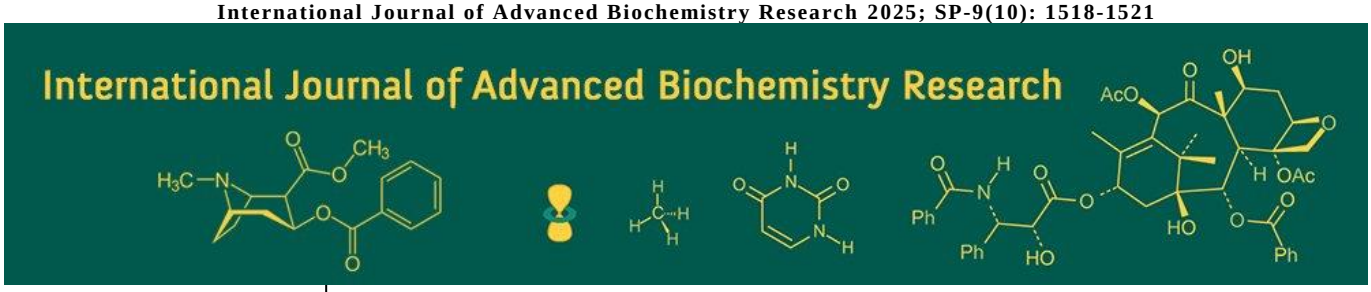

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Manish Kumar
Ph.D. Department of Vegetable Science, SVPUA&T, Meerut, Uttar Pradesh, India

Satya Prakash
Professor, SVPUA&T, Meerut, Uttar Pradesh, India

Mohd. Wamiq
Ph.D. Department of Vegetable Science, SVPUA&T, Meerut, Uttar Pradesh, India

Rupesh Kumar
Ph.D. Department of Vegetable Science, SVPUA&T, Meerut, Uttar Pradesh, India

Harshit Tomar
Ph.D. Department of Vegetable Science, SVPUA&T, Meerut, Uttar Pradesh, India

Akanksha Rai
Ph.D. Department of Vegetable Science, SVPUA&T, Meerut, Uttar Pradesh, India

Gunjan Singh
Ph.D. Department of Vegetable Science, SVPUA&T, Meerut, Uttar Pradesh, India

Saurabh
Ph.D. Department of Vegetable Science, SVPUA&T, Meerut, Uttar Pradesh, India

Saurabh Sonkar
Ph.D. Department of Vegetable Science, SVPUA&T, Meerut, Uttar Pradesh, India

Aayush Mishra
Ph.D. Department of Vegetable Science, SVPUA&T, Meerut, Uttar Pradesh, India

Corresponding Author:
Mohd. Wamiq
Ph.D. Department of Vegetable Science, SVPUA&T, Meerut, Uttar Pradesh, India

Evaluation of quality parameters in bitter gourd (*Momordica charantia* L.) involving 15 parents and their F_1 hybrids

Manish Kumar, Satya Prakash, Mohd. Wamiq, Rupesh Kumar, Harshit Tomar, Akanksha Rai, Gunjan Singh, Saurabh, Saurabh Sonkar and Aayush Mishra

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Abstract
The present study was conducted to evaluate fifteen parents and their F_1 hybrids of bitter gourd (*Momordica charantia* L.) for important quality parameters including total soluble solids (TSS), ascorbic acid, chlorophyll, vitamin C, and β-carotene content. Considerable variability was observed among the genotypes for all traits. Mean values of TSS ranged from 3.79 °Brix to 6.32 °Brix; ascorbic acid from 49.24 mg/100 g to 105.05 mg/100 g; chlorophyll from 0.50 mg/g to 1.37 mg/g; vitamin C from 50 mg/100 g to 107 mg/100 g; and β-carotene from 25 mg/100 g to 68 mg/100 g. Among the crosses, PUSA RASDAR × IC505630 exhibited the highest ascorbic acid and vitamin C content (105.05 mg/100 g and 107 mg/100 g respectively), while PUSA RASDAR × IC470546 recorded maximum β-carotene (68 mg/100 g). The cross PUSA VISHESH × IC116876 showed the highest TSS (6.32 °Brix). These findings revealed ample genetic diversity among parental lines and hybrids, indicating potential for selection and breeding of superior genotypes with improved nutritional quality.

Keywords: Bitter gourd, quality traits, TSS, ascorbic acid, vitamin C, β-carotene, chlorophyll, variability

Introduction
Bitter gourd (*Momordica charantia* L.) is one of the most important cucurbitaceous vegetables cultivated in tropical and subtropical regions. Commonly known as Karela or bitter melon, the crop is primarily grown for its immature fruits, which are consumed as a vegetable and valued for their medicinal and nutritional properties. Bitter gourd is believed to have originated in India and later spread to other parts of Asia (Schaefer and Renner, 2010) [9].

The fruits are rich in vitamin C, β-carotene, iron, calcium, and phosphorus, along with bioactive compounds such as *charantin*, *polypeptide-P*, and *momordicin*, known for their antidiabetic, antioxidant, and immunomodulatory effects (Behera *et al.*, 2010) [2]. The biochemical composition—particularly ascorbic acid, β-carotene, and total soluble solids (TSS)—plays a major role in determining both nutritional and sensory quality (Bharathi and John, 2013) [3].

With rising consumer demand for nutrient-rich vegetables, breeding programs have increasingly focused on improving fruit quality in addition to yield. Quality traits such as TSS, ascorbic acid, vitamin C, chlorophyll, and β-carotene are genetically controlled yet influenced by environment, hence showing significant variability among genotypes. Understanding the magnitude of variability among parental lines and hybrids helps breeders identify promising combinations that can be exploited in hybridization programs. Previous studies have documented variation in yield and morphological characters (Kumar *et al.*, 2020; Singh *et al.*, 2023) [6, 13], but limited information is available on nutritional quality traits. Therefore, the present investigation was undertaken to assess the mean performance of fifteen parents and their F_1 hybrids of bitter gourd for five quality-related characters TSS, ascorbic acid, chlorophyll, vitamin C, and β-carotene and to identify nutritionally superior combinations for future breeding work.

Materials and Methods

The experiment was conducted at Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, during the Zaid season (2022-2023) using a set of fifteen parents and their F_1 hybrids, totaling sixty-five genotypes of bitter gourd (*Momordica charantia* L.). The material included four female parents (PUSA RASDAR, PUSA DO MAUSAMI, PUSA VISHESH, and PUSA AUSHADHI) and one variety (ARKA HARIT), crossed with ten male lines (IC65972, IC66023, IC505629, IC470535, IC470546, IC505638, IC116876, IC505640, IC505630, and IC470553). The experiment was laid out in a Randomized Block Design (RBD) with three replications. Each genotype was represented by a single row of 3 m length, with 3.0 × 0.5 m spacing between and within rows. Recommended agronomic practices were followed throughout. The soil of the experimental field was sandy loam, fertile, and well-drained under hot, humid tropical conditions favorable for cucurbit growth.

Five quality traits were evaluated from three randomly selected fruits per genotype: total soluble solids (°Brix) measured by digital refractometer; ascorbic acid (mg/100 g) estimated by titration using 2,6-dichlorophenol-indophenol dye; chlorophyll

Table 1: List of genotypes and their source of collection

S. No.	Code. No.	Name of genotypes	Source of genotypes
A). Female Parents (Lines)			
1	L1	IC65972	NBPGR, New Delhi
2	L2	IC66023	NBPGR, New Delhi
3	L3	IC505629	NBPGR, New Delhi
4	L4	IC470535	NBPGR, New Delhi
5	L5	IC470546	NBPGR, New Delhi
6	L6	IC505638	NBPGR, New Delhi
7	L7	IC116876	NBPGR, New Delhi
8	L8	IC505640	NBPGR, New Delhi
9	L9	IC505630	NBPGR, New Delhi
10	L10	IC470553	NBPGR, New Delhi
B). Male Parents (Testers)			
1	T1	Pusa Rasdar	IARI, New Delhi
2	T2	Pusa Do Mousami	IARI, New Delhi
3	T3	Pusa Vishesh	IARI, New Delhi
4	T4	Pusa aushadhi	IARI, New Delhi
5	T5	Arka Harit	IIHR, Bangalore

Statistical Analysis

The experiment was conducted in a Randomized Block Design (RBD) with three replications to minimize environmental variation and ensure accuracy in the evaluation of parents and F_1 hybrids of bitter gourd for quality parameters. Each treatment (genotype or cross) was randomly allotted within each replication. The data recorded for each character were subjected to analysis of variance (ANOVA) appropriate for RBD as outlined by Panse and Sukhatme (1985) [7], in order to test the significance of differences among genotypes. The total variation was partitioned into replication, treatment, and error components. The significance of mean squares due to treatments was tested using the F-test at 5% and 1% probability levels. Standard error of mean (SEm), critical difference (C.D. at 5% and 1%), and coefficient of variation (C.V.%) were calculated to assess the precision and reliability of the experiment.

Results and Discussion

1. Total Soluble Solids (°Brix)

TSS content ranged from 3.79 °Brix (PUSA VISHESH × IC470553) to 6.32 °Brix (PUSA VISHESH × IC116876). Higher TSS values were observed in PUSA VISHESH × IC470535 (6.13 °Brix) and PUSA AUSHADHI × IC470535 (6.03 °Brix), indicating superior sweetness and better fruit taste. These findings are consistent with Priyadharshini *et al.* (2018) [8], who reported significant genotypic differences for TSS in bitter gourd.

2. Ascorbic Acid (mg/100 g)

Ascorbic acid content varied from 49.24 mg/100 g (PUSA VISHESH × IC470535) to 105.05 mg/100 g (PUSA RASDAR × IC505630). High ascorbic acid in PUSA RASDAR × IC505630, ARKA HARIT × IC505629 (101.92 mg/100 g), and PUSA DO MAUSAMI × IC505630 (101.45 mg/100 g) suggests their suitability for developing nutritionally enriched cultivars. Comparable variation was reported by Behera and Kaur (2006) [1] and Singh *et al.* (2024) [10].

3. Chlorophyll (mg/g)

Chlorophyll content ranged between 0.50 mg/g (IC116876) and 1.37 mg/g (PUSA RASDAR × IC470546). Crosses such as PUSA RASDAR × IC505629 (1.21 mg/g) and PUSA AUSHADHI × IC66023 (1.20 mg/g) also exhibited higher chlorophyll accumulation, indicating better photosynthetic potential and greener fruits. Similar variability for pigment content was observed by Kumar *et al.* (2020) [6].

4. Vitamin C (mg/100 g)

Vitamin C content ranged from 50 mg/100 g in PUSA VISHESH × IC470535 to 107 mg/100 g in PUSA RASDAR × IC505630. The hybrids PUSA RASDAR × IC505640 (102 mg/100 g) and PUSA VISHESH × IC505638 (102 mg/100 g) also recorded superior vitamin C levels. Such variability emphasizes the influence of parental combinations on biochemical composition (Thakur *et al.*, 2018) [14].

5. β-Carotene (mg/100 g)

β-Carotene content ranged from 25 mg/100 g (IC116876) to 68 mg/100 g (PUSA RASDAR × IC470546). Other crosses showing higher β-carotene were PUSA RASDAR × IC505629 (60 mg/100 g) and PUSA VISHESH × IC505629 (60 mg/100 g). The presence of wide variation suggests strong genetic potential for enhancing provitamin-A content through hybridization (Triveni *et al.*, 2021) [15].

Overall, substantial differences were observed among the parental lines and hybrids for all quality parameters. The superiority of crosses involving PUSA RASDAR and IC505630 indicates additive and non-additive gene actions for nutrient-related traits. Similar trends were reported by Singh *et al.* (2019) [11] and Singh *et al.* (2023) [13].

Table 2: Mean Performance of quality characters of Bitter Gourd (*Momordica charantia* L.)

Sl. No.	Crosses/Parents	TSS (°Brix)	Ascorbic Acid (mg/100 g)	Chlorophyll (mg/g)	Vitamin C (mg/100 g)	β-Carotene (mg/100 g)
1	PUSA RASDAR × IC65972	5.26	93.47	0.89	95	44
2	PUSA RASDAR × IC66023	5.89	64.25	0.91	66	45
3	PUSA RASDAR × IC505629	4.94	58.11	1.21	60	60
4	PUSA RASDAR × IC470535	5.74	75.50	1.15	77	57
5	PUSA RASDAR × IC470546	5.03	66.66	1.37	68	68
6	PUSA RASDAR × IC505638	5.21	84.62	1.01	86	50
7	PUSA RASDAR × IC116876	5.09	84.72	0.87	86	43
8	PUSA RASDAR × IC505640	6.13	99.74	0.87	102	44
9	PUSA RASDAR × IC505630	5.55	105.05	0.64	107	32
10	PUSA RASDAR × IC470553	4.96	68.25	1.27	70	63
11	PUSA DO MAUSAMI × IC65972	5.27	92.67	1.06	95	55
12	PUSA DO MAUSAMI × IC66023	5.93	63.77	1.16	65	58
13	PUSA DO MAUSAMI × IC505629	5.13	89.00	0.79	91	39
14	PUSA DO MAUSAMI × IC470535	5.00	73.95	0.82	76	41
15	PUSA DO MAUSAMI × IC470546	5.55	78.33	0.80	80	40
16	PUSA DO MAUSAMI × IC505638	4.65	55.55	1.26	57	63
17	PUSA DO MAUSAMI × IC116876	4.65	80.06	0.96	82	48
18	PUSA DO MAUSAMI × IC505640	5.11	85.15	0.63	87	32
19	PUSA DO MAUSAMI × IC505630	4.75	101.45	0.91	104	45
20	PUSA DO MAUSAMI × IC470553	5.22	65.14	1.14	66	57
21	PUSA VISHESH × IC65972	5.74	73.69	0.73	75	37
22	PUSA VISHESH × IC66023	5.56	82.14	0.97	84	47
23	PUSA VISHESH × IC505629	4.88	59.22	0.59	61	30
24	PUSA VISHESH × IC470535	6.13	49.24	0.84	50	42
25	PUSA VISHESH × IC470546	5.26	67.18	1.17	69	58
26	PUSA VISHESH × IC505638	5.56	99.63	0.65	102	33
27	PUSA VISHESH × IC116876	6.32	72.22	0.77	74	39
28	PUSA VISHESH × IC505640	4.71	78.63	1.06	80	53
29	PUSA VISHESH × IC505630	5.56	76.03	1.21	78	60
30	PUSA VISHESH × IC470553	3.80	66.91	0.92	68	46
31	PUSA AUSHADHI × IC65972	4.53	89.10	0.71	91	36
32	PUSA AUSHADHI × IC66023	5.24	92.15	1.20	94	60
33	PUSA AUSHADHI × IC505629	5.96	65.16	0.89	67	45
34	PUSA AUSHADHI × IC470535	6.03	54.93	0.81	56	41
35	PUSA AUSHADHI × IC470546	5.78	68.05	0.62	70	31
36	PUSA AUSHADHI × IC505638	5.46	91.99	0.99	94	49
37	PUSA AUSHADHI × IC116876	5.96	96.28	0.91	98	45
38	PUSA AUSHADHI × IC505640	4.66	78.02	1.09	80	55
39	PUSA AUSHADHI × IC505630	5.24	59.16	0.70	61	35
40	PUSA AUSHADHI × IC470553	5.34	69.15	0.68	71	34
41	ARKA HARIT × IC65972	5.29	96.95	0.83	99	42
42	ARKA HARIT × IC66023	5.88	75.26	1.11	77	56
43	ARKA HARIT × IC505629	5.03	101.92	0.78	104	39
44	ARKA HARIT × IC470535	5.98	84.66	0.94	87	47
45	ARKA HARIT × IC470546	6.26	69.17	1.18	71	59
46	ARKA HARIT × IC505638	4.85	81.30	0.97	83	49
47	ARKA HARIT × IC116876	5.60	89.63	0.67	92	34
48	ARKA HARIT × IC505640	5.33	61.11	1.23	63	61
49	ARKA HARIT × IC505630	4.85	93.75	1.08	96	54
50	ARKA HARIT × IC470553	6.24	88.50	0.75	91	38
51	PUSA RASDAR	4.79	72.66	0.75	74	38
52	PUSA DO MAUSAMI	5.26	65.33	1.07	67	53
53	PUSA VISHESH	5.02	74.69	1.26	76	63
54	PUSA AUSHADHI	4.73	54.96	0.59	56	29
55	ARKA HARIT	5.71	92.76	0.92	95	46
56	IC65972	6.01	85.55	1.02	87	51
57	IC66023	4.96	63.37	1.18	65	59
58	IC505629	4.37	102.85	0.55	105	28
59	IC470535	5.48	87.39	0.64	89	32
60	IC470546	5.73	58.14	0.90	60	45
61	IC505638	5.01	95.45	0.95	97	47
62	IC116876	4.55	49.52	0.50	51	25
63	IC505640	4.99	73.00	0.81	75	41
64	IC505630	6.21	87.11	0.80	89	40
65	IC470553	4.89	84.50	1.10	86	55
	Mean	5.32	80.15	0.93	81.97	0.39
	CV (%)	6.60	8.09	7.12	7.45	6.98
	SEm ±	0.20	3.14	0.04	3.26	0.03
	CD (5%)	0.57	8.78	0.12	9.12	0.08
	CD (1%)	0.75	11.6	0.16	12.05	0.11
	Minimum	3.80	49.24	0.50	50	0.26
	Maximum	6.32	105.05	1.37	107	0.52
	Replication	NS	NS	NS	NS	NS
	Treatment	S	S	S	S	S

Conclusion

The study revealed considerable genetic variation among the fifteen parents and their F_1 hybrids for all five quality parameters in bitter gourd. PUSA RASDAR × IC505630 exhibited the highest ascorbic acid and vitamin C content, PUSA RASDAR × IC470546 showed maximum β-carotene, and PUSA VISHESH × IC116876 recorded the highest TSS. These hybrids may be utilized in breeding programs aimed at developing nutritionally superior cultivars of bitter gourd. The wide variability observed among the genotypes provides substantial scope for selection and hybridization in future genetic improvement programs.

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