.12	1.18 ± 0.02	0.57 ± 0.03
PFG-34	25.12 ± 0.31	366 ± 0.001	360 ± 0.01	21.73 ± 0.33	4.51 ± 0.07	2.89± 0.06	0.49 ± 0.01	0.50 ± 0.02
PFG-35	24.96 ± 0.12	733 ± 0.001	1207 ± 0.14	16.49 ± 0.14	4.68 ± 0.03	3.63 ± 0.09	1.68 ± 0.02	0.45 ± 0.05
PFG-36	22.22 ± 0.09	333 ± 0.001	830 ± 0.05	16.63 ± 0.17	3.01 ± 0.02	2.67± 0.09	0.40 ± 0.02	1.31 ± 0.18
PFG-37	26.58 ± 0.22	1500 ± 0.001	1102 ± 0.12	24.58 ± 0.09	14.05 ± 0.22	2.47 ± 0.04	0.38 ± 0.04	0.48 ± 0.05
PFG-38	27.94 ± 0.33	333 ± 0.001	648 ± 0.13	20.48 ± 0.17	4.11 ± 0.28	4.00± 0.02	1.30 ± 0.006	0.59 ± 0.04
PFG-39	29.60 ± 0.38	1000 ± 0.001	149 ± 0.01	12.32 ± 0.05	4.75 ± 0.04	3.56 ± 0.15	0.59 ± 0.006	0.55 ± 0.04
Pant Ragini	27.66 ± 0.03	1200 ± 0.001	367 ± 0.02	15.27 ± 0.02	4.22 ± 0.02	3.57 ± 0.01	0.32 ± 0.01	0.90 ± 0.03
Pusa Early Bunching	28.49 ± 0.43	133 ± 0.001	1174± 0.03	13.26 ± 0.04	3.15 ± 0.08	1.77 ± 0.03	1.73 ± 0.09	0.41 ± 0.03
PFG-1	23.27 ± 0.26	300 ± 0.001	627 ± 0.15	07.66 ± 0.09	1.74 ± 0.03	3.51 ± 0.04	0.89 ± 0.01	0.94 ± 0.02
PFG-11	24.96 ± 0.18	800 ± 0.001	529 ± 0.01	20.07 ± 0.48	2.17 ± 0.01	4.04 ± 0.04	0.74 ± 0.009	0.86 ± 0.03
PFG-12	25.40 ± 0.52	466 ± 0.001	177 ± 0.01	13.26 ± 0.03	1.94 ± 0.03	2.62 ± 0.02	0.61 ± 0.01	0.46 ± 0.04
PFG-15	20.38 ± 0.13	333 ± 0.001	1189 ± 0.02	07.81 ± 0.03	1.73 ± 0.01	2.24 ± 0.03	0.64 ± 0.01	1.12 ± 0.04
PFG-17	22.28 ± 0.23	333 ± 0.001	456 ± 0.03	20.70 ± 0.03	3.78 ± 0.08	3.34 ± 0.04	0.79 ± 0.009	1.28 ± 0.12
PFG-18	21.57 ± 0.05	800 ± 0.001	521 ± 0.02	8.85 ± 0.01	1.63 ± 0.02	2.29 ± 0.02	0.64 ± 0.02	0.69 ± 0.03
PFG-20	23.81 ± 0.42	800 ± 0.001	753 ± 0.10	22.82 ± 0.39	13.10 ± 0.25	2.84 ± 0.04	1.01 ± 0.003	0.76 ± 0.04
PFG-21	26.45 ± 0.36	600 ± 0.001	726 ± 0.08	17.11 ± 0.47	3.11 ± 0.02	3.38 ± 0.02	0.84 ± 0.012	0.55 ± 0.03

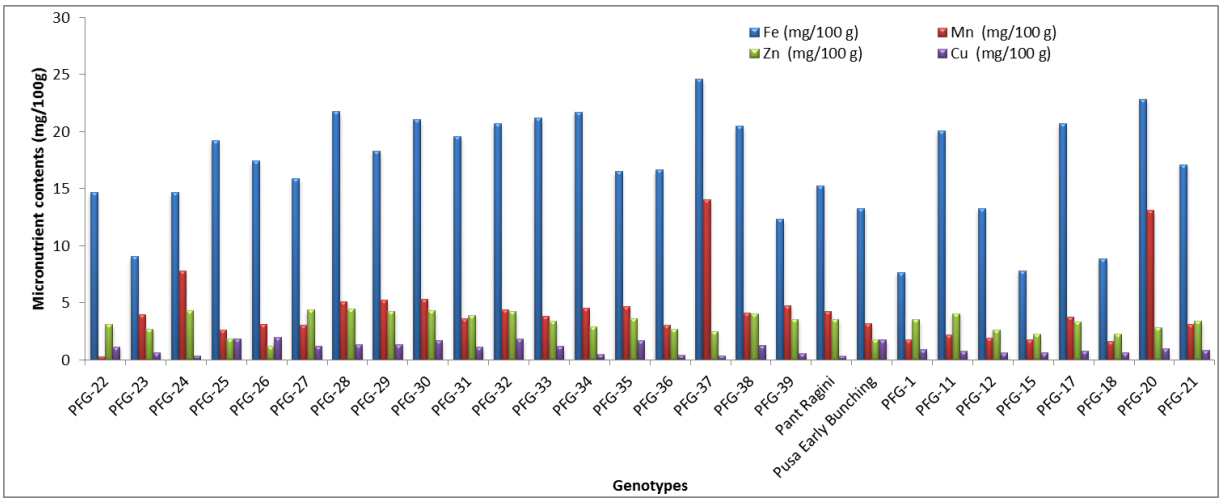

Fig 1: Variation in nutrient content in different genotypes of fenugreek

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