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Assessment of nutritional quality parameters in selected vegetable type pigeonpea genotypes

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Abstract

Sixteen genotypes of vegetable-type pigeonpea (*Cajanus cajan* L. Millsp.) were evaluated for nutritional quality so as to identify promising genotypes. The average content of total carbohydrate content at the green and the matured stage was found to be 50.2 mg/100 g and 57.1 mg/100 g respectively. The mean values proteins contents were 19.8 mg/100 g in the green stage and 22.3 mg/100 g in the mature stage. The average Calcium contents were 92.3 mg/100 g in the green stage and 110.7 mg/100 g in the mature stage. The mean values Iron content, Manganese content and Zinc content were found to be 5.2 mg/100 g at the green and 5.0 mg/100 g matured stage, 1.2 mg/100 g in the green stage and 1.3 mg/100 g in the mature stage and 2.9 mg/100 g in the green stage and 2.7 mg/100 g in the mature stage respectively. Overall nutritional status is that the genotypes showed a higher amount of protein, starch, manganese and calcium at the grain stage whereas the green stage legumes had higher amounts of minerals viz., iron and zinc. Clustering analysis based on nutritional quality in all sixteen genotypes resulted into a grouping of genotypes into a total of 4 clusters based on Gower's similarity coefficient. The genotypes were clustered into two major clusters viz. cluster-I and cluster- II. The cluster-I included fourteen genotypes and divided further into A and B sub-clusters. The sub-cluster A again divided into sub-sub-clusters a1 and sub-sub-cluster a2.

Keywords: Pigeonpea, Nutritional quality, Genotypes, Dendrogram

Introduction

Food legumes are of prime importance in human diet and animal feed contributing the major source of vegetable protein. They are an economic source of not only protein but of carbohydrate, minerals and B-complex vitamins particularly in a vegetarian diet (Salunkhe *et al.*, 1985) and hence correctly called as poor man's meat (Heiser 1990). Legumes are called the multi-purpose plants as apart from being used as food for humans, they are also used as animal feed, improve Physical, Chemical, and Biological properties of the soil and function as mini- nitrogen factories. Pulses are equally important for maintaining soil health and sustainability of different cropping systems. By virtue of being a restorer of soil fertility, pulses have a unique position in cropping systems and dry land rainfed agriculture. On an average, pulses contain 20-25 percent of protein in their dry seeds, which is almost 2.5-3.0 times the value normally found in cereals. Thus, the food legumes ensure nutritional security to the poor masses of the country (Chaturvedi and Ali, 2002). Legumes consumption is important in the prevention of chronic diseases such as cancer and heart disease as they contain phytochemicals that combat oxidative stress in the body and helps to maintain a balance between oxidants and antioxidants (Khyade and Jagtap 2016). Keeping the importance of legumes and pulses in view, the year of 2016 has been declared as "International Year of Pulses" by the Food and Agricultural Organisation of United Nations with the slogan Nutritious seeds for a sustainable future (IYP, 2016).

Pigeonpea is one of the major pulse crops of dry land agriculture because of its deep tap root system and inherent drought resistance. Its ability to produce a high amount of biomass per unit area makes it useful as fodder and for thatching for the rural masses. Large quantities of foliage drop add to the organic matter of the soil.

Vegetable pigeonpea (at the R₆ stage) is a good source of protein, vitamins (A, C B complex), minerals (Ca, Fe, Zn, Cu) carbohydrates and dietary fibers in comparison to green peas (*Pisum sativum*). The anti-nutritional factors like phytolectines are also present in pigeonpea, but it is heat sensitive and destroyed during cooking. The vegetable pigeonpea has five times more beta-carotene content, three times more thymine, riboflavin and niacin content, double vitamin C content. The pigeonpea seeds at R₆ stage (for the vegetable purpose) are considered superior to pigeonpea seeds at R₈ stage (for *dal*) in general nutrition.

The observations recorded at ICRISAT and some other laboratories show that pigeonpea *dal* is better than a vegetable with respect to starch and protein (Table 1). On the contrary, the pigeonpea grains at R₆ stage have higher crude fiber, fat, and protein digestibility. As far as trace and mineral elements are concerned, the green peas are superior in phosphorus by 28.2%, potassium by 17.2%, zinc by 48.3%, copper by 20.9%, and iron by 14.7%. In addition to protein, pigeonpea provides carbohydrates and 5-fold higher levels of Vitamin A and C. Pigeonpea seeds are known to be rich in proteins (generally varying from 18 to 25% and as high as 32%), carbohydrates and minerals. Likewise, the seeds are rich in sulfur-containing amino acids, methionine and cysteine. Its abundance of protein makes it an ideal supplement to traditional cereal, banana or tuber-based diets of poor farmers that are generally protein deficient (Sharma *et al.*, 2011). The information about the nutritional potential of pigeonpea both at R₆ and R₈ stages are lacking so the present investigation was carried out to evaluate the nutritional potential of pigeonpea genotypes at both the stages.

Material and Methods

Plant material

The sixteen germplasm lines of pigeon pea for the vegetable purpose were acquired from the germplasm maintained at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola and different sources (Table 2) for the present investigation.

Experimental design and setting the experiment

A field experiment was conducted at the experimental farm of Agricultural Botany, Dr. P.D.K.V, Akola, Maharashtra, India. Field experiments were laid out in a randomized complete block design (RCBD) with three replications. The spacing of row to row and plant to plant was of 90 × 20 cm. Seeds were sown using drill method during *Kharif*- 2016. The fertilizers were applied at the rate of 25 Kg N, 50 Kg P₂O₅ and 30 Kg K₂O per hectare at the time of sowing. Fertilizers were applied in the form of urea, single super phosphate and murrate of potash. As flowering initiated, 2-3 irrigations were provided as per requirement. Harvesting was done as per maturity of the genotypes.

Data collection

Five plants from each replicate were randomly selected for various traits at grain and mature stages. Qualitative characters *viz.*, protein, total sugar and oil content were estimated from all genotypes of each replication. Micro-nutritional traits *viz.*, calcium, iron, zinc, and manganese were analyzed using the Atomic Absorption Spectrophotometer at R₆ and R₈ stages.

Carbohydrate analysis

Carbohydrate (starch) content of seeds from pods harvested at green stage and at maturity was determined using Anthrone reagent test. The principle behind it is when the sample is treated with 80% alcohol, the sugars are removed and the starch is extracted with perchloric acid. In a hot acidic medium, starch is hydrolyzed to glucose and dehydrated to hydroxyl methyl furfural. This compound forms a green coloured product with anthrone (Sengar and Chaudhary, 2014).

Protein content

The protein content of seeds from pods harvested at green stage and at maturity was determined using Folin-Lowry's

method (Sengar and Chaudhary, 2014). The principle behind it is the aromatic amino acids (tyrosine and tryptophan) present in the proteins react with phosphomolybdic acid and tungstate present in Folin-Ciocalteu reagent and form a blue coloured complex which can be measured spectrophotometrically at 660 nm.

Macro and Micro-nutritional traits analysis

Calcium was analyzed by titration with EDTA- Ethylene Diamine Tetraacetic acid using Sodium hydroxide buffer and Calcon indicator. The principle behind it is EDTA is a powerful ligand and forms a stable metal complex with many metals at different pH and the nutrients can be analyzed by using a standard indicator.

The micronutrients contents *viz.* Iron, zinc, and manganese content present in the seeds at green stage and grain stage were measured using the Atomic Absorption Spectrophotometer (AAS). The readings from Atomic Absorption spectroscopy were multiplied with dilution factor and readings were recorded in milligram

Table 1: Comparison of green pigeonpea seeds and *dal* for important quality constituents

Constituent	Green Seed	<i>Dal</i>
Starch content (%)	48.4	57.6
Protein (%)	21.0	24.6
Protein digestibility (%)	66.8	60.5
Soluble sugar (%)	5.1	5.2
Crude fiber (%)	8.2	1.2
Fat (%)	2.3	1.6

Adopted from Saxena *et al.* (2010)

Table 2: List of 16 genotypes of vegetable pigeonpea and their sources

No.	Genotypes	Source
1	AKTM-11-06	Dr. PDKV, Akola
2	AKTM-11-07	Dr. PDKV, Akola
3	AKTM-11-10	Dr. PDKV, Akola
4	AKTM-11-11	Dr. PDKV, Akola
5	AKTM-11-12	Dr. PDKV, Akola
6	AMAR	CSAUAT, Kanpur, U.P.
7	AZAD	CSAUAT, Kanpur, U.P.
8	BAHAR	Bihar
9	BDN-2004-2	Badnapur, M.S.
10	BDN-716	Badnapur, M.S.
11	CORG-9701	TNAU, T.N.
12	ICPL-151	ICRISAT, Hyderabad
13	GT-100(check)	Navsari Agri. University, Gujarat
14	PKV-TARA(check)	Dr. PDKV, Akola
15	SKN-0632	Badnapur
16	AKTM-1644	Dr. PDKV, Akola

of nutrient per 100 gram of seed (mg/100 g). The basic principle behind this process is AAS is based on the principle that when atomic vapors of an element are irradiated by the radiation of a characteristic wavelength (i.e. the light from a source whose emission lines are those of the element in question), they absorb in direct proportion to the concentration of the element being determined.

Statistical analysis for nutritional traits

All the nutritional traits were analyzed using the online analysis resource-OPSTAT-HAU. The significance was given by the F-Test and the genotypes were ranked using the critical difference at 1%.

Hierarchical cluster analysis, based on Gower's similarity

coefficient was carried out using software XLSTAT 2017 ver19.02.01.44037.

Result and Discussion

Carbohydrate content

Carbohydrates are the primary energy sources for the human body. Starch and sugars are the major forms of energy sources for the body. In the pigeonpea genotypes, Total carbohydrate content ranged between 48.0 mg/100 g to 60.30 mg/100 g. The highest carbohydrate content was observed in the mature stage of AKTM-1644 (60.30 mg/100 g) and the lowest carbohydrate content was found in green stage of AMAR (48.0 mg/100 g). The mean values were 50.2 mg/100 g in the green stage and 57.1 mg/100 g in the mature stage. Similar results were reported by Saxena *et al.* (2010).

Protein content

Proteins are building blocks of human body needed for growth, development and body repair cells. In the pigeonpea genotypes, protein content ranged between 15.6 mg/100 g to 29.0 mg/100 g. The highest protein content was observed in the mature stage of AKTM-11-06 (29.0 mg/100 g) and the lowest protein content was found in green stage of CORG-9701 (15.6 mg/100 g). The mean values were 19.8 mg/100 g in the green stage and 22.3 mg/100 g in the mature stage. Similar results were reported by Patil *et al.* (2015).

Calcium content

Calcium is the most important plentiful mineral found in the human body which helps in maintaining strong bones and teeth, blood clotting, neurotransmission, muscular movements, hormonal activities and maintaining a normal heartbeat (U.S. National Library of General Medicine). Among the pigeonpea genotypes, calcium content ranged between 89.5 mg/100 g to 118.6 mg/100 g. The highest calcium amount was observed in the mature stage of BDN 2004-2 (118.6 mg/100 g) and lowest calcium content was found in green stage of AMR (89.5 mg/100 g). The mean values were 92.3 mg/100 g in the green stage and 110.7 mg/100 g in the mature stage. Similar reports were given by Saxena *et al.* (2010) and Patil *et al.* (2015).

Iron content

Iron is an essential mineral as it is needed for hemoglobin

synthesis and its deficiency causes iron-deficiency anemia which is a common problem in women and children (U.S. National Library of General Medicine). In the pigeonpea genotypes, iron content ranged between 4.0 mg/100 g to 6.3 mg/100 g. The highest iron content was observed in green stage of BAHAR (6.3 mg/100 g) and the lowest iron content was found in the matured stage of GT-100 (4.0 mg/100 g). The mean values were 5.2 mg/100 g in the green stage and 5.0 mg/100 g in the mature stage. Similar results were reported by Saxena *et al.* (2010).

Manganese content

Manganese is a mineral that is found in several foods including nuts, legumes, seeds and leafy vegetables. Deficiency of manganese leads to osteoporosis and other illnesses. In the present study pigeonpea genotypes showed manganese content ranging from 0.6 mg/100 g to 2.2 mg/100 g. The highest manganese content was observed in green stage of AKTM-11-11 (2.2 mg/100 g) and the lowest manganese content was found in the mature stage of AKTM 11-07 (0.6 mg/100 g). The mean values were 1.2 mg/100 g in the green stage and 1.3 mg/100 g in the mature stage. Similar observations were reported by Singh *et al.* (1984).

Zinc content

Zinc is an important trace mineral needed for the body's immune system, cell division, wound healing and sense of smell and taste. Pigeonpea genotypes had zinc content ranged between 3.6 mg/100 g to 0.8 mg/100 g. The highest zinc content was observed in green stage of AZAD and ICPL-151 (3.6 mg/100 g) and the lowest zinc content was found in the mature stage of AKTM-11-07 (0.8 mg/100 g). The mean values were 2.9 mg/100 g in the green stage and 2.7 mg/100 g in the mature stage. Similar results were reported by Saxena *et al.* (2010) and Patil *et al.* (2015).

The overall nutritional composition is mentioned in Table 3. Overall nutritional status is that at the grain stage the genotypes showed a higher amount of protein, starch, manganese and calcium. The increase in protein and starch may be due to the fact that the simple amino acids and simple sugars are converted to

Table 3: Nutritional composition of pigeonpea genotypes

Sr. No.	Genotypes	Zinc (mg/100 g)		Manganese (mg/100 g)		Iron (mg/100 g)		Calcium (mg/100 g)		Carbohydrate (g/100 g)		Protein (g/100 g)	
		Green	Mature	Green	Mature	Green	Mature	Green	Mature	Green	Mature	Green	Mature
1	AKTM-11-06	2.3	3.0	1.3	1.3	5.4	5.6	90.7	109.3	49.8	55.1	24.0	29.0
2	AKTM-11-07	2.5	0.8	1.1	0.6	4.5	4.3	90.2	107.7	48.2	55.4	18.8	19.1
3	AKTM-11-10	2.7	2.4	1.5	1.5	5.5	4.5	92.9	110.4	48.6	55.3	22.4	27.2
4	AKTM-11-11	2.9	2.3	1.2	2.2	5.4	5.0	91.2	112.2	48.6	60.3	19.3	20.2
5	AKTM-11-12	2.3	2.8	1.1	1.9	5.1	4.5	92.5	115.2	49.7	56.6	20.9	25.1
6	AMAR	3.1	3.0	1.3	1.2	5.6	4.9	89.5	104.3	48.0	58.4	19.8	22.1
7	AZAD	3.6	2.5	1.4	1.3	5.6	5.2	94.7	111.3	49.4	59.9	18.8	21.1
8	BAHAR	3.0	2.9	1.3	1.0	6.3	5.8	94.0	113.1	53.1	53.4	20.0	21.3
9	BDN-2004-2	2.6	3.5	1.0	1.5	5.2	5.5	96.3	118.6	52.1	55.9	18.7	20.0
10	BDN-716	3.0	2.5	1.2	1.1	5.2	5.2	93.8	115.2	53.3	57.1	19.3	24.2
11	CORG-9701	2.9	2.4	1.1	1.2	5.1	4.4	90.4	109.2	50.9	55.6	15.6	20.2
12	ICPL-151	3.6	2.8	1.2	1.1	5.5	5.2	90.3	107.2	48.8	57.4	18.8	20.2
13	GT-100	3.2	2.7	1.2	1.4	4.2	4.0	90.0	109.5	48.8	57.8	19.7	23.2
14	PKV-TARA	2.7	3.1	0.9	1.3	4.1	5.7	91.6	106.6	52.3	55.9	18.8	20.2
15	SKN-0632	3.3	3.2	1.3	1.2	5.2	5.0	94.2	111.5	52.3	59.9	23.6	20.7
16	AKTM-1644	2.7	3.4	1.4	1.4	5.2	5.5	93.7	110.5	49.3	60.3	18.6	22.7
	Mean	2.9	2.7	1.2	1.3	5.2	5.0	92.3	110.7	50.2	57.1	19.8	22.3
	Range	0.8 - 3.6		0.6 - 2.2		4.0 - 6.3		89.5 - 118.6		48.0 - 60.3		15.6 - 29.0	
	SE(m)	0.06		0.01		0.07		0.31		0.24		0.37	
	CD @5%	0.17		0.03		0.20		0.86		0.67		1.02	
	F Test	S		S		S		S		S		S	

complex substances i.e. protein and starch respectively during maturation (Geervani and Umadevi, 1989). Calcium content may rise due to the accumulation of calcium in the seed coat during seed maturation (Cabanne and Doneche, 2003).

The green stage legumes had higher amounts of minerals viz., iron and zinc. This may be due to the fact that seeds contain enzymes in the living state and they prevent nutrient losses in the green seeds (Lynn, 2002).

Clustering

The above all nutritional parameters were recorded for all the sixteen genotypes, both at green and grain stage, that were collected from different places of the country. The observations recorded in a matrix were subjected to statistical analysis using software XLSTAT 2017 ver19.02.01.44037.

Clustering analysis based on nutritional quality in all sixteen genotypes resulted into a grouping of plant samples into a total of 4 clusters based on Gower's similarity coefficient. The dendrogram generated for Gower's similarity coefficient has been present in Fig. 1. The genotypes were clustered into two major clusters viz. cluster-I and cluster-II. The cluster-I included fourteen genotypes and divided further into A and B sub-clusters. The sub-cluster A again divided into sub-sub-clusters a1 including AKTM-11-11, AZAD, GT-100, SKN-0632, AKTM-1644 and sub-sub-cluster a2 including AKTM-11-07, AMAR, CORG-9701, ICPL-151, PKV-TARA. The sub-cluster B included four genotypes viz. AKTM-11-12, BAHAR, BDN-2004-2, BDN-716.

Only two genotypes viz. AKTM-11-06, AKTM-11-10 was grouped under cluster-II.

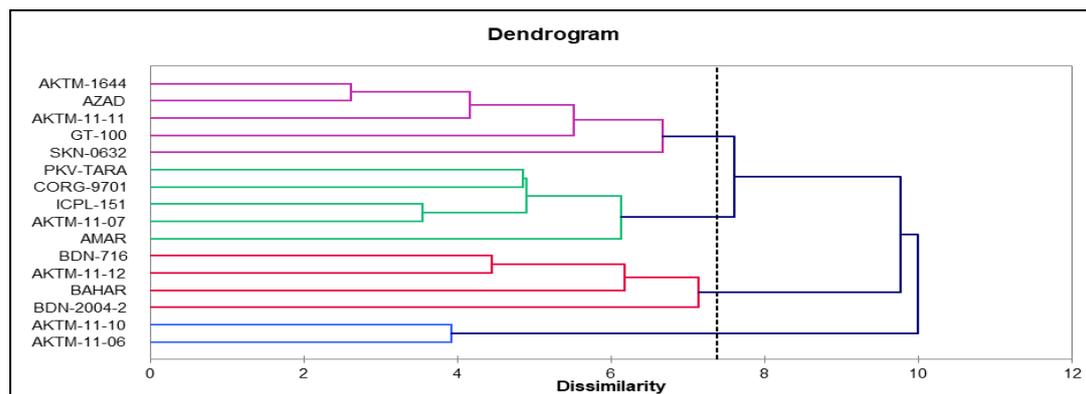


Fig 1: Cluster diagram based on nutritional traits

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