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Antioxidant Activities and Biochemical Changes in Different Cultivars of Brinjal (*Solanum melongena* L.)

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ABSTRACT

This experiment has been conducted to study antioxidant activities and biochemical changes in round as well as long cultivars of brinjal. Results showed that maximum protein content, amino acids, important minerals (Ca, P, K) and crude fibres were recorded in Pusa Purple Round Pusa Purple Long. Maximum phenolic content of brinjal fruit in round varieties was obtained in Pusa Purple Round followed by Pant Rituraj and NDBH-1 (86.13 mg/100 g). Phenolic content was maximum in Pusa Purple Long followed by Pusa Kranti and NB-2 in long varieties and Pusa Purple Round in round varieties. A linear relation between the total phenolic content and DPPH activities of the extracts was observed. Antioxidant activity of brinjal fruit was noticed between (182.01-234.13 μg) in round varieties and (172.11-219.92 μg) in long varieties. Maximum antioxidant activity of brinjal fruit in round varieties was obtained in Punjab Bahar followed by Pusa Purple Round and NB-1. However in long varieties of brinjal fruit it was maximum in NDBH-2 followed by Pusa Purple Long and NB-1. While, lowest activity was recorded in round variety NDBH-1 and Pant Samrat in long variety. On the basis of biochemical investigation, it can be concluded that brinjal is very nutritive and useful vegetable because it is rich source of protein, minerals, crude fibre, phenolic content, antioxidant activity and important essential amino acids.

Key words: Brinjal, antioxidant activities, phenolic contents, mineral content, amino acids, crude fibres

INTRODUCTION

Brinjal or egg plant (*Solanum melongena* L.) belongs to family Solanaceae. It is one of the most commonly grown vegetable crops in India. The brinjal crop has much importance in the warm areas of far east, being grown extensively in India, China, Turkey, Japan, Egypt, Italy, Indonesia, Iraq, Syria, Spain and Philippines. Brinjal has been a staple vegetable in diet since ancient times and liked by poor as well as rich person. The unripe fruits are primarily used as cooked vegetable for the preparation of various dishes in different regions of the world. It is supposed to contain certain medicinal properties. The white brinjal is said to be-good for diabetic patient (Choudhury, 1976).

Foods rich in antioxidants play an essential role in the prevention of chronic and degenerative diseases such as cardiovascular diseases and cancer (Ames *et al*., 1993). Plant foods contain an array of bioactive compounds which are actively being researched for their health care potential, including flavonoids, plant sterols/stanols, salicylates and glucosinolates. Research on health

concern of plant-rich diets has paying attention on the well-known vitamins. The existing data are not realistic and the thrust continues to identify other supplementary components a healthy diet which may reduce the risk of chronic disease (Hooper and Cassidy, 2006). Bajaj *et al.* (1979) reported that on an average the oblong brinjal fruit cultivars are rich in total water soluble sugars, whereas the round fruit cultivars contain large amount of free reducing sugars, anthocyanin, phenols, dry matter, amide proteins and glycoalkaloids. Sidhu *et al.* (1982) in their studies concluded that there is much variation in the chemical constituents of the fruits of different cultivars and chlorophyll, true protein and total phenols are influenced by other constituents of fruits besides, the effect of dry matter, especially on anthocyanin and ortho-hydroxy phenols.

The systematic biochemical studies of the recommended varieties are rare, it is due to this reason, the present investigation was undertaken to evaluate and compare the antioxidant activity, phenolic content and biochemical changes of different varieties of egg plant.

MATERIALS AND METHODS

The experiment was conducted at the instructional Main Vegetable Experimental Farm, Narendra Deva University of Agriculture and Technology Narendra Nagar (Kumarganj), Faizabad (UP) located in the Indo, Gangetic Plains of Eastern Uttar Pradesh at latitutude 26.47°N, longitude 82.12°E and altitude 113 m above the main sea level. This area falls in subtropical zone. Healthy and uniform brinjal seeds of round varieties viz., NB-1, NDBH-3, Punjab Bhara, Pusa Purple Round and Pant Rithuraj and long varieties viz., NB-1, NDBH-2, ND-3, Pusa Purple Long, Pant Samrat and Pusa Kranti, were sown on 5th July 2007 on well prepared raised beds. All the recommended package of practices were adopted for raising the seedlings. Twenty five to thirty days old seedlings were uprooted and transplanted in main plot at the spacing of 73×60 cm. The main plot prepared well by repeated ploughing. The harvesting of fruit was done when it attains a good size and colour. At edibles stage five fruit from each varieties were collected and their biochemical analysis was carried out in Biochemistry Laboratory. The biochemical analysis of the experimental material was carried out in the Laboratory of Biochemistry Department to determine various biochemical parameters such as sugar, amino acid, anthocyanin, chlorophyll, crude fibre, total mineral, phosphorus, calcium and potassium content. The statistical analysis of the data obtained was carried out by method as suggested by Fisher and Yates (1957).

Protein content: Protein content in brinjal fruit was analyzed by Lowry *et al.* (1951).

Amino acid contents: Amino acids viz., tryptophan content was estimated by the method of Spies and Chambers (1949), methionine content by Horn *et al.* (1946) and lysine content by Felker *et al.* (1978).

Total mineral content: Total mineral content in brinjal fruit was estimated with the help of method by Fisher and Hart (1971):

$$\text{Total mineral content (\%)} = \frac{\text{Wt. of ash (w)}}{\text{Wt. of sample}} \times 100$$

Weight of ash = Weight of crucible+ash-weight of silica crucible

Or:

$$W = W_2 - W_1$$

Mineral content: Phosphorus content was determined by triacid digestion method as described as Jackson (1973), calcium content by method of Piper (1966) and potassium content in oven dried sample of brinjal fruit have been analyzed by the method given by Jackson (1973).

Crude fibre content: The content of crude fibre in fruits was analyzed by methods as described by Fisher and Hart (1971).

The percentage of crude fibre present in the sample was calculated by equation given bellow:

$$\text{Crude fibre (\%)} = \frac{W_2 - W_1}{W_3} \times 100$$

Where:
W_1 = Weight of gooch crucible
W_2 = Wt of gooch crucible+sample after removing from over
W_3 = Weight of sample

Total phenolic content: Total phenolic contents were determined using Folin-ciocalteu reagent and ex-pressed as Gallic Acid Equivalents (GAE) (Singleton and Rossi, 1965). Folin-ciocalteu reagent contains metals like polytungston. Phenolic content from the sample reduce the metal and change the colour from yellow to Prussian blue. The intensity of the colour is directly proportional to the phenolic content. The extracts were diluted with the same solvent used for extraction, to a suitable concentration for analysis and 0.5 mL of commercial Folin-ciocalteu reagent was added. The contents were mixed well and kept for 5 min at room temperature followed by the addition of 1 mL of 20% aqueous sodium carbonate. After incubation at room temperature for one and half hour, the absorbance of the developed blue colour was read at 760 nm (Shimadzu UV-2450 Shimadzu corporation, Kyots, Japan) against reagent blank and results were calculated as gallic acid equivalents (mg/100 g) of sample. The reaction was conducted in triplicate and results were averaged.

Antioxidant activity: Free radical scavenging activity of the eggplant extracts were determined by using a stable 2,2-diphenyl-1-picrylhydrazyl radical (DPPH) (Brand-Williams *et al.*, 1995). DPPH is a free radical of violet colour. The antioxidants in the sample scavenge the free radicals and turn it into yellow colour. The change of colour from violet to yellow is proportional to the radical scavenging activity. Briefly, the assay contained 1 mL of 0.1 mM DPPH in ethanol and various concentrations of methanol extracts and standards in the same solvent and made up to 3.5 mL with methanol. The contents were mixed well immediately and then incu-bated for 30 min at room temperature (24-30°C). The degree of reduction of absorbance was recorded in UV-Vis spectrophotometer at 517 nm (Shimadzu UV-Vis, 2450).

The percentage of scavenging activity was calculated as:

$$\frac{Ac - As}{Ac} \times 100$$

where, 'Ac' is the absorbance of control (without extract) and 'As' is the absorbance of sample. Percentage of radical scavenging activity was plotted against the corresponding concentration of

the extract to obtain IC_{50} value. IC_{50} is defined as the amount of antioxidant material required to scavenge 50% of free radical in the assay system. The IC_{50} values are inversely proportional to the antioxidant activity.

RESULTS AND DISCUSSION

The data pertaining to protein content in brinjal fruit regarding to long and round varieties have been given in Table 1.

Protein content (percent): Protein content of brinjal fruit was noticed between (1.18-1.53%) in round varieties and (1.27-1.67%) in long varieties. Maximum protein content of brinjal fruit in round varieties was obtained in Pusa Purple Round (1.53%) followed by NDBH-1 (1.45%) and NB-1 (1.18%). Maximum protein content in long varieties of brinjal fruit was found in Pusa Purple Long (1.67%) followed by NDBH-2 (1.42%) and NB-2 (1.27%). Lowest protein content in round and long varieties were recorded in NB-1 (1.18%) and NB-2 (1.27%). It may be probably due to the protein bosynthesis in plants and ultimately improved the quality status by increasing the osmophyllic bodies. However, they alter the protein biosynthesis because of accumulation of amino acids in the tissues of solanaceous crops. The present inferences are well supported by Prabhakar *et al.* (1996).

Amino acid contents: Three essential amino acid viz., lysine, tryptophane and methionine were analysed in brinjal frut and data have been displayed in Table 1.

Tryptophan content: Tryptophan content of brinjal fruit was noticed between (0.64-0.82 g/16 gN) in round varieties and (0.59-0.87 g/16 gN) in long varieties. Maximum tryptophan content of brinjal fruit in round varieties was obtained in Pusa Purple Round (0.82 g/16 gN) followed by NDBH-1 (0.77 g/16 gN) and NB-1 (0.64 g/16 gN). Maximum

Table 1: Estimates of biochemical parameters in different cultivars of brinjal

Varieties	Protein content (%)	Amino acid content (g/16 gN)			Total mineral content (%)	Mineral content (mg/100 g)			Crude fibre content (%)	Antioxidant activity (µg)	Total phenol content (mg/100 g)
		Tryptophan	Lysine	Methionine		Ca	P	K			
Round varieties											
NB-1	1.180	0.64	4.510	0.730	0.470	11.87	39.450	192.310	1.350	213.420	82.320
NDBH-1	1.450	0.77	4.770	0.830	0.620	17.88	37.860	200.440	1.840	182.010	86.130
NDBH-3	1.340	0.76	4.750	0.750	0.500	15.75	45.750	195.550	1.640	198.430	84.420
Pant rituraj	1.320	0.75	4.760	0.690	0.450	13.95	43.850	196.530	1.530	208.440	99.640
Punjab bahar	1.440	0.73	4.370	0.870	0.650	16.72	46.780	197.430	1.640	234.130	79.330
Pusa puple round	1.530	0.82	4.950	0.840	0.760	16.28	47.850	200.410	1.840	230.640	103.420
Long varieties											
NB-2	1.270	0.59	4.460	0.860	0.430	13.36	39.350	192.220	1.340	200.130	91.230
NDBH-2	1.420	0.74	4.830	0.770	0.840	15.86	42.590	193.190	1.430	219.920	84.320
ND-3	1.250	0.63	4.520	0.770	0.340	11.49	39.640	192.250	1.380	192.300	87.360
Pusa puple long	1.670	0.87	5.080	0.870	0.850	18.46	48.450	200.460	1.880	210.220	95.180
Pant samrat	1.480	0.83	4.710	0.860	0.640	14.72	42.480	197.330	1.730	172.110	90.260
Pusa kranti	1.470	0.84	4.750	0.630	0.650	15.72	42.640	198.520	1.750	183.200	92.100
SEm+	0.067	0.041	0.096	0.035	0.047	0.490	0.842	1.708	0.062	1.803	0.928
CD at 5%	0.198	0.121	0.204	0.101	0.137	1.438	2.470	5.009	0.183	5.102	2.840

tryptophan content in long varieties of brinjal fruit was noticed in Pusa Purple Long (0.87 g/16 gN) followed by NDBH-2 (0.74 g/16 gN) and NB-2 (0.59 g/16 gN). Minimum tryptophan content in round and long varieties were recorded in NB-1 (0.64 g/16 gN) and NB-2 (0.59 g/16 gN).

Lysine content: Lysine content of brinjal fruit was noticed between (4.51-4.95 g/16gN) in round varieties and (4.46-5.08 g/16 gN) in long varieties. Highest lysine content of brinjal fruit in round varieties was obtained in Pusa Purple Round (4.95 g/16 gN) followed by NDBH-1 (4.77 g/16 gN) and NB-1 (4.51 g/16 gN). Maximum lysine content in long varieties of brinjal fruit was noticed in Pusa Purple Long (5.08 g/16 gN) followed by NDBH-2 (4.83 g/16 gN) and NB-2 (4.46 g/16 gN). Lowest lysine content was recorded in NB-1 and NB-2 (4.51 g/16 gN) and (4.46 g/16 gN) respectively in round and long varieties.

Methionine content: Methionine content of brinjal fruit was noticed between (0.73-0.87 g/16 gN) in round varieties and (0.33-0.87 g/16 gN) in long varieties. Maximum methionine content of brinjal fruit in round varieties was obtained in Pusa Purple Round (0.87 g/16 gN) followed by NDBH-1 (0.83 g/16 gN) and NB-1 (0.73 g/16 gN). Maximum methionine content in long varieties of brinjal fruit was noticed in Pusa Purple Long (0.87 g/16 gN) followed by NDBH-2 (0.77 g/16 gN) and NB-2 (0.64 g/16 gN). Minimum content of this amino acid was recorded in Pant Rituraj (0.69 g/16 gN) in round varieties and NDBH-2 (0.77 g/16 gN) in long varieties.

The enhancement of the amino acids may be due to low activiy of peroxidase enzyme which oxidze the nitrates into nitrite. The poor activity of this enzyme may favours high protein synthesis in brinjal fruit. Since, nitrates found in the fruit can not be oxidize rapidly once again to nitrate. This mechanism is due to the disturbance in nitrgen metabolism which results in the synthesis of large amount of protein and amino acids. The results are inagreement to Dwivedi and Singh (1982).

Crude fibre content (percent): The crude fibre content of brinjal fruit was noticed between (1.35-1.84%) in round varieties and (1.34-1.88%) in long varieties. Maximum crude fibre content of brinjal fruit in round varieties was noticed in Pusa Purple Round (1.84%) followed by NDBH-1 (1.82%) and NB-1 (1.35%). Maximum crude fibre content in long varieties of brinjal fruit was obtained in Pusa Purple Long (1.88%) followed by NDBH-2 (1.43%) and NB-2 (1.34%). Minimum crude fibre content was recorded in NB-1 (1.35%) in round variety and NB-2 (1.34%) in long variety. The round as well as long varieties of brinjal fruit regarding crude fibre content were found statistically non significant. There was a continuous increase crude fibre content of fruit upto sixty days after flowering which is conformity with the observaion made by Dalal *et al.* (2000). The crude fibre content during growth and development of brinjl ruitsas observed by Dutta *et al.* (1972). The higher crude fibre content was noticed in long varieties after flowering. It may be due to the synthesis of polysaccharides by enhancing the rate of photosynthesis as well as other biochemical processes of the plant. Which confirmation the observations made by Ni (2000).

Total mineral content (percent): The total mineral content of brinjal fruit was noticed between (0.47-0.76%) in round varieties and (0.43-0.85%) in long varieties. Maximum total mineral content of brinjal fruit in round varieties was obtained in Pusa Purple Round (0.76%) followed by NDBH-1 (0.62%) and NB-1 (0.47%). Maximum total mineral content in long varieties of brinjal fruit was recorded in Pusa Purple Long (0.85%) followed by NDBH-2 (0.84%) and NB-2 (0.43%).

Lowest total mineral content was observed in NB-1 (0.47%) in round variety and NB-3 (0.34%) in long variety. There was significant increase in total mineral content of brinjal fruit throughout its growth and development which is in conformatin with observation made by Patil and Patil (2000). There was increase in total mineral content in round as well as long varieties due to the fact that phosphorus element is act as predominant mineral observed continuous by the plant for various bio synthesis reaction. Which is inaccordance with the observations made by Kumar and Veeragavatham (1999).

Important mineral contents

Calcium content: The calcium content of brinjal fruit was noticed between (11.87-18.28 mg/100 g) in round varieties and (13.36-18.46 mg/100 g) in long varieties. Maximum calcium content of brinjal fruit in round varieties was obtained in Pusa Purple Round (18.28 mg/100 g) followed by NDBH-1 (17.88 mg/100 g) and NB-1 (11.87 mg/100 g). Maximum calcium content in long varieties of brinjal fruit was recorded in Pusa Purple Long (18.46 mg/100 g) followed by NDBH-2 (15.86 mg/100 g) and NB-2 (13.36 mg/100 g). Lowest calcium content was observed in NB-1 (11.87 mg/100 g) in round variety and NB-3 (18.49 mg/100 g) in long variety.

Phosphorus content: The phosphorus content of brinjal fruit was noticed between (39.46-47.85 mg/100 g) in round varieties and (39.35-48.45 mg/100 g) in long varieties. Maximum phosphorus content of brinjal fruit in round varieties was obtained in Pusa Purple Round (47.85 mg/100 g) followed by NDBH-1 (37.86 mg/100 g) and NB-1 (39.45 mg/100 g). Maximum phosphorus content in long varieties of brinjal fruit was recorded in Pusa Purple Long (48.45 mg/100 g) followed by NDBH-2 (42.59 mg/100 g) and NB-2 (39.35 mg/100 g). Lowest phosphorus content was shown in NDBH-1 (37.86 mg/100 g) in round variety and NB-2 (39.35 mg/100 g) in round and long varieties respectively.

Potassium content: The potassium content of brinjal fruit was noticed between (192.31-200.444 mg/100 g) in round varieties and (192.22-200.46 mg/100 g) in long varieties. Maximum potassium content of brinjal fruit in round varieties was obtained in Pusa Purple Round (200.44 mg/100 g) followed by NDBH-1 (200.41 mg/100 g) and NB-1 (192.31 mg/100 g). Maximum potassium content in long varieties of brinjal fruit was obtained in Pusa Purple Long (200.46 mg/100 g) followed by NDBH-2 (193.39 mg/100 g) and NB-2 (192.22 mg/100 g). Lowest potassium content was recorded in round variety NB-1 (192.31 mg/100 g) and NB-2 (192.22 mg/100 g) in long variety.

The enhancement of important mineral contents may be due to high activity of cytochrome oxidase which helps in oxidative phosphorylation in plant. The prescence of potassium element in brinjal fruit helps in the metabolism of anthocyanin and provide the colour to the fruits. It also involve in bosyntheis of amino acids and other phenolic compound which confirm the observations made by Leonardi and Giuffrina (1999).

Total phenolic content: Polyphenols are the large group of phytochemicals that are gaining acceptance as being responsible for the health benefits associated with fruits and vegetables. Because of their chemical structure, plant polyphenols can scavenge free radicals and inactive other pro-oxidants and also interact with a number of biological relevance. Total phenol content of brinjal

fruit was noticed between (79.33-103.42 mg/100 g) in round varieties and (84.32-95.18 mg/100 g) in long varieties. Maximum phenolic content of brinjal fruit in round varieties was obtained in Pusa Purple Round (103.42 mg/100 g) followed by Pant Rituraj (99.64 mg/100 g) and NDBH-1 (86.13 mg/100 g). Maximum phenolic content in long varieties of brinjal fruit was obtained in Pusa Purple Long (95.18 mg/100 g) followed by Pusa Kranti (92.10 mg/100 g) and NB-2 (91.23 mg/100 g). However, lowest phenolic content was recorded in round variety Punjab Bahar (79.33 mg/100 g) and NDBH-2 (84.32 mg/100 g) in long variety.

Antioxidant activity: DPPH is a free radical compound and has been widely used to test the free radical scavenging ability of various samples. IC_{50} value (the amount of antioxidant material required to scavenge 50% of free radical in the assay system) of standard was observed as 183.90 lg mL^{-1}. There was an inverse relationship between IC_{50} and antioxidant activity. A linear relation between the total phenolic content and DPPH activities of the extracts was observed. Antioxidant activity of brinjal fruit was noticed between (182.01-234.13 μg) in round varieties and (172.11-219.92 μg) in long varieties. Maximum antioxidant activity of brinjal fruit in round varieties was obtained in Punjab Bahar (234.13 μg) followed by Pusa Purple Round (230.64 μg) and NB-1 (213.42 μg). Maximum antioxidant activity in long varieties of brinjal fruit was obtained in NDBH-2 (219.92 μg) followed by Pusa Purple Long (210.22 μg) and NB-1 (200.13 μg). However, lowest antioxidant activity was recorded in round variety NDBH-1 (182.01 μg) and Pant Samrat (172.11 μg) in long variety. The results are in agreement to Nisha *et al*. (2009).

CONCLUSION

From the experimental findings it could be concluded that brinjal is very nutritive and useful vegetable because it is rich source of protein, minerals, crude fibre, phenolic content, antioxidant activity and important essential amino acids.

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