

Morphological and biochemical properties of garlic (*Allium sativum* L.) collections

P C Tripathi*, H M Jadhav, A A Qureshi, V Sankar, V Mahajan & K E Lawande

ICAR- Directorate of Onion and Garlic Research, Rajgurunagar-410 505, Dist. Pune (Maharashtra)
*E-mail: prakaashtripathii2000@yahoo.co.in

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Abstract

Garlic (*Allium sativum* L.) is an important constituent of many of traditional medicines. The nutrient composition and biochemical ingredients of garlic vary among varieties and locations. The current experiment was conducted with 35 genotypes of garlic to study variation in morphological and biochemical properties among these genotypes. The weight of bulbs ranged from 6.9 g to 22.6 g. Highest number of clove bulb⁻¹ was recorded in collection -286 (44.6) followed by GG-2 (40.6). Clove weight was higher in collection - 316 (1.41 g). The dry weight ranged from 28.6 per cent to 38.65 per cent. Highest total soluble solids were found in collection -79 (35.1°Brix). Potassium, iron and zinc content were higher in GG-2 (1.70%, 47 ppm and 19.2 ppm, respectively). Sulphur and copper content were higher in G-41. Manganese content ranged from 6.90 to 23.1 ppm. Highest anthocyanin pigment was found in the peel of cv. Godavari (5.35 mg). There was not much difference in anthocyanin content in pulp of purple and white colour varieties. Pyruvic acid content ranged from 20.9 μ mol ml⁻¹ to 24.9 μ mol ml⁻¹. Over all cvs. G-50, G-41, collection -316 were found superior over others.

Keywords: analysis, collections, garlic, microelements

Introduction

Garlic (*Allium sativum* L.) is an integral part of most of the cuisines throughout the world. The crop is cultivated in about 1.5 million hectares with an annual global production of about 28.49 million metric tons (FAO 2018). Though originated in Central Asia, it is being cultivated in about 150 countries worldwide. China is the largest producer of garlic in the world and accounts for 78 per cent of total garlic production. India ranks second and produces

6 per cent of the total production. The average productivity of the garlic in the world is 13 tonnes but the productivity in China is more than 25 tonnes ha⁻¹ (Gupta 2015). Rajasthan and Madhya Pradesh are the leading states in India contributing more than 50% in both area and production. The other major garlic growing states are Gujarat, Uttar Pradesh and Maharashtra (Anonymous 2018). Apart from its use in cuisine, garlic has historically been used to alleviate pains, leprosy, deafness, diarrhoea, constipation, parasitic infection,

fever, stomach ache etc. since long (Woodward 1996; Tattelman 2005; Rana *et al.* 2011; Tripathi *et al.* 2013). More than 100 varieties of garlic and several hundred landraces of garlic are grown throughout the world. They are broadly classified as hard-neck and soft-neck. Most of the varieties grown in India are soft neck type. The cultivars vary in size, shape, colour, number of cloves bulb⁻¹, clove size etc. and in their storability because of their inherent dormancy. However, very little information is available on chemical composition of these varieties. Thus the current research was carried out to study morphological and biochemical variations among some garlic varieties and collections.

Materials and methods

Garlic varieties and collections used in the study were from germplasm collection of ICAR- Directorate of Onion and Garlic Research, Rajgurunagar, Pune, Maharashtra. Recommended cultural practices were followed for cultivation. Due care was taken to draw samples from same plots and at same maturity stage. Twenty-five bulbs of each collection were taken for observation and analysis.

Morphological observations

Cured bulbs were cleaned properly and extra roots were removed. The bulb weight, fruit length, fruit diameter was recorded using analytical balance and digital vernier calipers. Fruit shape and fruit colour were recorded as per standard fruit shape and colour charts. The bulbs were broken to record the number of cloves bulb⁻¹. The total soluble solids were recorded using ERMA hand refractometer. The samples were peeled and cut into small pieces using a clean knife and used for various analyses.

Ascorbic acid

Ascorbic acid content of fruits (10 g pulp) was analyzed by Dichlorophenol-indophenol visual titration method. The ascorbic acid content was

determined as per Ranganna (1986).

Moisture and dry matter content

One hundred gram fresh edible portion was used for estimation of moisture content and dry weight. The samples were air dried followed by oven drying for 48-72 hours at 58 °C till the samples attained a constant weight. The dried samples were weighed and dry matter content calculated. The dried samples were powdered using a grinder fitted with stainless steel blades and stored in polythene bags for analysis.

Pyruvic acid

Pyruvic acid was estimated using the method described by Yoo *et al.* (1995) using 2, 4-dinitrophenylhydrazine (DNPH). The colour intensity was measured at 420 nm. Standard graph was prepared using various concentrations of sodium pyruvate and colour intensity was plotted on a graph.

Total anthocyanin content

Total monomeric anthocyanin content was quantified using a pH differential method described by Giusti & Wrolstad (2001). Samples were diluted in two buffer solutions: potassium chloride buffer 0.025 M (pH 1.0) and sodium acetate buffer 0.4 M (pH 4.5) and then the absorbance was measured simultaneously at 516 nm and 700 nm (to correct for haze) after 15 minutes of incubation at room temperature against distilled water as blank. A Jasco V 530 UV-Vis Spectrophotometer was used for measurement. The monomeric anthocyanin pigment concentration was calculated according to the following equation: $C \text{ (mg l}^{-1}\text{)} = A \times MW \times DF \times 1000 / E \times l$, Where: $A = (A_{516} - A_{700})$ at pH 1.0 - $(A_{516} - A_{700})$ at pH 4.5, MW is the molecular weight, DF is the dilution factor and l is the path length (1 cm). The total monomeric anthocyanin content was expressed as cyanidin-3-glucoside equivalents (MW=449.2 and $\epsilon = 26900$). Each sample was analyzed in triplicate and the results were expressed as the average of the two measurements.

Analysis of mineral content

Powdered (dried) samples were used for extracting nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, zinc, copper and manganese contents. Nitrogen in plant sample was determined as described by Piper (1966) after digestion with concentrated sulphuric acid. Phosphorus in the digested sample was estimated by vanadomolybdophosphoric yellow colour method (Piper 1966) by measuring absorbance at 490 nm using Spectrophotometer and expressed as uptake in kg ha⁻¹. The potassium concentration in plant sample was determined by flame photometric method (Piper 1966). Sulphur in plant sample was determined by turbidimetric method, following the procedure given by Piper (1966).

The content of Cu, Fe, Mn and Zn were estimated by using Atomic Absorption Spectrophotometer Piper (1966).

Data analysis

All the data were statistically analyzed by ANOVA (Panse & Sukhatme 1995) considering the treatment as the independent variable. The means were separated by the Tukey's test ($P < 0.05$).

Results and discussion

Bulb characteristics

The bulb characters of garlic varieties and collections *viz.*, bulb weight, equatorial diameter, polar diameter, neck thickness, no. of cloves/bulb, bulb shape and colour are given in Table 1. The average weight of bulbs ranged from 6.71 g to 22.6 g. It was highest in G-50 (22.6 g) followed by collection- 316 (21.37 g), G-41 (18.7 g) and GG-2 (17.5 g). These were significantly higher than all other genotypes. The minimum weight of bulb was recorded in collection -260 (6.71 g). Highest equatorial diameter (41 mm) of bulb was recorded in collection - 177 and collection - 316 followed by G-50 (39.9 mm), GG-2 (39.1 mm) and G-41

(37.2 mm). The lowest equatorial diameter was recorded in collection 260 which was 28 mm. The highest polar bulb diameter was recorded in G-41 (27.4 mm), followed by GG-2 (27.2 mm), collection- 316 (27 mm) and G-50 (26.3 mm). The number of cloves/bulb ranged from 9.6 to 44.6. The highest cloves bulb⁻¹ was recorded in collection-286 (44.6), GG-2 (40.6), collection-15 (28.9) while lower number of cloves bulb⁻¹ was recorded in collection-215 (9.6), collection-314 (10.9), collection-43 (12.28), collection-323 (18.40) and G-282 (20.4) (Table 1). Lesser number of cloves in collection-215, collection-314 and collection-43 was due to poor development of bulbs which has confirmed by their low bulb weight. This may be due to climatic conditions as it is a well proven fact that bulb development in garlic is strongly influenced by temperature. The temperate garlic varieties /lines produced very small or no bulbs under tropical conditions (Danna *et al.* 2000; Yebirzaf Yeshiwas *et al.* 2018). The bulb shape was oblong in most of the collections and varieties. The bulbs were round in cvs. G-282, GG-2, GG-3, Collection-286, collection-326 and collection-227. The bulb colour was white in most of the genotypes. Collection-64, collection-179 and collection-326 had purple colour bulbs while DARL-50, collection-163 and collection-46 had pinkish white bulbs (Table 1). The neck thickness was higher in varieties and collections with bigger size bulbs.

Clove characteristics

The clove characters *viz.*, length, girth, weight, colour and clove arrangement are given in Table 2. The clove weight ranged from 0.39 g to 1.41 g it was higher in collection- 316 (1.41 g), collection-177 (0.92 g), G-41 (0.82 g), G-50 (0.83 g), collection-109 (0.75 g) and G-323 (0.75 g). Lower clove weight was found in collection-15 (0.45 g), collection-163 (0.48 g) and collection-6 (0.51 g). The clove length ranged from 13.3 mm to 22.1 mm. It was higher in collection-79 (22.1 mm) followed by G-41 (20.40 mm) and G-50 (19.5 mm). Lower clove length was recorded in collection-43 (13.30 mm), GG-1 (14.8 mm) and Godavari (15.50

Table 1. Bulb characters of garlic varieties and collections

Variety/ Collection No.	Bulb weight (g)	Equatorial diameter (mm)	Polar diameter (mm)	Neck thickness (mm)	No. of cloves/ bulb	Bulb shape	Bulb colour
G1	10.10	29.50	23.10	4.00	25.00	Oblong	white
G41	18.70	37.20	27.40	4.00	21.60	Round	white
G50	22.60	39.90	26.30	5.00	25.70	Oblong	white
G282	12.70	33.70	23.20	4.00	20.50	Round	white
G323	15.60	36.10	25.90	4.00	18.40	Oblong	white
GG2	17.50	39.10	27.20	5.00	40.60	Round	white
GG3	11.10	32.90	22.10	4.00	27.90	Round	white
Godavari	10.90	33.50	23.10	4.00	18.30	Oval	Purple
DARL50	15.70	36.30	25.00	4.00	26.60	Oblong	Pinkish white
Collection 4	9.46	32.00	23.00	4.00	13.10	Oblong	White
Collection 6	10.50	33.00	21.00	4.00	31.20	Oblong	White
Collection 15	8.71	33.00	24.00	4.00	28.90	Oblong	White
Collection 43	12.28	33.00	25.00	4.00	12.28	Oblong	White
Collection 46	10.46	32.00	23.00	4.00	23.40	Oblong	Pinkish white
Collection 64	12.07	34.00	23.00	4.00	15.60	Oblong	Purple
Collection 79	12.06	34.00	23.00	3.00	17.60	Oblong	White
Collection 109	11.44	33.00	23.00	4.00	17.90	Round	White
Collection 162	13.76	38.00	27.00	5.00	22.20	Oblong	White
Collection 163	6.90	29.00	23.00	4.00	19.30	Oblong	Pinkish white
Collection 177	12.72	41.00	23.00	4.00	17.30	Oblong	Purple
Collection 215	8.73	30.00	21.00	4.00	9.60	Oblong	White
Collection 224	9.48	30.00	21.00	4.00	22.80	Round	White
Collection 227	10.41	31.00	21.00	4.00	27.70	Round	White
Collection 260	6.71	28.00	20.00	4.00	19.63	Oblong	White
Collection 273	11.67	29.00	19.00	3.00	16.50	Oblong	White
Collection 279	10.14	33.00	24.00	3.00	13.90	Oblong	White
Collection 286	7.76	29.00	19.00	3.00	44.60	Round	White
Collection 294	8.61	30.00	20.00	4.00	26.90	Oblong	White
Collection 301	10.87	33.00	21.00	4.00	29.30	Oblong	White
Collection 304	9.65	32.00	20.00	3.00	26.00	Oblong	White
Collection 314	11.44	34.00	24.00	4.00	10.90	Oblong	White
Collection 316	21.37	41.00	27.00	4.00	18.70	Oblong	White
Collection 320	10.47	34.00	22.00	4.00	20.10	Oblong	White
Collection 326	12.36	34.00	21.00	4.00	33.90	Round	Purple
Max	22.60	41.00	27.40	5.00	44.60	-	-
Min	6.71	28.00	19.00	3.00	9.60	-	-
Average	11.91	33.48	22.98	3.94	22.47	-	-
CD (0.05)	1.54	7	6	1	4.51	-	-

Table 2. Clove characters of different garlic varieties and collections

Variety/ collection No	Clove length (mm)	Clove girth (mm)	Length/ girth	Clove weight (g)	Clove colour	Clove arrangement
G1	16.5	5.80	2.84	0.40	white	Regular
G41	20.40	8.20	2.49	0.82	white	Irregular
G50	19.50	7.80	2.50	0.83	white	Irregular
G282	16.20	6.90	2.35	0.63	Pinkish white	Regular
G323	18.70	8.10	2.31	0.75	white	Irregular
GG2	17.00	5.60	3.04	0.40	white	Regular
GG3	14.80	5.60	2.64	0.39	white	Regular
Godavari	15.50	7.60	2.04	0.57	Purple white	Regular
DARL50	16.80	6.80	2.47	0.53	Pinkish white	Regular
Collection 4	18.50	6.80	2.72	0.64	White	Irregular
Collection 6	17.60	6.50	2.71	0.51	White	Irregular
Collection 15	15.60	6.00	2.60	0.45	White	Irregular
Collection 43	13.30	7.70	1.73	0.87	White	Irregular
Collection 46	18.80	6.90	2.72	0.69	Pinkish White	Irregular
Collection 64	18.10	7.50	2.41	0.76	Purple	Irregular
Collection 79	22.10	6.70	3.30	0.79	White	Irregular
Collection 109	19.40	6.70	2.90	0.75	White	Irregular
Collection 162	17.90	6.40	2.80	0.68	White	Irregular
Collection 163	16.60	6.30	2.63	0.48	Pinkish White	Irregular
Collection 177	19.30	8.00	2.41	0.92	Purple	Irregular
Collection 215	17.20	7.50	2.29	0.88	White	Irregular
Collection 224	17.20	7.20	2.39	0.61	White	Irregular
Collection 227	17.60	8.20	2.15	0.58	White	Irregular
Collection 260	16.80	6.80	2.47	0.48	White	Irregular
Collection 273	18.50	7.80	2.37	0.87	White	Irregular
Collection 279	17.30	5.80	2.98	0.61	White	Irregular
Collection 286	16.30	6.20	2.63	0.45	White	Irregular
Collection 294	17.20	6.70	2.57	0.61	White	Irregular
Collection 301	16.90	7.80	2.17	0.67	White	Irregular
Collection 304	16.70	7.10	2.35	0.62	White	Irregular
Collection 314	17.50	7.90	2.22	0.80	White	Irregular
Collection 316	18.70	8.50	2.20	1.41	White	Irregular
Collection 320	16.80	7.10	2.37	0.61	White	Irregular
Collection 326	17.90	6.50	2.75	0.61	Purple	Irregular
Max	22.10	8.50	3.30	1.41	-	-
Min	13.30	5.60	1.73	0.39	-	-
Average	17.49	7.03	2.52	0.67	-	-
CD (0.05)	4.43	1.63	0.36	0.36	-	-

mm). The clove girth ranged from 5.60 mm to 8.50 mm. It was higher in collection-316 (8.5 mm) followed by collection-227, G-41 (8.20 mm) and collection-314 (7.90 mm). Lower clove girth was recorded in GG-2, GG-3 (5.6 mm) and collection-179, G1 (5.8 mm). The clove weight was in correspondence with the length and width of the clove. The data also revealed that collection-79, collection-279, G-1, collection-109 and GG-2 were slender while the collection-43 had short and stout clove. The arrangement of clove was irregular in most of the genotypes. Only few genotypes such as G-1, GG-2, GG-3, Godavari and DARL-50 had regular arrangement of clove. Most of the clove varieties and collections were white in colour they were pinkish white in G 282, collection 46, collection 163, while it was purple in collection 64, collection 177, collection 326 and Purple white in cv. Godavari. The varieties with bigger cloves are usually high yielding and require less time for table and processing purposes hence, preferred in the market.

Moisture and dry matter content

The dry weight of garlic collections ranged from 28.6 per cent to 38.65 per cent (Table 3). It was highest in G-41 (38.65%) followed by GG-2 (37.45%), collection-109 (37.40%) and collection 279 (36.8%). Lower dry weight was recorded in collection-4 (28.6%), collection-177 (29.2%), collection-6 (29.60%) and collection-64 (29%). The moisture content was least in G-41 followed by GG-2, collection-109 and collection-279 (Table 3).

Total soluble solids, titrable acidity and ascorbic acid

The highest total soluble solids were found in collection -79 (35.1° Brix), while higher total soluble solids were recorded in G-323 (32.99° Brix), collection -320 (32.9° Brix), DARL - 50 (32.54° Brix) and G-41 (32.4° Brix) compared to other genotypes. Lower total soluble solids were recorded in collection -227 (28.5° Brix), G-282 (28.17° Brix) and G-50 (28.77° Brix) (Table 3). There was no correlation between

total soluble solids and dry matter content. The titrable acidity ranged from 0.72 per cent to 1.61 per cent. It was highest in collection-326 and collection-109 (1.61%) followed by collection-15 (1.54%) and Collection-163 (1.39%). Among the released varieties, it was highest in cv. G-282 (1.22%) followed by DARL-50 (1.19%). The titrable acidity was lowest in cv. G-1 (0.72%) followed by Collection-43 (0.73%), G-323 (0.81%) and G-41 (0.83%). There was no correlation among dry matter content, total soluble solids and titrable acidity (Table 3). The ascorbic acid content ranged from 13.8 mg to 33.80 mg/100 g fresh weight. It was highest in collection-260 (33.80 mg) followed by collection-162 (29.9 mg) and lowest in GG2 (13.8 mg). Among the varieties, highest ascorbic acid was recorded in cv. DARL-50 (23.5 mg) followed by cv. Godavari (22.7 mg) (Table 3). The varieties and collections with higher total solid solids may be useful for processing purposes due to higher recovery.

Macro and micro elements

Among the nine varieties analyzed, nitrogen content ranged from 2.10 per cent to 3.0 per cent. It was higher in cv. Godavari (3.0%), G-282 (2.80%), G-1 (2.70%) and G- 323 (2.70%). Lowest nitrogen content was recorded in G-41 (2.10%). The phosphorus content ranged from 0.90 per cent to 1.80 per cent. It was highest in DARL -50 (1.80%) and lowest in GG-3 (0.90%). Potassium content was highest in GG-2, (1.70%) and lowest in G-41 and GG-3 (0.9%). Sulphur content was higher in G-41 and GG-3 (0.4%). The iron content was highest in GG-2 (47 ppm) and lowest in cv. Godavari (21.8 ppm). Manganese content ranged from 6.90 to 23.1 ppm. It was highest in G-41 and lowest in G-323. Zinc content was highest in GG-2 (19.2 ppm) and lowest in GG-3 (8 ppm). Copper content was highest in G-41. Higher content of minerals in small clove varieties was also reported by Islam *et al.* (2020). The results may be useful for selection of varieties with higher micronutrients for specific medicinal uses.

Table 3. Chemical composition of different garlic varieties and collections

Variety/ collection No	Dry weight (%)	Moisture (%)	TSS (°Brix)	Titration acidity (%)	Ascorbic acid (mg 100gm ⁻¹)
G1	32.55	67.45	31.07	0.72	22.15
G41	38.65	61.35	32.40	0.83	13.65
G50	36.15	63.85	28.77	1.12	17.85
G282	32.05	67.95	28.17	1.22	14.35
G323	30.25	69.75	32.99	0.81	21.80
GG2	37.45	62.55	30.40	1.12	13.80
GG3	32.35	67.65	31.10	0.94	19.85
Godavari	34.40	65.60	31.83	0.88	22.70
DARL50	33.80	66.20	32.54	1.19	23.50
Collection 4	28.60	71.40	28.20	1.10	20.80
Collection 6	29.60	70.40	31.10	1.03	29.00
Collection 15	35.00	65.00	28.90	1.54	20.80
Collection 43	31.20	68.80	28.70	0.73	26.90
Collection 46	34.40	65.60	28.00	1.03	27.30
Collection 64	29.00	71.00	29.80	1.32	25.10
Collection 79	34.60	65.40	35.10	1.03	22.10
Collection 109	37.40	62.60	30.30	1.61	21.70
Collection 162	35.20	64.80	28.80	1.25	29.90
Collection 163	30.00	70.00	31.90	0.95	20.40
Collection 177	29.20	70.80	30.60	1.25	28.60
Collection 215	30.80	69.20	29.10	1.10	21.20
Collection 224	30.80	69.20	32.30	1.17	21.70
Collection 227	34.20	65.80	28.50	1.10	27.30
Collection 260	34.60	65.40	30.10	1.03	33.80
Collection 273	32.80	67.20	29.70	0.95	21.70
Collection 279	36.80	63.20	31.10	1.03	21.70
Collection 286	31.40	68.60	32.50	1.03	24.30
Collection 294	33.50	66.50	28.70	1.03	19.50
Collection 301	32.00	68.00	32.90	1.39	28.20
Collection 304	33.40	66.60	29.70	1.03	19.90
Collection 314	31.40	68.60	28.70	1.10	21.70
Collection 316	34.40	65.60	29.70	1.10	25.10
Collection 320	32.40	67.60	32.90	1.03	23.40
Collection 326	33.40	66.60	28.90	1.61	23.80
Max	38.65	71.40	35.10	1.61	33.80
Min	28.60	61.35	28.00	0.72	13.65
Average	33.05	66.95	30.46	1.10	22.81
CD (0.05)	2.71	4.83	1.90	0.42	2.51

Table 4. Nutrient composition of garlic varieties

Name of variety	% N	% P	% K	% S	Fe ppm	Mn ppm	Zn ppm	Cu ppm	Anthocyanin pigment of peel (mg 100gm ⁻¹)	Anthocyanin pigment of clove (mg 100g ⁻¹)	Pyruvic acid ($\mu\text{mol ml}^{-1}$)
G-1	2.70	1.50	1.60	0.30	24.30	11.80	15.80	2.70	0.61	0.26	21.30
G-41	2.10	1.60	1.70	0.40	25.50	23.10	12.60	5.70	0.76	0.44	23.10
G-50	2.70	1.00	1.00	0.30	30.00	7.50	12.20	4.30	1.22	0.40	24.90
G-282	2.80	1.10	1.30	0.20	29.50	7.90	16.40	4.80	1.32	0.53	21.30
G-323	2.70	1.10	1.10	0.30	28.10	6.90	11.80	3.40	1.12	0.46	24.60
GG-2	2.30	1.70	1.70	0.30	47.00	16.70	19.20	4.70	1.88	0.50	20.90
GG-3	2.70	0.90	0.90	0.40	24.50	7.10	8.50	4.20	0.96	0.50	21.50
Godavari	3.00	1.50	1.60	0.30	21.80	12.50	11.60	3.10	5.35	0.28	23.40
DARL50	2.70	1.80	1.60	0.30	22.60	16.00	14.20	5.30	3.61	0.47	21.30
Max	3.00	1.80	1.70	0.40	47.00	23.10	19.20	5.70	5.35	0.53	24.90
Min	2.10	0.90	0.90	0.20	21.80	6.90	8.50	2.70	0.61	0.26	20.90
Average	2.63	1.36	1.39	0.31	28.14	12.17	13.59	4.24	1.87	0.43	22.48
CD (0.01)	0.61	0.31	0.42	0.13	2.10	5.70	4.50	1.70	0.41	0.17	1.41

Anthocyanin and pyruvic acid

As far as the colour pigments are concerned, highest anthocyanin pigment was found in the peel of cv. Godavari (5.35 mg) followed by cv. DARL-50 (3.61 mg). It was least in white colour varieties. There was not much difference in anthocyanin content in pulp of purple colour varieties and white colour varieties. It was highest in G-282 (0.53 ppm). DARL-50 had 0.47 ppm while Godavari had only 0.28 ppm. The pyruvic acid content ranged from 20.9 to 24.9 μ mol ml⁻¹. It was higher in G-50 (24.9), G-41 (32.1), G-323 (24.9) and Godavari (24.5 mg) (Table 4).

The data revealed wide variability in garlic genotypes with varying morphological and biochemical characteristics. There are no definite trends of higher nutritive values in the small clove garlic collections. The nutritive value of coloured garlic varieties and white coloured varieties was almost similar except for the higher anthocyanin content in the peel in coloured varieties. Results revealed that genotypes G-50, G-41 and collection-316 were better than other genotypes with respect to morphological and biochemical characteristics.

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