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Phytochemical diversity in okra (*Abelmoschus esculentus*) genotypes

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ABSTRACT

The phytochemical content of okra (*Abelmoschus esculentus* L. Moench) genotypes varied in accordance of type of compound and genotype. Out of 20 genotypes, only three genotypes (Kashi Lalima, Kashi Kranti and VROB-178) showed significantly higher amount of phytochemicals (ascorbic acid, total chlorophyll, anthocyanin, total carotenoids, total phenolics and total antioxidants activity). Among these genotypes Kashi Lalima showed highest ascorbic acid (19.63 mg/100 g) and anthocyanin content (0.14 mg/100 g) while highest chlorophyll content (5.75 mg/100 g) and total carotenoids content (1.71 mg/100 g) were recorded in Kashi Kranti. The amount of total anthocyanin and phenol compound varied from 0.08 to 0.14 mg/100 g of fresh weight (FW) and 38.88 to 62.82 (mg catechol equivalent/100 g fresh weight), respectively. The total moisture content and total crude fiber content also showed a significant difference within the range of 80.14 to 93.16% and 1.30 to 4.40 % of fresh weight, respectively. The highest total phenolics and moisture content was observed in genotype VROB-178, while highest crude fiber percentage was represented by Kashi Satdhari. Hence, selected okra genotypes containing good amount of phytochemicals, which can be further used for nutritional quality improvement of okra in future breeding programs.

Key words: Antioxidants, Ascorbic acid, Chlorophyll, Moisture, Okra, Phytochemicals.

Okra (*Abelmoschus esculentus* L. Moench) belongs to family Malvaceae and genus *Abelmoschus* is categorized among most important vegetables in India and also for whole world scenario. Mature green fruits are valued for its high nutritional value throughout the world as these are the rich source of fibers, vitamins and minerals (Kumari *et al.* 2017). The mucilage content of fruits used for medicinal purpose, as it acts as plasma replacer or blood volume expander.

A polyunsaturated fatty acid, i.e. linoleic acid (47.4 %) essential for human nutrition present in high amount in the oil of okra seeds. The nutritional and biological activities in pods and seeds of okra were reported by many authors (Kumar *et al*., 2010). The okra fruit holds a good amount of water (86.1%), protein (2.2%), fat (0.2%), CHO (9.7%), fiber (1.0%) and ash (0.8%) (Saifullah and Rabbani 2009). Okra fruits are rich in fiber content but low in cholesterol which is beneficial for human health (Kumar *et al*. 2010). Higher amount of antioxidants like chlorophyll, total phenolics and total flavonoids present in young fruits than mature fruits (Nwachukwu *et al*. 2014). The chemical compounds of natural origin in plant cell are known as phytochemicals and it is also useful against urinary disorders, spermatorrhoea and chronic dysentery.

The antioxidant, anti-inflammatory and anti-microbial activity of phenolic compounds is mainly due to more amounts of phenolic and flavonoid. Their ratios and distributions in vegetables enhanced the physiological and biochemical activities (Ali and Deokule 2008). The Reactive oxygen species (ROS) are partially reduced forms of molecular oxygen. Excessive accumulation of reactive oxygen species in human body leads to several chronic diseases. Hence, the presence of antioxidants in vegetable helps in down regulating the high level of reactive oxygen species by scavenging them to avoid accumulation of toxic levels in the cell.

The phytochemical content of fruits and vegetables is mainly influenced by genotypic and environmental factors but the information on functional properties of these okra genotypes is still lacking. Hence, present research findings may show a new path for improving okra genotypes for future breeding program to develop new varieties with high phytochemical content. Therefore, present investigation was conducted to determine the phytochemical properties

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(ascorbic acid, total chlorophyll, anthocyanin, total carotenoids, total phenolics, total antioxidants activity as well as crude fiber content) of 20 diverse okra genotypes.

MATERIALS AND METHODS

A total of 20 genotypes were used for research experiment, which were collected from different sources (Table 1). Field layout was prepared in three replications using randomized complete block design (RCBD) at Vegetable Research Farm, Bihar Agricultural University, Sabour, Bhagalpur, Bihar (India). Physico-chemical properties of soil was determined by as per standard procedure. Experimental soil was analysed having pH 7.6 with available 277 kg N, 18.5 kg P_2O_5 and 135 kg K_2O/ ha. Therefore, fertility of the soil was medium in nitrogen and potash and low in phosphorus during 2015-16. Crop was fertilized with 120 kg N, 60 kg P_2O_5 and 60 kg K_2O per ha. All the recommended practices were followed and irrigation was given as when required.

Randomly harvested fresh and healthy okra pods from each genotype were used as sample for phytochemical analysis. These pods were cut into small pieces for individual genotypes and homogenized for 2 min then analysis for different phytochemicals was carried out.

Ascorbic acid content

Estimation of ascorbic acid was carried out by using 2,6-dichlorophenol indophenol titration method (AOAC 1975). The 2g of pulp was crushed with 3% metaphosphoric acid solution to prepare the sample and volume make up to 100 ml with 3% metaphosphoric acid in a volumetric flask. Then the solution was kept for 10 min and the aliquot of filtrate was titrated against standard dye to get pink solution at the end point. The concentration of ascorbic acid was represented in mg/100 g fresh weight.

Total chlorophyll content

Total chlorophyll extraction was done by following the spectrophotometer based method as described by Arnon (1949). The 1 g of fresh sample was extracted by using 80% acetone and crushed it properly with the help of pestle and mortar and then kept the sample under cold condition for 2 days in dark. Later, strained the sample with fine muslin cloth and centrifuged it at 5000 rpm for 5 min and the supernatant was collected in volumetric flask. After that, final volume was made using 1 ml of supernatant and 9 ml of 80% acetone. From this 1 ml was taken and diluted with 80% acetone to make up 5 ml volume and absorbance was measured at 663 nm and 645 nm against a reagent blank in UV–Vis spectrophotometer. The amount of chlorophyll content was estimated in mg/100 g fresh weight as per the formula given below:

$$\text{chl a (mg/100g)} = [\{(12.7 \times A_{663}) - (2.63 \times A_{645})\} \times D]/100$$

$$\text{chl b(mg /100g)} = [\{(22.9 \times A_{645}) - (4.68 \times A_{663})\} \times D]/100$$

$$\text{Total chlorophyll (mg /100g)} = [\{(20.2 \times A_{645}) + (8.02 \times A_{663})\} \times D]/100$$

where, A_{663}= optical density at 663nm, A_{645}= optical density at 645nm, D= dilution.

Table 1 Okra genotypes used in the experiment, its source and fruit characters

Genotype	Source	Fruit characters
BO-13	IIVR, Varanasi	Five ridges, green fruited, medium fruit pubescence and yellow petal colour
Pusa Makhmali	IARI, New Delhi	Five ridges, light green fruited, weak fruit pubescence and yellow petal colour
Kashi Pragati	IIVR, Varanasi	Five ridges, green fruited, medium fruit pubescence and yellow petal colour
Kashi Mohini	IIVR, Varanasi	Five ridges, light green fruited, medium fruit pubescence and yellow petal colour
Pusa Sawani	IARI, New Delhi	Five ridges, light green fruited, weak fruit pubescence and yellow petal colour
Punjab-8 (EMS-8)	PAU, Ludhiana	Five ridges, green fruited, medium fruit pubescence and yellow petal colour
Kashi Lalima	IIVR, Varanasi	Five ridges, red fruited, medium fruit pubescence and red petal colour
VROB-159	IIVR, Varanasi	Five ridges, red fruited, medium fruit pubescence and red petal colour
SB-2	IIVR, Varanasi	Five ridges, light green fruited, medium fruit pubescence and yellow petal colour
307-10-1	IIVR, Varanasi	Five ridges, green fruited, medium fruit pubescence and yellow petal colour
Kashi Kranti	IIVR, Varanasi	Five ridges, dark green fruited, weak fruit pubescence and yellow petal colour.
Kashi Satdhari	IIVR, Varanasi	Seven ridges, green fruited, strong fruit pubescence and yellow petal colour
CO-3	TNAU, Coimbatore	Five ridges, green fruited, medium fruit pubescence and yellow petal colour
IC-14909	NBPGR, New Delhi	Five ridges, light green fruited, medium fruit pubescence and yellow petal colour
VROB-178	IIVR, Varanasi	Five ridges, green fruited, medium fruit pubescence and yellow petal colour
Arka Anamika	IIHR, Bengaluru	Five ridges, light green fruited, medium fruit pubescence and yellow petal colour
IBS-02	IIVR, Varanasi	Five ridges, light green fruited, medium fruit pubescence and yellow petal colour
VRO-109	IIVR, Varanasi	Five ridges, light green fruited, medium fruit pubescence and yellow petal colour
Azad Bhindi-1	CSAUA&T, Kanpur	Five ridges, green fruited, medium fruit pubescence and yellow petal colour
VRO-106	IIVR, Varanasi	Five ridges, dark green fruited, medium fruit pubescence and yellow petal colour

Carotenoids content

The protocol standardized by Roy (1973) with slight modifications was used for estimation of carotenoid content. Sample of about 5 g was continuously crushed with mortar and pestle in 80% acetone till colour disappears. Then, the liquid portion was separated from solid portion by using separating funnel. Later on, coloured solution was separated in 50 ml volumetric flask and required volume was maintained by adding the petroleum ether. Finally, the absorbance of sample was measured in spectrophotometer at 452 nm wavelength. The amount of carotenoid content was measured in mg/100 g fruit weight.

$$\text{Total carotenoids (mg carotene/100g)} = \frac{3.857 \times \text{Absorbance} \times \text{Vol. made up} \times \text{Dilution} \times 100}{\text{Weight of sample} \times 1000}$$

Anthocyanin content

The estimation of total anthocyanin content was carried out in methanolic HCl, by adopting the procedure described by Ranganna (1977). In this method, 1 g of crushed sample was dissolved in 10 ml of Methanolic HCl [85 ml ethanol+15 ml 1(N) HCl for 100 ml Methanolic HCl] then transferred it into test tube and kept in cool place for 3 days. After that, 1 ml of strained sample taken and then UV absorption was measured against prepared reagent blank (85% of Methanolic HCl) at 535 nm. The anthocyanin content was calculated as mg 100 g^{-1} fresh weight basis as per the given below formula:

$$\text{Total OD per 100 g of smaple} = \frac{\text{OD} \times \text{Volume made up} \times 100}{\text{Weight of sample}}$$

$$\text{Total anthocyanin content (mg/100g)} = \frac{\text{Total OD per 100g}}{98.2}$$

Total phenol content

Folin–Ciocalteu reagent based on spectrophotometer absorbance was used for estimation of total phenol content (Singleton *et al*. 1999). Grinding of sample with the help of mortar and pestle was done in acidic methanol. After that, took the aliquot and final solution of sample was prepared by adding 2.9 ml deionized water, 0.5 ml Folin–Ciocalteu reagent and 2.0 ml of 20% Na_2CO_3 solution in 100 µl extract (80% ethanol) and kept it for 90 min. The absorbance was measured at 760 nm (Varian Cary 50) against reagent blank. The total phenol content was articulated as mg/100g fresh weight catechol equivalent.

Crude fibre content

Dry sample (crude fiber) was determined by using AOAC (2005) method. The sample (1 g) was taken from fat free material and boil with 1.25% dilute H_2SO_4 then washed with water and again boiled with 1.25% dilute sodium hydroxide. After that, transferred the residue in weighed crucible (W_1) and dried it overnight at 80°C-100°C. The crucible was heated in muffle furnace at 600°C for 2-3 hr and then cooled in desiccators. After cooling, weighed the crucible (W_3) and the left over residue after digestion was treated as crude fiber (%).

Moisture content

The sample was prepared using 100g fresh pods, chopped them properly and kept it in oven at 80°C for drying, till to obtain the constant weight. Then, cooled this dried sample in desiccators and the moisture content of pods was calculated separately with the following formula.

$$\text{Moisture (\%)} = \frac{\text{Fresh weight}}{\text{Dry weight}} \times 100$$

Statistical analysis

The statistical analysis was carried out using analysis of variance procedures suggested by Fisher (1948). The values at 1% and 5% level of significance were treated as significant. The phenotypic and genotypic coefficient of variation was calculated by adopting the formula suggested by Burton (1952). The broad sense Heritability (h^2b) was calculated using standard formula given by Burton and Devane (1953). The expected genetic advance was calculated by following the formula as described by Johnson *et al*. (1955). Phenotypic and genotypic correlation coefficients were computed by adapting the formula given by Al- Jibouri *et al*. (1958). To calculate the genetic advance as per cent of mean (GA% M) the following formula was used.

$$\text{Genetic advance as per cent of mean} = \left(\frac{GA}{\overline{X}}\right) \times 100$$

where, GA = Genetics advance, $\overline{X}$ = Mean of a character.

RESULTS AND DISCUSSION

Chlorophyll 'a'

Among different plant pigments, chlorophyll is most valued due to its role in photosynthesis.

Among all genotypes, highest chlorophyll 'a' content was observed in Kashi Kranti (3.85mg/100g FW) followed by VRO-106 (3.75mg/100g FW), Azad Bhindi-1 (3.73mg/100g FW) and IC-14909 (2.18mg/100gm FW), while Kashi Lalima was devoid of chlorophyll pigment (Table 2). The average value of all treatment for chlorophyll pigment was 1.18mg/100g FW. The phenotypic and genotypic coefficient of variation for this trait was 114.34 and 114.32%, respectively with very high broad sense heritability (99.97%) coupled with high genetic advance as per cent of mean (235.48) and very low expected mean for next generation (4.13) (Table 3). These results were similar to findings of Rai and Balasubramanian (2009) with significantly higher values of chlorophylls content (60mg $100g^{-1}$ FW) probably due to differences in genotype and/ or pod size at harvest stage.

Table 2 Mean performance of 20 okra genotype for 9 quantitative biochemical characters

Genotype	Chlorophyll a (mg/100 g FW)	Chlorophyll b (mg/ 100 g FW)	Total Chlorophyll content (mg/100g FW)	Total carotenoids content (mg/100g FW)	Anthocyanin content (mg/100 gm FW)	Ascorbic acid content (mg/100 g FW)	Total phenolics content (mg catechol equivalent/ 100g FW)	Crude fiber content (%)	Moisture content (%)
BO-13	0.16	0.14	0.30	0.87	0.00	10.32	50.49	3.20	79.46
Pusa Makhmali	0.23	0.22	0.45	1.67	0.00	12.12	42.14	2.00	93.12
VRO-6	0.65	0.40	1.05	1.63	0.00	10.79	48.82	3.50	80.14
Kashi Mohini	0.23	0.23	0.46	1.03	0.00	12.75	45.21	2.20	82.19
Pusa Sawani	0.47	0.37	0.84	1.45	0.00	11.89	46.17	2.50	92.30
Punjab-8	0.46	0.35	0.81	1.02	0.00	11.84	46.60	4.10	88.55
Kashi Lalima	0.00	0.00	0.00	0.63	0.14	19.63	41.87	1.30	81.85
VROB-159	0.90	0.62	1.52	1.13	0.00	12.07	46.08	4.10	87.79
SB-2	0.68	0.44	1.12	1.25	0.00	12.92	50.59	1.60	91.78
307-10-1	1.28	0.78	2.06	1.06	0.00	14.73	38.88	1.90	82.80
Kashi Kranti	3.85	1.90	5.75	1.71	0.00	18.66	43.62	2.10	91.89
Kashi Satdhari	0.37	0.23	0.60	1.64	0.00	12.43	38.98	4.40	82.23
CO-3	0.67	0.58	1.25	1.69	0.00	13.95	41.17	2.60	85.78
IC-14909	2.18	1.06	3.24	1.56	0.00	13.61	51.34	3.20	92.71
VROB-178	0.01	0.01	0.02	0.65	0.08	14.30	62.82	2.60	93.16
Arka Anamika	1.93	1.23	3.16	1.29	0.00	13.80	44.90	3.20	87.93
IBS-02	1.61	0.35	1.96	1.14	0.00	13.85	44.27	2.60	91.18
VRO-109	0.38	0.09	0.47	0.25	0.00	16.72	44.67	1.50	92.03
Azad Bhindi-1	3.73	1.67	5.40	1.48	0.00	14.96	46.83	2.60	82.29
VRO-106	3.75	1.87	5.62	1.65	0.00	13.85	41.98	2.30	87.42
General mean	1.18	0.63	1.80	1.24	0.01	13.76	45.87	2.68	87.33
Range lowest	0.00	0.00	0.00	0.25	0.00	10.32	38.88	1.30	79.46
Range highest	3.85	1.90	5.75	1.71	0.14	19.63	62.82	4.40	93.16
CV (%)	1.81	5.04	2.57	1.33	4.59	4.42	0.92	4.02	2.27
SEm±	0.01	0.02	0.03	0.01	0.00	0.35	0.24	0.10	1.14
LSD (P=0.05)	0.04	0.06	0.08	0.04	0.00	1.00	0.70	0.20	3.27

Chlorophyll 'b'

The results showed that maximum chlorophyll 'b' was in Kashi Kranti (1.90mg/100gm FW) followed by VRO-106 (1.87mg/100g FW), Azad Bhindi-1 (1.67mg/100g FW) and IC-14909 (1.06 mg/100g FW), whereas it was absent in Kashi Lalima (Table 2). The overall mean value of chlorophyll 'b' recorded as 0.63 mg/100g FW. The phenotypic and genotypic coefficient of variation was 106.45% and 106.33%, respectively. The high heritability in broad sense (99.78%) coupled with high genetic advance as per cent of mean (218.80) and very low expected mean for next generation (2.12mg/100g) were observed for this character (Table 3). These were similar to the findings of Petropoulos *et al.* (2018) as reported increased chlorophyll content.

Total chlorophyll content

With respect to total chlorophyll content, Kashi Kranti was superior performer (5.75 mg/100g FW) succeeded by VRO-106 (5.62mg/100g FW), Azad Bhindi-1 (5.40mg/100g FW) and IC-14909 (3.24mg/100g FW), while Kashi Lalima was lacking in total chlorophyll content. The overall mean value of total chlorophyll reported as 1.80mg/100g FW (Table 2). They also reported the phenotypic and genotypic coefficient of variation of 110.87% and 110.84%, respectively with high broad sense heritability (99.95%) and coupled with high genetic advance as per cent of mean (228.27) and very low expected mean for next generation (6.23) for this trait (Table 3). Piloo and Kabir (2011) also described that dark green varieties are rich in chlorophyll content, total carotenoids content and fiber content.

Total carotenoids content

Carotenoids are naturally occurring orange, yellow and red pigments having good antioxidant property and protect human body against cellular damage, the effects of aging, and even some chronic diseases. Among all genotypes, Kashi Kranti (1.7mg/100gm FW) denoted

Table 3 GCV, PCV, heritability, genetic advance as percentage of mean and expected mean next generation for 9 quantitative characters in okra

Character	General mean	Range		GCV (%)	PCV (%)	h² (Broad sense) %	Gen. Adv. as % of mean (5%)	Exp. mean next generation
		Lowest	Highest					
Chlorophyll 'a' (mg/100g FW)	1.18	0.00	3.85	114.32	114.34	99.97	235.48	4.13
Chlorophyll 'b' (mg/100g FW)	0.63	0.00	1.90	106.33	106.45	99.78	218.80	2.12
Total Chlorophyll content (mg/100g FW)	1.80	0.00	5.75	110.84	110.87	99.95	228.27	6.23
Total carotenoids content (mg/100g FW)	1.24	0.25	1.71	64.97	64.98	99.96	133.80	4.33
Anthocyanin content (mg/100g FW)	0.01	0.00	0.14	366.02	366.05	99.98	753.95	0.08
Ascorbic acid content (mg/100g FW)	13.76	10.32	19.63	16.87	17.44	93.59	33.62	18.37
Total phenolics content (mg CE /100g FW)	45.87	38.88	62.82	11.66	11.70	99.38	23.95	56.86
Crude fiber content (%)	2.68	1.30	4.40	32.86	33.11	98.53	67.19	0.44
Moisture content (%)	87.33	79.46	93.16	5.39	5.84	84.94	10.23	96.26

the highest total carotenoids contents followed by CO-3 (1.69 mg/100g FW), Pusa Makhmali (1.67mg/100g FW) and VRO-106 (1.65mg/100g FW), whereas lowest was in VRO-109. The overall mean value of total carotenoids content was 1.24 mg/100g FW (Table 2). Similarly, Piloo and Kabir (2011) described that the dark green varieties are rich in total carotenoids content. The coefficient of variation for genotype and phenotype was 64.98 % and 64.97%, respectively. The broad sense heritability for this trait was very high (99.96%) which coupled with high genetic advance as per cent of mean (133.80) and very low expected mean for next generation (4.33) (Table 3).

Anthocyanin content

Anthocyanin is responsible for purple colour of the fruits. Kashi Lalima (0.14mg/100g FW) showed the maximum anthocyanin content which was succeeded by VROB-178 (0.08mg/100g FW) while remaining genotypes did not have anthocyanin content. The overall mean value of anthocyanin content was 0.01mg/100g FW (Table 2). The phenotypic and genotypic coefficient of variation reported up to 366.05% and 366.02%, respectively. The broad sense heritability was very high (99.98%) along with high genetic advance as per cent of mean (753.95) and very low expected mean for following generation (0.08) were observed for this trait (Table 3).

Ascorbic acid content

Ascorbic acid is an imperious factor of the anti-oxidative defense mechanism in cells and tissues and acts as reducing and a chelating agent. The highest ascorbic content was observed in Kashi Lalima (19.63mg/100g FW) followed by Kashi Kranti (18.66mg/100g FW) and VRO-109 (16.72mg/100g FW), while lowest was observed in BO-13. The average amount of ascorbic content was 13.76mg/100g FW (Table 2). The phenotypic and genotypic coefficient of variation was 17.44 and 16.87%, respectively. The high heritability in broad sense (93.59%) coupled with high genetic advance as per cent of mean (33.62) and low expected mean for next generation (18.37) were observed for this character (Table 3). Solankey and Singh (2009) reported similar variation for ascorbic acid content in okra.

Total phenolics content

The antioxidant activities in biological system are mainly due to presence of phenolic compounds which acts as scavengers for singlet oxygen and free radicals (Rice *et al*., 1997). Among the 20 genotypes,VROB-178 (62.82mg catechol equivalent/100g FW) expressed the maximum total phenolics content followed by IC-14909 (51.34mg CE/100gm FW), SB-2 (50.59mg CE/100gm FW) and BO-13 (50.49mg CE/100g FW) but the minimum was reported in 307-10-1(Table 2). The average value of total phenolics content was 45.87mg CE/100g FW. The phenotypic and genotypic coefficients of variation were expressed as 11.70% and 11.66%, respectively. This trait also showed high heritability in broad sense (99.38%) coupled with high genetic advance as per cent of mean (23.59) and expected mean for subsequent generation (56.86) (Table 3). Nwachukwu *et al*. (2014) reported the parallel outcomes in Malaysian variety and suggested that phenolic content is influenced by stage of maturity as they found lowest phenolic content in mature fruits.

Crude fiber content

The results showed that lowest crude fiber content was observed in Kashi Lalima (1.3%) followed by VRO-109 (1.5%), SB-2 (1.6%) and 307-10-1 (1.9%), whereas highest was detected in Kashi Satdhari. It is clearly indicated that the seven ridges varieties having more crude fiber content than five ridges varieties. Moreover, the variety Kashi Lalima which has more anthocyanin on the place of chlorophyll is resulting that more anthocyanin content directly reduces the crude fiber content in okra pods. Similar discoveries were reported by Pillo and Kabir (2011).The overall mean value of crude fiber content was 2.7% (Table 2). The phenotypic and genotypic coefficient of variation was 33.11% and 32.86%, respectively. The high heritability in broad sense (98.53%) united with high genetic advance as per cent of mean (67.19)

and very low expected mean for next generation (0.44) were observed for this trait (Table 3).

Moisture content

The results expressed that moisture content ranged from 79.46% (BO-13) to 93.16% (VROB-178) with over all mean value of 87.33%. VROB-178 showed the highest moisture content which was in consonance with Pusa Makhmali, Pusa Sawani, SB-2, Kashi Kranti, IC-14909, IBS-02 and VRO-109 (Table 2). The phenotypic and genotypic coefficient of variation was 5.84% and 5.39%, respectively. The heritability in broad sense (84.94%) was high with moderate genetic advance as per cent of mean (10.23%) for this trait. However, the expected mean for succeeding generation was high (96.26%) (Table 3). These outcomes were analogous with findings of Nwachukwu *et al.* (2014) as they reported the higher moisture content in young okra pod.

Correlation coefficient among the different phytochemicals

Chlorophyll content showed positive and highly significant correlation (Table 4) with total carotenoids content while, negative and significant correlation with anthocyanin content. Total carotenoids content expressed negative and showed highly significant association with total phenolics content moreover, it exhibited negative and significant correlation with anthocyanin content. Highly significant and positive correlation found between anthocyanin and ascorbic acid content while negative and highly significant association reported between anthocyanin and crude fiber content. Crude fiber content expressed negative and significant correlation with moisture content (rg= -0.218). It is suggesting that the anthocyanin increase the fruit tenderness or reduces the crude fiber content in okra pods. Similar pattern of correlation in okra were also reported by Binalfew and Alemu (2016).

The above findings concluded that considerable variability is present among 20 selected okra genotypes with respect to their colour (pigments), phytochemical properties and fiber content. The genotypes with red colour were rich in anthocyanin and phytochemicals especially ascorbic acid and total phenolics content, whereas the green fruited genotypes were rich in chlorophyll, total carotenoids content, moisture content and crude fiber content. Therefore, the existing variability offers an opportunity to improve the phytochemical properties of okra. Moreover, these genotypes will be very useful for improvement of the quality traits in okra with respect to nutritional point of view. These results also exposed that most of biochemical compounds decrease in its quantity from young fruits to mature fruits which may be due to aging and ripening. It leads to reduction in antioxidant activity. Hence, nutritional point of view fruits should be harvested at optimum maturity stage.

Table 4 Phenotypic (rp) and genotypic (rg) correlation coefficients for 9 characters in 20 okra genotypes

Character		Chlorophyll a (mg/100g FW)	Chlorophyll b (mg/100g FW)	Total Chlorophyll content (mg/100g FW)	Total carotenoids content (mg/100g FW)	Anthocyanin content (mg/100g FW)	Ascorbic acid content (mg/100g FW)	Total phenolics content (mg CE /100g FW)	Crude fiber content (%)	Moisture content (%)
Chlorophyll 'a' (mg/100g FW)	rp	0.972**	0.997**	0.513**	-0.252*	0.280*	-0.182	-0.064	0.086
	rg	0.973**	0.997**	0.513**	-0.252*	0.289*	-0.182	-0.065	0.093
Chlorophyll 'b' (mg/100g FW)	rp		0.988**	0.555**	-0.270*	0.215*	-0.214	-0.031	0.054
	rg		0.988**	0.556**	-0.270*	0.222*	-0.215*	-0.032	0.061
Total Chlorophyll content (mg/100g FW)	rp			0.530**	-0.259*	0.260*	-0.194	-0.053	0.076
	rg			0.530**	-0.259*	0.268*	-0.194	-0.054	0.083
Total carotenoids content (mg/100g FW)	rp				-0.264*	0.176	-0.323**	0.011	0.154
	rg				-0.264*	0.182	-0.324**	0.011	0.166
Anthocyanin content (mg/100g FW)	Rp					0.585**	0.004	-0.372**	-0.183
	Rg					0.605**	0.004	-0.375**	-0.201
Ascorbic acid content (mg/100g FW)	Rp						-0.208	-0.595**	0.139
	rg						-0.219*	-0.623**	0.133
Total phenolics content (mg CE /100g FW)	rp							0.096	0.274*
	rg							0.097	0.303**
Crude fiber content (%)	rp								-0.203
	rg								-0.218*

*, ** Significant at 5 % and 1 % probability level, respectively.

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