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Evaluation of Various Genotypes of Bitter Gourd (*Momordica charantia* L.) on Quality Traits

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field investigation is done in which thirty-six genotypes of bitter gourd were evaluated to estimate the quality traits under study. Randomized block design is followed and the genotypes are replicated twice. The study was conducted during *Rabi* 2021. Major variations have been observed

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among the genotypes for each character that are studied, based on the analysis of variance. Genotype VBGC-9 had a high TSS (4.60^{0}Brix), While genotype VBGC-22 had the highest Vitamin-C content (114.50 mg/100mg). The highest titratable acidity was found in genotype VBGC-13 (0.05%), and was followed by VBGC-18 (0.05%) and VBGC-33 (0.05%). The genotype VBGC-27 had its highest total sugar content (3.77%), VBGC-18 (3.25%) has the highest amount of reducing sugars, followed by VBGC-31 (3.25%) and VBGC-32 (3.25%). Therefore, after several years and locations of testing, the best-performing genotypes may be recommended for commercial cultivation and used to promote bitter gourd cultivation efforts as elite germplasm lines or varieties.

Keywords: Bitter gourd; genotype; reducing sugars; quality; vitamin-C.

1. INTRODUCTION

The *Cucurbitaceae* family consists of an economically important bitter gourd (*Momordica charantia* L.), that is grown extensively in Africa, South America, Asia, and India [1,2]. There are other names for it, like bitter melon, bitter cucumber, balsam pear, and African cucumber [3]. Kerala, Tamil Nadu, Maharashtra, and Karnataka are India's four fastest-growing states [4]. The bitter gourd has spread across the Old and New Worlds having its Indo-Malayan origins [5]. With a total production of 1,137,000 MT, bitter gourd is grown on 97,000 hectares in India (NHB, 2018). It is grown at the altitudes from1600 to 1700 meters above sea level. It is best for growing bitter gourd at the temperature between 24 and 27 °C [6]. It is a fast- growing warm season climber. The tendril-bearing, herbaceous vine may reach a length of five meters. Each plant produces different male and female flowers, and the simple, alternating leaves that are 4–12 cm broad with 3–7 deeply divided lobes [7]. The bitter gourd is an excellent source of minerals, vitamins A, B_2, and C, carbohydrates, proteins, and lipids. Certain Indian bitter gourd variations have unusually high levels of protein (930 mg per 100 g) and vitamin C (95 mg per 100 g), as reported by Raja et al. (2007). According to Robinson and Decker-Walters [8], bitter gourd fruits are popular as vegetables and are well-known for having anti-diabetic and other health benefits. Vitamin A, C, iron, phosphorus, and carbohydrates are rich in them [9,10] and these vitamins and minerals improve the body's defenses against infections [11]. The other two alkaloids found in the fruit are momordicin and cucurbitacin. According to Chander and Chandra (1990), momordicin is a glycoside of tetracyclic triterpenoids which includes cucurbitacin. As a summer vegetable, bitter gourd usually grows in kitchen gardens. However, it is being cultivated as a commercial crop near urban areas as well. Because of the phytochemical components of bitter gourd which improve health, dispite the bitter taste that turns off some people, bitter gourd has found its please in a diet.

2. MATERIALS AND METHODS

Each replication of the experimental field had 36 treatments, for a total of 72 treatments in 2 replications. One meter in row and one meter spacing between the rows. To ensure a good harvest, the field was well-prepared, and standard cultural, manual, and plant protection methods were utilized. We have identified five quality parameters for the observations: titratable acidity (%), total sugars (%), reducing sugars (%), vitamin C (mg/100 mg), and TSS (°Brix). Several biometrical and statistical parameters have been investigated for these traits. List of genotypes used in the study and their sources are presented in Table1.

Total soluble solids (^{0}Brix): A hand refractometer was used to measure the fruits' total soluble solids TSS content. Juice from entirely ripe fruits of bitter gourd was extracted, and a drop of juice was placed on refractometer for a readout as TSS content as a ^{0}Brix.

Titrable acidity (%): The acid content of the juice was determined by titrating 5 ml of the extracted juice against N/10 NaOH and using phenolphthalein as an indicator.Using the A.O.A.C. [12] method, acidity was determined as anhydrous citric acid per 100 milliliters of bitter gourd juice.

Ascorbic acid content: The amount of ascorbic acid expressed in mg/100g of fruits was determined by titration using the 2,6-dichlorophenolindophenol [12].

Total sugars (%): The total sugar analysis was done applysing the technique described by A.O.A.C. [12]. A conical flask with 20 ml of fruit juice and five ml of 6 N HCl to determine the total sugar content of bitter gourd fruits. After an 8-

minute water bath boil, the mixture was allowed to cool to room temperature. By adding 40% NaOH drop by drop and using two drops of phenolphthalein indicator to neutralize the acids, the amount was raised to 100 ml. Using methylene blue indicator, 10 ml of Fehling's solution (A+B) was added to the sample and titrated while it was heated. The solution was allowed to titrate until it turned brick red, at the point where the percentage of total sugars was estimated using the appropriate formula.

Reducing sugars: The A.O.A.C. [12] method was analyze reducing sugars. We added 20 ml of fruit juice to a conical flask to estimate the amount of sugar that is reduced in bitter gourd fruits. Fruit juice was mixed with two drops of phenolphthalein indicator and 40% NaOH (drop by drop) to neutralize the acids and increase the volume up to 100 ml. Shake in 10 ml of the neutral lead acetate solution and let it stand for 10 minutes. Little quantities of potassium oxalate solution should be added until no further precipitation occurs. Increase the concentration while passing the mixture what's man filter paper. Pour the filtrate into an off-set-tip 50 ml burette. Using methylene blue indicator, titrate the sample with a hot 10 ml of Fehlings solution (A+B) when it is hot. Continue the process of titration until the sample turns brick red, in which point the % of reducing sugars has was measured using the method.

Table 1. List of genotypes used in the study and their sources

S. No	Genotype	NBPGR accession number	Source
1	VBGC-1	IC33275	NBPGR, Thrissur
2	VBGC-2	IC44413	NBPGR, Thrissur
3	VBGC-3	IC44418	NBPGR, Thrissur
4	VBGC-4	IC44419	NBPGR, Thrissur
5	VBGC-5	IC44420A	NBPGR, Thrissur
6	VBGC-6	IC44423	NBPGR, Thrissur
7	VBGC-7	IC44424	NBPGR, Thrissur
8	VBGC-8	IC44426	NBPGR, Thrissur
9	VBGC-9	IC68232	NBPGR, Thrissur
10	VBGC-10	IC68275	NBPGR, Thrissur
11	VBGC-11	IC68309	NBPGR, Thrissur
12	VBGC-12	IC68314	NBPGR, Thrissur
13	VBGC-13	IC68335	NBPGR, Thrissur
14	VBGC-14	IC470554	NBPGR, Thrissur
15	VBGC-15	IC470556	NBPGR, Thrissur
16	VBGC-16	IC470557	NBPGR, Thrissur
17	VBGC-17	IC470558	NBPGR, Thrissur
18	VBGC-18	IC470559	NBPGR, Thrissur
19	VBGC-19	IC213307	NBPGR, Thrissur
20	VBGC-20	IC213308	NBPGR, Thrissur
21	VBGC-21	IC264770	NBPGR, Thrissur
22	VBGC-22	IC469512	NBPGR, Thrissur
23	VBGC-23	IC427433	NBPGR, Thrissur
24	VBGC-24	IC433630	NBPGR, Thrissur
25	VBGC-25	IC427694	NBPGR, Thrissur
26	VBGC-26	IC541218	NBPGR, Thrissur
27	VBGC-27	IC541435	NBPGR, Thrissur
28	VBGC-28	IC596980	NBPGR, Thrissur
29	VBGC-29	IC599421	NBPGR, Thrissur
30	VBGC-30	IC599424	NBPGR, Thrissur
31	VBGC-31	IC599429	NBPGR, Thrissur
32	VBGC-32	IC599434	NBPGR, Thrissur
33	VBGC-33	IC541436	NBPGR, Thrissur
34	Amalapuram Local	Local germplasm	Amalapuram (East Godavari)
35	Venkataramannagudem Local	Local germplasm	Venkataramannagudem (West Godavari)
36	Arka Harit (check)	-	IIHR, Bengaluru

3. RESULTS AND DISCUSSION

Quality parameters: To evaluate the significance of variations among the genotypes, the data on five qualitative characteristics was subjected to analysis of variance. Table 2 represents the findings of the analysis of variance, which found that all the characters had highly significant mean squares attributed to genotypes. Table 3 shows the average performance of the various genotypes for the bitter gourd quality traits.

TSS (^{0}Brix): Low acidity and high total soluble solids (TSS, expressed in °Brix) are thought to be the most crucial elements in the production process of processed goods. Table 3 reveals that there was a significant variance throughout genotypes for TSS (°Brix), with a general mean of 3.76 and a range of 3.35 (VBGC-33) to 4.60 (VBGC-9). Among the 36 genotypes, 32 genotypes (VBGC-1 to 7, VBGC-10 to 26, and VBGC-28 to 35) were showed no significant difference similar to the control variety Arka Harit (3.60 °Brix), while three genotypes (VBGC-8 (4.35 °Brix), VBGC-9 (4.60 °Brix), and VBGC-27 (4.15 °Brix)) exhibited significantly higher TSS levels.

Vitamin -C (mg/100 mg): Bitter gourd's high ascorbic acid concentration improves both its nutritional value and the goods' ability to maintain its natural color and flavor. Numerous factors, including plant species and climatic circumstances, could impact ascorbic acid levels. Table 3 shows the significant variance in vitamin-C (mg/100 mg) content among genotypes. The range of values was 71.50 mg/100 mg (VBGC-4) to 114.50 mg/100 mg (VBGC-22), with a mean of 90.40 among the genotypes. From the 36 genotypes, 23 genotypes (VBGC-1, VBGC-2, VBGC-5 to 8, VBGC-10 to 13, VBGC-17, VBGC-20 to 21, VBGC-23 to 25, VBGC-27, and VBGC-30 to 35) are statistically similar to the control variety Arka Harit (88.00 mg/100 mg). The ten genotypes (VBGC-3, VBGC-9, VBGC-14 to 16, VBGC-18, VBGC-22, VBGC-26, VBGC-28, and VBGC-29) are significantly higher level of vitamin-C than control variety Arka Harit (88.00 mg/100 mg).

Total sugars (%): Table 3 shows that there was a significant variation among the genotypes for total sugars (%), with a general mean of 3.07 with a range of 2.34 (VBGC-3) to 3.77 (VBGC-27). A single genotype VBGC-27 (3.77%) out of the 36 exhibited no significant difference from the control variety Arka Harit (3.76%). All other genotypes exhibited lower amounts of total sugars compared to the control variety.

Reducing sugars (%): Table 3 shows the significant variation in reducing sugars (%) among genotypes, with a general mean of 2.63 with a range of 2.15 (VBGC-26) to 3.55 (VBGC-19). Eight genotypes showed significantly higher levels than the check variety Arka Harit (2.83): VBGC-6 (3.24), VBGC-7 (2.94), VBGC-17 (3.16), VBGC-18 (3.25), VBGC-27 (2.45), VBGC-29 (3.24), VBGC-31 (3.25), and VBGC-32 (3.25). The remaining genotypes showed lower levels compared to control.

Titrable acidity (%): The most important organic acids in bitter gourd are citric and malic acids, both of which constitute more than 10% of the fruit's dry solid composition. It is widely recognized that fruit acidity contributes to the health of the fruit and its shelf life since it reduces the possibility of fungal infections in bitter gourds. Table 3 shows that there was a significant variation throughout genotypes for titratable acidity (%), with a general mean of 0.03, with a range of 0.02 (VBGC-1) to 0.05 (VBGC-26).

TSS is a critical factor in determining bitter gourd's shelf life and overall quality, irrespective of whether it has been utilized for processing or fresh consumption. In addition, TSS concentrations had an important effect on bitter gourd's texture and flavor. The TSS level differed significantly among the evaluated genotypes ranging from 3.35 °Brix (VBGC-9) to 4.60 °Brix (VBGV-32). Priyadarshini et al. [13] observed similar results with TSS, ranging from 3.250 °Brix to 5.900 °Brix in bitter gourd. The fruits of the bitter gourd are widely consumed as vegetables and are popular for having medicinal and anti-diabetic traits particularly due to the significant vitamin C content. Among all the genotypes that were investigated, VBGC-22 has the highest ascorbic acid concentration (114.50 mg/100 g), while VBGC-4 has the lowest ascorbic acid level (82.60 mg/100 g). These results, ranging from 80.86 to 123.62 mg/100 g, are consistent with data published by Priyadarshini et al. [14]. This experimental data shows the high ascorbic acid concentration in VBGC-22. In comparison with the other offsprings, it performed superior on the quality standards evaluated. Table 3 shows a significant variation in the titratable acidity levels between 0.02 and 0.05 percent. These results match with the findings of Sidhu et al. [15], which similarly noted acidity levels between 0.02 and 0.05 percent. The range for reducing sugars was 2.15 to 3.55, while for total sugars it was 2.34 to

Table 2. Analysis of variance for different characters in Bitter gourd *Momordica charantia* L

S. No.	Character	Mean sum of squares		
		Replication	**Treatment**	**Error**
d.f		2	35	35
	TSS (^{0}Brix)	0.860235	0.134792*	0.065120
	Vitamin C (mg/100mg)	17.013890	194.166270***	13.271032
	Total sugars (%)	0.022756	0.441246*	0.0014330
	Reducing sugars (%)	0.00002	0.331623**	0.001508
	Titrable acidity (%)	0.000001	0.000077*	0.000036

*** significant at 5%*

Table 3. Mean performance of bitter gourd germplasm lines evaluated at COH, VENKATARAMANNA GUDEM for qualitative characters

S. NO	Treatment	GENOTYPE	IC NO	TSS (^{0}Brix)	Vitamin C (mg)	Total sugars (g/100 g)	Reducing sugars (g/100 g)	Titrable acidity (%)
1	T1	VBGC-1	IC33275	3.47	81.00	3.14	2.65	0.02
2	T2	VBGC-2	IC44413	3.70	85.50	3.05	2.53	0.03
3	T3	VBGC-3	IC44418	3.50	97.00	2.34	2.17	0.04
4	T4	VBGC-4	IC44419	3.70	71.50	2.55	2.34	0.04
5	T5	VBGC-5	IC44420A	3.75	86.00	2.75	2.46	0.04
6	T6	VBGC-6	IC44423	3.85	81.50	3.45	3.24	0.03
7	T7	VBGC-7	IC44424	3.70	91.00	3.76	2.94	0.03
8	T8	VBGC-8	IC44426	4.35	87.00	3.27	2.67	0.04
9	T9	VBGC-9	IC68232	4.60	96.00	2.52	2.38	0.03
10	T10	VBGC-10	IC68275	4.05	73.50	2.86	2.38	0.03
11	T11	VBGC-11	IC68309	3.60	86.50	2.67	2.22	0.04
12	T12	VBGC-12	IC68314	3.70	93.50	2.96	2.61	0.04
13	T13	VBGC-13	IC68335	3.75	84.00	2.84	2.53	0.05
14	T14	VBGC-14	IC470554	4.10	105.50	3.22	2.35	0.04
15	T15	VBGC-15	IC470556	4.00	95.50	3.41	2.74	0.03
16	T16	VBGC-16	IC470557	3.60	101.00	3.27	2.46	0.04
17	T17	VBGC-17	IC470558	3.55	87.00	3.44	3.16	0.04
18	T18	VBGC-18	IC470559	3.40	109.00	3.61	3.25	0.05
19	T19	VBGC-19	IC213307	3.60	90.00	2.46	2.16	0.04
20	T20	VBGC-20	IC213308	3.75	84.00	2.54	2.33	0.04

S. NO	Treatment	GENOTYPE	IC NO	TSS (^{0}Brix)	Vitamin C (mg)	Total sugars (g/100 g)	Reducing sugars (g/100 g)	Titrable acidity (%)
21	T21	VBGC-21	IC264770	3.75	76.00	2.64	2.34	0.04
22	T22	VBGC-22	IC469512	3.85	114.50	3.50	2.83	0.03
23	T23	VBGC-23	IC427433	4.05	93.50	3.60	3.31	0.04
24	T24	VBGC-24	IC433630	3.60	85.50	2.47	2.26	0.04
25	T25	VBGC-25	IC427694	3.45	88.50	3.60	2.46	0.04
26	T26	VBGC-26	IC541218	3.65	105.50	2.85	2.45	0.05
27	T27	VBGC-27	IC541435	4.15	85.00	3.77	3.55	0.04
28	T28	VBGC-28	IC596980	3.90	96.00	2.56	2.25	0.04
29	T29	VBGC-29	IC599421	3.80	107.00	3.66	3.24	0.04
30	T30	VBGC-30	IC599424	3.75	87.00	2.57	2.20	0.04
31	T31	VBGC-31	IC599429	3.70	78.00	3.74	3.25	0.03
32	T32	VBGC-32	IC599434	3.70	84.50	3.60	3.25	0.04
33	T33	VBGC-33	IC541436	3.35	91.00	2.65	2.22	0.05
34	T34	Amalapuram Local	Local germplasm	3.85	95.00	2.59	2.17	0.04
35	T35	Venkataramanna gudem Local	Local germplasm	3.65	93.50	3.14	2.88	0.03
36	T36	VBGC-36	Aka Harit	3.60	88.00	3.76	2.83	0.03
CD at 5%	-	-	-	0.51	7.39	0.07	0.07	0.01
S.E	-	-	-	0.1804	2.5759	0.0267	0.0275	0.0042

3.77. Sidhu et al. [15] indicated significant differences in total sugars ranging from 2.06 to 3.12 and in reducing sugars ranging from 1.57 to 2.4, which is similar to the present findings [16-18].

4. CONCLUSION

The genotype VBGC-9 had the greatest TSS content (4.60 °Brix) among the quality attributes, whereas VBGC-22 had the highest vitamin C content (114.50 mg/100g). VBGC-13 had the greatest titratable acidity, followed by VBGC-18, VBGC-26, and VBGC-33, VBGC-27 (3.77%) had the highest total sugar content. VBGC-18 had the high reducing sugar concentration, whereas VBGC-31 and VBGC-32 had below it. Among the quality traits under investigation, genotypes such as VBGC-9, VBGC-13 andVBGC-22 shown remarkable performance. These high-performing genotypes may be important sources of germplasm for further breeding programs.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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