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Genetic diversity analysis for fruit quality traits and nutrient composition in different horticultural groups of muskmelon

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ABSTRACT

Sixty seven muskmelon genotypes from three horticultural groups were analysed for 13 fruit quality traits including 9 minerals. The range of variation was about 8-10 times for many fruit quality traits such as total caretonoids, P, K, Ca, Mg, Na, Zn, Mn, Cu and Fe contents, which reflect the high selection prospects for these traits to improve the performance through breeding programme. Sixty seven genotypes were classified into 13 distinct clusters based on 13 fruit quality traits. Cluster I comprised of maximum number of genotypes (26) mostly *inodorous* type and the mean value of this cluster for many quality traits was also high. The second largest cluster XIII consisted of 19 genotypes comprised *cantaloupensis* type and all 6 commercial Indian varieties were grouped together in this cluster. Based on higher genetic distance among clusters and higher mean value of genotypes for quality traits, yield and TSS, DM-31, DM-145, DM-159 and DM-162, DM-56 genotypes from cluster I and Pusa Madhuras, Kashi Madhu and Punjab Sunheri from cluster group XIII could be exploited in breeding programmes as potential donors for developing nutrient-rich muskmelon varieties.

Key words: *Cucumis melo*, *Cantaloupensis*, *inodorous*, quality, variability.

INTRODUCTION

Muskmelon (*Cucumis melo* L.; 2n = 24) is one of important vegetables for summer which is being grown for their edible fruits in most of the frost free regions of the world. Muskmelon is highly relished as dessert because of its attractive and unique aromatic musky flavour, sweet taste and being a rich source of vitamins and nutrients (Munshi and Choudhary, 5). It is often regarded as a health food because of its low calorie content and presence of many vitamins and other phytonutrients. Muskmelon fruits contain about 95% water that keeps body hydrated and acts as diuretic. African continent especially eastern region of south Sahara desert was generally regarded as the centre of origin of muskmelon. However, recent studies showed that both cucumber and muskmelon are of Asian origin and wide diversity of wild species of *Cucumis melo* L. exists in India and China (Sebastian *et al*., 9).

Multivariate analysis of elite genotypes is prerequisite for choosing promising genetically diverse lines for improvement of specific traits. Study of genetic diversity in muskmelon may play significant role in identification of desirable genotypes which will be helpful in development of variety/hybrids and pre breeding lines with higher nutritional content. In the past, limited attempt has been made to estimate genetic divergence in muskmelon genotypes for fruit quality traits and nutritional content. Hence, this study was carried out for assessment of genetic diversity in nutritional composition and other fruit quality traits among different horticultural groups of muskmelon genotypes to indentify genotypes rich in specific nutrient which can be utilized in future breeding programme.

MATERIALS AND METHODS

A total of 67 genotypes from three different horticultural groups including 36 accessions procured through NBPGR New Delhi and six commercially popular Indian varieties, viz., Durgapura Madhu, Kashi Madhu, Pusa Madhuras, Hara Madhu, Arka Jeet and Punjab Sunheri were taken for this study. It comprised of 20 accessions from *C. melo* var. *inodorous*, 45 from *C. melo* var. *cantaloupensis* and 2 from *C. melo* var. *momordica*. This experiment was conducted in a randomized block design with three replications during the Feb-June season of 2014. Seeds were sown on both sides of channels on well prepared hills with a spacing of 2 m in between channels and 60 cm between hills. Twenty plants per genotype in each replication were maintained. Fruits were cut into two halves and flesh from a composite samples of five random fruits were taken for analysis of 9 mineral content (P, K, Ca, Mg, Na, Zn, Mn, Cu and Fe) and 4 other quality traits (TSS, acidity, vit. C and total carotenoids). The samples were dried at 65°C in hot-air oven for 72 h and then grinded for making powder which were used for

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the estimation of nutrient content. Nutrient content was estimated according to standard procedure of analytical methods (AOAC, 1). Phosphorus was determined by vanado-phosphomolybdate yellow colour method using spectrophotometer (Elico-Mini Spec SL 171, India). Potassium and sodium were estimated by using flame photometer (Systronics, India limited). Calcium and magnesium content in fruit samples was determined by atomic absorption spectrophotometer (Model-Analytikjena ZEEnit 760, Germany) according to (Jackson, 3). Different micronutrients copper, iron, manganese and zinc content in fruits were estimated from diacid digested fruit samples by using Inductively Coupled Plasma Mass Spectrometry (ICP-MS (Model NexION 300X, Perkin Elmer, USA). The concentration of all phytonutrients was expressed in mg/100g (dry weight basis). Total soluble solids (TSS, expressed as °Brix) were measured from fruit juice using a digital hand refractometer. Titrable acidity (%) was determined by titration of a fruit juice sample with 0.05 N NaOH, using phenolphthalein as indicator. Total carotenoids were estimated by the method described by (Thomas and Joshi, 10). Statistical analyses like ANOVA, principal component analysis (PCA) were performed using Statistical Analysis Software, Version 9.2 (SAS, 8). The sample similarities were calculated on the basis of pair-wise Euclidean distance and the unweighted pair-group method with arithmetic averaging (UPGMA) algorithm was used for establishing cluster to search natural groupings among the genotypes for nutrient content.

RESULTS AND DISCUSSION

Analysis of variance showed highly significant mean sum of square due to treatments for 13 fruit quality traits including TSS, acidity and mineral contents and fruit yield indicating substantial amount of genetic diversity in the genetic materials used for this study. The range of variation was about 8-10 times for many fruit quality traits such as total carotenoids (16.52-192.93 µg/100 g), P (4.45-28.72 mg/100 g), K (25.80-235.26 mg/100 g), Ca (3.13-29.22 mg/100 g), Mg (3.13-29.22 mg/100 g), Zn (0.15-1.93 mg/100 g), Mn (0.15-1.44 mg/100 g), Cu (0.08-0.85 mg/100 g) and Fe (0.12-1.92 mg/100 g) content, which reflect the high selection prospects for these traits to improve the performance through breeding programme. Total soluble solids (TSS) is one of most important fruit quality traits which range (data is not presented) from 5.50˚Brix (IC274026 from *C. melo* var. *momordica*) to 15.67˚Brix (DM-56 from *C. melo* var. *inodorous*) with a mean of 10.82, which indicated wide range of diversity for this trait in the population under study as well as presence of large number of genotypes with higher TSS. Snapmelon genotypes (DSM-11, IC 274026) showed the highest level of acidity (0.22%), while lower range was recorded for *C. melo* var. *inodorous* genotypes (DHM-149; 0.06%, DM-56; 0.07%) and it also indicated that variability for acidity was low. The range for total carotenoids was varied more than 10 times from 16.52 µg/100 g (Durgapura Madhu) to 192.93 µg/100 g (DM-162). Fruits with orange coloured flesh were high in carotenoids content while fruits with green or white flesh colour were having lower carotenoids content. The vitamin C content was ranged from 11.2 mg/100 g (DM-54 from *C. melo* var. *cantaloupensis)* to 25.0 mg/100 g (DMDR-1). Potassium (mg/100 g) content ranged from 25.80 mg/100 g (DM-6) to 235.26 mg/100 g (DM-153). The lowest sodium (mg/100 g) content was recorded in DM-31 and the highest ratio of K/Na was also recorded by DM-31. High phosphorus content was recorded in several genotypes, *viz.* DM-7 (28.72 mg/100 g) and DM-12 (27.63 mg/100 g). Calcium (mg/100 g) content was found maximum in genotype DM-147 (29.22 mg/100 g). There was moderate amount of Mg content among the genotypes under study which ranged from DM-2 (7.82 mg/100 g) to DM-31 (26.19 mg/100 g). The genotypes Durgapura Madhu (1.93 mg/100 g), DM-155 (1.9 mg/100 g), DM-36 (1.86 mg/100 g), DM-174 (1.84 mg/100 g) and DM-169 (1.83 mg/100 g) had high value of zinc content. High iron content was recorded in genotypes DM-7 (1.92 mg/100 g), DM-145 (1.75 mg/100 g) and Pusa Madhuras (1.67 mg/100 g). Most of the genotypes recorded lower content of Cu and Mn. The genotypes, DM-7, DM-145 and Pusa Madhuras were found to be superior for iron content, whereas DM-31 was found superior for sodium content. Commercial variety, Durgapura Madhu was found to be superior for zinc, while Arka Jeet was found superior for manganese and DM-45 and Pusa Madhuras for copper content. The values of sodium, zinc, manganese, copper and iron contents obtained in the present study were consistent with the earlier report (Lester, 4).

For an initiation of successful breeding programme, it is desirable to select genetically divergent suitable parents based on information about the genetic variability and genetic diversity present in the available germplasm. Sixty seven muskmelon genotypes were classified into 13 distinct clusters using D^2 statistics based on 13 fruit quality traits. Among 13 clusters (Table 1), Cluster I comprised of maximum number of genotypes (26) and most of them (15) belong to *inodorous* type. The second largest cluster XIII consist of 19 genotypes belong to *cantaloupensis* type and all 6 commercial Indian varieties could be grouped together in this cluster. All other 11 clusters consisted of 2 genotypes in each. Two snapmelon (*C. melo*

Table 1. Clustering pattern of 67 muskmelon genotypes based on fruit quality traits.

Cluster	No.	Genotypes
I	26	DM-31, DM-35, DM-38, DM-54, DM-55, DM-56, DM-145, DM-143, DM-144, DM-146, DM-150, DM-152, DM-147, DM-153, DM-156, DM-159, DM-160, DM-162, DM -163, DM-169, DM-2, DM-3, DM-4, DM-5, DM-6, DM-175
II	2	M-2, DM-172
III	2	DM-10, DM-180
IV	2	DM-20, DM-173
V	2	Ananas, DM-154
VI	2	DM-151, DM-17
VII	2	DM-177, DM-178
VIII	2	DM-170, DM-176
IX	2	DSM-11, IC274026
X	2	DM-16, DM-18
XI	2	DM-19, DM-171
XII	2	DM-148, DM-15
XIII	19	DM-7, DM-8, DM-11, DM-12, DM-13, DMDR-1, DM-14, Kashi Madhu, Hara Madhu, MS-1, ArkaJeet, Punjab Sunheri, DM-46, Durgapura Madhu, Pusa Madhuras, DM-149, DM-155, DM-174, DM-36

var. *momordica*) genotypes DSM-11, IC274026 could be grouped together in a separate cluster IX. Amongst fruit quality attributes (Table 2), iron content (36.05%), total carotenoids (12.21%), manganese content (10.63%), potassium content (10.58%) and TSS (5.02%) contributed mainly for the genetic divergence. Among the 13 clusters, cluster XIII showed the highest intra cluster distance (41.75) and possessing 19 genotypes followed by the cluster I (37.17) having 26 genotypes (Table 3). It reflected the existence of maximum distance among the genotypes of cluster XIII, which consisted all 6 Indian commercial cultivars and 13 other genotypes from *cantalouensis* group. Based on inter-cluster distance the maximum diversity was observed between clusters XIII and

Table 2. Contribution of different fruit quality traits towards genetic diversity.

Trait	First rank	Contribution (%)
Total soluble solids (°Brix)	111	5.02
Acidity (%)	58	2.62
Vitamin C (mg/100 g)	26	1.18
Total carotenoids (µg/100 g)	270	12.21
Phosphorus (mg/100 g)	27	1.22
Potassium (mg/100 g)	234	10.58
Calcium (mg/100 g)	97	4.39
Magnesium (mg/100 g)	8	0.36
Sodium (mg/100 g)	36	1.63
Zinc (mg/100 g)	272	12.3
Manganese (mg/100 g)	235	10.63
Copper (mg/100 g)	40	1.81
Iron (mg/100 g)	797	36.05
Total	2211	100

Table 3. Average intra- (bold face) and inter-cluster distance (D^2) among muskmelon genotypes.

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
I	**37.17**	32.18	36.65	35.63	36.49	33.98	32.56	31.42	45.52	36.39	31.55	32.85	41.35
II		**8.76**	24.25	14.16	13.29	12.18	20.85	18.05	28.66	19.46	19.96	12.65	41.41
III			**9.60**	21.11	20.57	24.70	26.41	17.93	24.96	25.88	19.06	25.52	46.78
IV				**9.82**	11.53	15.37	23.49	19.21	22.29	18.67	20.68	15.49	44.45
V					**9.94**	12.84	21.69	20.23	20.77	17.30	22.67	15.79	45.55
VI						**9.97**	14.86	17.00	27.09	13.95	22.25	15.04	43.06
VII							**11.23**	18.02	31.91	16.23	24.44	20.20	40.66
VIII								**11.60**	31.41	21.02	14.28	21.07	41.60
IX									**13.82**	23.59	35.43	27.91	53.09
X										**14.30**	27.37	18.88	44.28
XI											**15.46**	22.96	41.34
XII												**16.53**	41.16
XIII													**41.75**

IX (53.09), followed by clusters XIII and III (46.78), clusters XIII and V (45.55), clusters IX and I (45.52) and clusters XIII and IV (44.45), suggesting that the genotypes belonging to above clusters are more divergent, hence, can be undertaken in hybridization programme. Based on fruit quality traits, genotypes from *inodorous, cantaloupensis* and *momordica* could be broadly grouped in distinct clusters. Therefore, cluster analysis was useful in forming core subsets for grouping the genotypes with similar characters into homogeneous categories. Grouping of muskmelon genotypes on the basis of yield traits have been reported by Reddy *et al.* (6), Tomar *et al.* (11) and Rukam *et al*. (7), but grouping based on fruit quality traits could not be found. However, variability of cucumber germplasm for nutrients composition have been reported by Arivalagan *et al.* (2). In general, the genotypes grouped together in one cluster were less divergent for quality traits than those which were placed in different clusters. Further, higher intra-cluster distance indicates high degree of divergence within that cluster. The genotypes of cluster I (Table 4) recorded maximum total soluble solids (11.53˚Brix) followed by cluster XI (11.50˚Brix), cluster VIII (11.35˚Brix), while cluster III (8.18˚Brix) recorded minimum total soluble solids. Cluster IX recorded maximum acidity (0.22%), while cluster I recorded minimum acidity (0.11%); cluster XIII recorded maximum vitamin C (15.15 mg/100 g), while cluster III recorded minimum (12.60 mg/100 g); the higher total carotenoids was found in cluster III (163.52 µg/100 g), while it was lower in cluster IV (71.87 µg/100 g). Cluster XIII recorded the maximum calcium content (15.67 mg/100 g), while cluster V recorded the minimum calcium content (4.19 mg/100 g). The higher and lower sodium content were found in clusters VII (8.69 mg/100 g) and IX (4.30 mg/100 g), respectively. Cluster XIII recorded the maximum zinc content (1.11 mg/100 g), while clusters VI and VIII had minimum zinc content (0.20 mg/100 g); cluster XI recorded the maximum manganese content (0.90 mg/100 g), while cluster × recorded minimum manganese content (0.25 mg/100 g). The higher and lower iron content was found in clusters XIII (0.87 mg/100 g) and cluster VI (0.18 mg/100 g), respectively. In general, no two clusters taken together had the similar pattern for all the traits indicating wide diversity in the experimental material for majority of the traits. For getting better heterosis, the genotypes from higher degree of divergence with high mean performance may be the best combination of parents for improvement of various economic characters. Thus, genotypes from cluster I and XIII consisted of better yield and fruit quality traits may be utilized for heterosis breeding.

Table 4. Cluster means of 13 fruit quality traits in muskmelon.

Cluster	Total soluble solids (°Brix)	Acidity (%)	Vitamin C (mg/100g)	Total carotenoids (µg/100 g)	P (mg/100g)	K (mg/100g)	Ca (mg/100g)	Mg (mg/100g)	Na (mg/100g)	Zn (mg/100g)	Mn (mg/100g)	Cu (mg/100g)	Fe (mg/100g)
I	11.53	0.11	14.82	119.40	10.43	111.18	13.66	14.70	5.48	0.70	0.77	0.22	0.54
II	10.40	0.12	13.40	37.80	7.93	88.74	7.61	11.02	4.48	0.30	0.80	0.14	0.36
III	8.18	0.17	12.60	163.52	7.37	45.26	5.80	9.25	5.04	0.30	0.82	0.15	0.25
IV	9.87	0.16	14.90	35.49	6.41	34.52	10.00	13.39	5.32	0.35	0.78	0.17	0.38
V	8.47	0.14	13.10	39.62	9.17	50.34	4.19	10.95	6.03	0.30	0.70	0.11	0.31
VI	10.28	0.12	14.10	45.11	8.96	72.87	7.30	14.02	6.50	0.20	0.47	0.13	0.18
VII	10.52	0.12	14.40	102.02	11.37	84.53	14.04	17.46	8.69	0.31	0.28	0.14	0.21
VIII	11.35	0.13	15.10	133.53	7.51	61.64	9.27	12.17	4.71	0.20	0.56	0.17	0.22
IX	5.52	0.22	13.08	40.26	7.08	55.23	9.44	11.58	4.30	0.34	0.53	0.11	0.24
X	9.85	0.16	14.70	49.47	7.43	89.55	9.92	15.28	8.15	0.24	0.25	0.14	0.23
XI	11.50	0.12	15.00	138.17	6.67	44.31	6.75	10.81	5.95	0.41	0.90	0.20	0.38
XII	10.00	0.14	13.60	41.24	8.95	86.30	12.44	16.67	6.68	0.30	0.80	0.21	0.48
XIII	11.22	0.12	15.15	99.82	13.52	119.13	15.67	16.59	5.73	1.11	0.64	0.39	0.87

Table 5. Principal component analysis for 67 muskmelon genotypes based on fruit quality traits.

Parameter	PC 1	PC 2	PC 3	PC 4	PC 5
Cumulative Eigen value	4.10	2.70	1.41	1.20	1.08
Explained variation (%)	29.27	19.29	10.06	8.57	7.74
Cumulative explained variation (%)	29.27	48.57	58.63	67.20	74.94
Trait			Eigen value		
Total soluble solids (°Brix)	0.23	0.89	0.23	-0.16	-0.08
Acidity (%)	-0.24	-0.82	-0.07	0.22	-0.08
Vitamin C (mg/100 g)	0.04	0.69	0.36	0.03	-0.46
Total carotenoids (µg/100 g)	0.02	0.42	0.04	-0.17	0.68
Phosphorus (mg/100 g)	0.70	-0.20	0.22	0.39	0.00
Potassium (mg/100 g)	0.66	-0.17	0.39	0.34	0.01
Calcium (mg/100 g)	0.66	-0.23	0.12	-0.39	-0.20
Magnesium (mg/100 g)	0.73	-0.36	0.11	-0.10	-0.13
Sodium (mg/100 g)	0.21	-0.40	0.09	-0.59	0.29
Zinc (mg/100 g)	0.69	0.24	-0.45	0.02	-0.13
Manganese (mg/100 g)	0.11	0.33	-0.46	0.50	0.26
Copper (mg/100 g)	0.86	0.04	-0.29	-0.08	0.02
Iron (mg/100 g)	0.83	0.11	-0.35	-0.05	0.06
Yield per plant (kg)	0.39	-0.01	0.60	0.23	0.41

Principal component analysis was carried out using 14 traits comprising of fruit quality traits including mineral composition and fruit yield per plant to understand the underlying inter relationships in the whole set of nutrient composition data and to select the best linear combination of nutrients that explains the largest proportion of the variation in the data set. Estimation of PCA revealed that the first three principal components (PCs) together governed 58.63% of the total variability (Table 5). PC1 and PC2 individually explained about 29.27 and 19.29 of the total variance, respectively. PC1 showed positive factor loading for phosphorus (0.70), potassium (0.66), calcium (0.66), magnesium (0.73), sodium (0.21), zinc (0.69), manganese (0.11), copper (0.86), iron (0.83) and yield per plant (0.39). PC2 showed highest positive factor loading for total soluble solids (0.89) and vitamin C (0.69). The first component is a measure of the overall nutrient content, since the first Eigen vector showed approximately equal loadings on all nutrients except manganese and sodium, which have less loading. The second Eigen vector has high positive loadings on TSS followed by vitamin C, total carotenoids and manganese content.

Hence, it is clear that iron and copper followed by phosphorus and potassium contributed much towards the total variability among the muskmelon genotypes studied. There was wide diversity among the muskmelon genotypes with respect to phosphorus, potassium, calcium, magnesium, sodium, zinc, manganese, copper and iron contents. On the basis of fruit quality attributes and yield, 7 genotypes, *viz.,* DM-162, DM-159, DM-143, DM-145, DM-31, DM-56 were identified as superior and were group in a single cluster I. Based on higher genetic distance among clusters and higher mean value of genotypes for quality and yield traits, DM-145, DM-159 and DM-162, DM-56 genotypes from *inodorous* group and Pusa Madhuras, Kashi Madhu, Punjab Sunheri and DM-31 from *cantaloupensis* group should be utilized in hybridization programme for developing nutrient rich muskmelon varieties/ hybrids.

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