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Nutritional Evaluation of Bitter Gourd Hybrids and Parents

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ABSTRACT: Sensory evaluation among the consumers is inevitable before releasing a variety of bitter gourd as the local preference for different traits varies. Hence in the present study, sensory attributes, nutritional potentials, and shelf life of six bitter gourd hybrids and their parents were examined. The varieties used for the experiment include three monoecious lines viz., Preethi, Priyanka, and MC 133, and a gynoecious line KAU-MCGy-101. Six hybrids were developed by crossing KAU-MCGy-101 with Preethi, Priyanka, and MC 133. Sensory evaluation was carried out using a panel of 15 judges. All the dark green fruited hybrids and the gynoecious parent scored less (4.48 to 6.03) for overall acceptability when compared with the white and light green fruited parents Preethi, Priyanka, and MC133 (8.13, 7.64, and 8.02 respectively). Among the hybrids, Preethi × KAU-MCGy-101 secured the highest score for overall acceptability (6.03). The gynoecious parent, KAU-MCGy-101 was found superior for the calcium content (6.24 mg/100g). Iron content was highest in the hybrid KAU-MCGy-101 × Priyanka (1.00 mg/100g). Preethi and KAU-MCGy-101 × Priyanka exhibited the highest shelf life with less physiological loss in weight (20.35 and 24.41 % after 6 days of storage) among the parents and hybrids respectively.

Keywords: *Momordica charantia*, gynoecious hybrids, sensory evaluation, ascorbic acid, shelf life.

INTRODUCTION

Cucurbitaceaeis the most diverse plant family, cultivated all around the world. Bitter gourd (*Momordica charantia* L.) is found to be one of the important members of Cucurbitaceae, with unique nutritional and medicinal properties (Rolnik and Olas 2020). *Momordica* means "to bite" which refers to the shape of the leaf of bitter gourd plants; the leaf has uneven edges and looks as if it has been bitten (Grover *et al.*, 2004). The origin of this crop is probably India with a secondary center of diversity in China (Grubben, 1977). Bitter gourd grows well in tropical and subtropical regions, including parts of East Africa, Asia, the Caribbean, and South America, where it is used not only as food but also as a medicine (Krishnendu and Nandini 2016).

Bitter gourd has a higher nutritional profile than other cucurbitaceous vegetables. The immature fruit is a good dietary source of ascorbic acid, beta-carotene, folic acid, vitamin A, calcium, phosphorus, and iron (Yuwai *et al.*, 1991; Thamburaj, 2001). A 100 g portion of bitter gourd fruit can meet 8, 17, and 190 percent of the recommended daily allowances of vitamin A, vitamin E, and ascorbic acid, respectively (Dhillon *et al.*, 2016). Furthermore, it contains twice the beta-carotene of broccoli, twice the calcium of spinach, and twice the potassium of a banana (Aboa *et al.*, 2008; Wu and Ng 2008).

As a medicinal plant, it has been reported to have antilipolytic, analgesic, abortifacient, antiviral, cytotoxic, hypoglycemic and antimutagenic properties (Singh *et al.*, 1998). The fruits, leaves, and roots of bitter gourd are conventionally established as a medicine for reducing blood sugar levels for diabetic patients (Morton *et al.*, 1967). El Batran *et al.* (2006) described the anti-diabetic, hepato-renal protective, and hypolipidemic effects of bitter gourd extract in alloxan-induced diabetic rats. The whole part of bitter gourd fruits is a good source of phenolic compounds and studies revealed the high anti-oxidant potential of the flesh, aril, and seeds (Horax *et al.*, 2005). Phenolic compounds are regarded as beneficial for human health, decreasing the risk of degenerative diseases by reduction of oxidative stress and inhibiting macromolecular oxidation (Silva *et al.*, 2004; Kubola and Siriamornpun 2008).

The green warty fruits of bitter gourd show variation in size, color, skin pattern, and shape throughout the cultivated area (Robinson and Decker-Walters 1999). Around 20 market type of cultivated bitter gourd has been segmented out based on these fruit traits (Dhillon *et al.*, 2016). Naturally, a region-specific contrariety in consumer preference is observed for fruit color, shape, and size (Dey *et al*., 2008, Sorifa, 2018). The north Indians require long or medium long, spindle-shaped glossy green fruits whereas south Indians prefer long but white fruits. In eastern parts of the country, small and dark green-fruited (var. muricata) types are demanded.Hence, a sensory evaluation among the consumers is inevitable before releasing a variety of bitter gourd as the local preference for different traits varies. Furthermore, there is little information on phytonutrient variation among varieties of different market types (Dey *et al*., 2006, Dhillon *et al*., 2016, Barua *et. al*., 2020, Hazra *et al*., 2022). In the present study, six bitter gourd hybrids and their gynoecious and monoecious parents were evaluated for their sensory attributes, nutritional qualities and shelf life.

MATERIALS AND METHODS

Sample preparation. Four varieties of bitter gourd and their hybrids were tested in the experimental field of the Department of Vegetable Science, College of Agriculture, Vellanikkara, Kerala Agricultural University, Thrissur, during the period 2019-2020. The varieties used for the experiment include three monoecious lines *viz*., Preethi, Priyanka and MC 133, and a gynoecious line, KAU-MCGy-101. Preethi and Priyanka are having light green fruits while MC 133 is white-colored and KAU-MCGy-101 is dark green colored. Six hybrids were developed by crossing KAU-MCGy-101 with Preethi, Priyanka, and MC 133. All six hybrids were gynoecious and characterized by dark green fruits. The experiments were conducted in randomized complete block designs with three replications. Plants were grown on upright trellises with 2 × 2 m spacing and by following recommended cultivation practices (KAU, 2016). Weeds were controlled by covering the beds with silver-colored plastic mulches. Irrigation was provided by the drip irrigation system.

The bitter-gourd fruits having uniform maturity at the commercial edible stage were collected. Fruits were washed with water, drained, and cut in half lengthwise. The flesh was thinly sliced after removing the seeds. These samples were used for the estimation of ascorbic acid, iron, and calcium. A part of sliced fruits was, dried under shade and then in a hot air oven at 70°C. After oven drying the samples were powdered in a grinder and then sieved for the estimation of calcium and iron. Fresh fruit samples were kept for estimating ascorbic acid and shelf life. Samples were boiled for a uniform time and taken for sensory evaluation.

Sensory evaluation. Sensory evaluation of the fruits was done by a panel of fifteen members. They are assigned for evaluating the appearance, flavor, texture, bitterness and overall acceptability of bitter gourd varieties and hybrids using a 9-point Hedonic scale, varying from like extremely (rated as 9) to dislike extremely (rated as 1). Each panelist was given samples of boiled bitter gourd fruits, a questionnaire form and a bottle of drinking water to rinse before and between sample testing. The parameters selected for this study were appearance, texture, flavour, bitterness and overall acceptability. After sample testing, the questionnaire was collected and compiled.

The Hedonic scale hierarchy was as follows:

1 = dislike extremely	6 = like slightly
2 = dislike very much	7 = like moderately
3 = dislike moderately	8 = like very much
4 = dislike slightly	9= like extremely
5 = neither like nor dislike	

Estimation of Calcium and Iron. Dried and powdered bitter gourd samples were digested using a di acid mixture (HNO_3: $HClO_4$). Digested samples were diluted to 50 ml and absorbance was measured in an atomic absorption spectrometer (Perkin-Elmer Corporation, 1996).

Estimation of Ascorbic acid. Ascorbic acid content was determined by visual titration using 2,6-dichlorophenol- indophenol dye solution (Ranganna, 1995). Two gram of fresh bitter gourd fruit was made into pulp and extracted using 10 ml of 4percent oxalic acid solution. Then 5 ml of solution was pipetted out into a conical flask and titrated against the dye. In this oxidation-reduction reaction, ascorbic acid in the extract was get oxidized and the indophenol dye was reduced to a colourless compound. The endpoint of the titration was detected when an excess of the unreduced dye gave a rose pink colour to the acid solution. The titration was repeated for the concordant values. The quantity of ascorbic acid (mg) present in 100 g of sample was calculated as follows.

Ascorbic acid (mg / 100 g) = [0.5/V1 × V2/5 ml × 50 ml/ wt of sample × 100]

V1= volume of dye occupied by the working standard (ascorbic acid)

V2= volume of dye occupied by the fruit sample (bitter gourd)

Physiological loss in weight. The fruit sample was kept at room temperature to determine the extent to which it could be stored without damage. The shelf life in terms of physiological loss in weight (PLW) was determined by noting the difference between initial and subsequent fruit weight and was expressed in terms of percentage (Koraddi and Devendrappa 2011)

Physiological loss in weight (%) = [(initial fruit weight – weight of fruit on observation day) / initial fruit weight] × 100

Statistical analysis. The data generated from the experiment were subjected to analysis of variance. Statistical analysis was carried out to study the effect of different parameters on all the dependent variables. Analysis of variance (ANOVA) was conducted with randomized block design (RBD) using the software GRAPES **(**Gopinath *et al*., 2020)**.**

RESULTS AND DISCUSSION

Sensory evaluation. The bitter gourd fruits were boiled and assessed for sensory attributes by a panel of fifteen judges, using a 9-point hedonic scale scheme for diverse parameters like appearance, texture, flavour, bitterness and overall acceptability. The mean values of the score for these parameters were measured for assessing the quality (Fig. 1). Light green and white fruited parents, Preethi, Priyanka and MC 133 secured the highest score for appearance. Among them, white fruited MC 133 scored the highest (8.08) followed by light green fruited Priyanka (8.00) and Preethi (7.90). Dark green fruited gynoecious parent and the six hybrids obtained the least score for the appearance and it ranged from 6.19 to 6.69.The score given for the texture was also higher for Priyanka (7.42), Preethi (7.41) and MC 133 (7.39).The gynoecious parent, KAU-MCGy-101 scored 6.26 for texture. All the hybrids scored less compared to the white and light green fruited parents (5.11 to 6.49). While the hybrid, MC133 × KAU-MCGy-101 scored the least 5.11, KAU-MCGy-101 × Preethi scored the maximum (6.49).

The highest flavour score was secured by the monoecious parent Preethi (7.30) followed by Priyanka (6.45) and MC 133 (6.35). The lowest score was obtained by KAU-MCGy-101 (4.75), while the hybrids scored between 5.01 to 5.51. In the case of bitterness, the score was higher for white and light green fruited parents (5.46 to 6.49). The dark green fruited gynoecious parent and hybrids secured less score for bitterness (4.61 to 5.00). Most of the judges preferred bitter gourd fruits with less bitterness. Hence, they liked the less bitter white fruited varieties and scored more. Finally, the overall acceptability was higher for the white and light green fruited parents Preethi, Priyanka and MC133 (8.13, 7.64 and 8.02 respectively) compared to the dark green fruited gynoecious parent, KAU-MCGy-101 (5.57) and hybrids. The hybrids, Preethi × KAU-MCGy-101, Priyanka × KAU-MCGy-101, MC133 × KAU-MCGy-101, KAU-MCGy-101 × Preethi, KAU-MCGy-101 × Priyanka and KAU-MCGy-101 × MC 133 scored 6.03, 5.64, 5.37, 4.48, 5.16 and 5.35 respectively.

Immature bitter gourd fruits show a broad colour spectrum, ranging from white to dark green (Cheng *et al*., 2012). Most of the cultivating varieties in Kerala are white or light green fruited, and the consumers scarcely prefer dark green fruits. This reflects in the sensory analysis of the present study. The bitter gourd fruits with white and light green colour have a more pleasant flavor and appearance than dark green fruits, which leads to a good score for overall acceptability. Bitterness is the main factor that affects the flavour of bitter gourd fruits and it is due to the presence of a non-toxic alkaloid momordicine (Krawinkel and Keding 2006). The panel of judges also scored white and light green fruits for less bitterness. This is similar to the observations of Islam and Jalaluddin (2019), who reported a variation in bitterness depending on the color of fruits. Green bitter gourd fruits tend to be the most bitter, while white fruits are less bitter. Hence the flavor difference can be attributed to the difference in bitterness between the white and green varieties. However, bitterness tends to be a deterrent for some people, some others are preferring bitterness. Generally, the bitterness of immature bitter gourd fruits is stronger and more intense in the darker green skins and the lighter skin tends to be less bitter (Aminah and Anna 2014; Tan *et al*., 2008; Islam and Jalaluddin 2019).

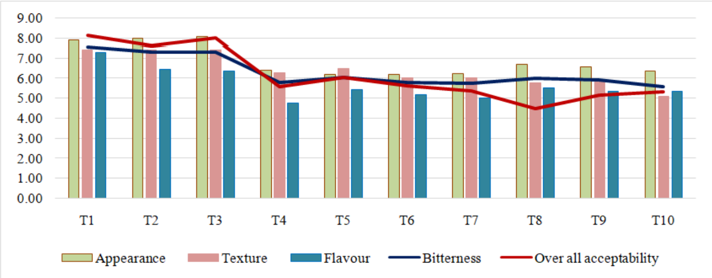
Nutritive value. The nutritive value of bitter gourd genotypes is studied and summarized in Table 1. Ascorbic acid is a vital nutrient essential to maintaining a healthy immune system and reducing chronic inflammatory diseases (Sorice *et al*., 2014). When comparing the various levels of ascorbic acid in the parents and hybrids, significantly high values were observed in Preethi, Priyanka and MC 133 (122.07,117.37 and 115.68 mg/100g respectively). Whereas, KAU-MCGy-101 and the hybrids recorded comparatively low levels and it was ranged from 93.90 to 109.95 mg/100g. The gynoecious parent, KAU-MCGy-101 had93.90 mg/100gof ascorbic acid. Among the hybrids, MC 133 × KAU-MCGy-101showed ahigh value (109.95 mg/100g), followed by Priyanka × KAU-MCGy-101 (105.63 mg/100g).

Calcium content in fruits was significantly varied among the parents and hybrids. The hybrid, KAU-MCGy-101 × MC 133was found superior with 17.05 mg/100g calcium. Preethi was the most promising among the parents with15.62 mg/100 g. Other hybrids, Preethi × KAU-MCGy-101, MC 133 × KAU-MCGy-101, KAU-MCGy-101 X Priyanka, Priyanka × KAU-MCGy-101, and KAU-MCGy-101 × Preethi registered 14.88, 13.42, 11.65, 8.15 and 7.80mg/100 g calcium respectively. The iron content was comparatively less in the monoecious parents Preethi, Priyanka and MC 133 (0.50, 0.49 and 0.47 mg/100 g respectively). The dark green fruited hybrid KAU-MCGy-101 × Priyanka showed maximum value (1.00 mg/100 g) followed by MC 133 × KAU-MCGy-101(0.87 mg/100 g). The gynoecious parent KAU-MCGy-101 had an intermediate value of0.61 mg/100 g.

The quality and quantity of different bioactive compounds present in bitter gourd could depend on many factors such as the time of harvest, temperature, maturity stage, size, shape, colour of fruits (Tan *et al*., 2014; Singh *et al*., 2013). An array of studies conducted worldwide have shown the richness of bitter gourd in ascorbic acid (Sorice *et al*., 2014, Gayathry and John, 2022). The results from the present study mark a difference in the levels of ascorbic acid content between dark green and light green fruits. The light green and white fruited parents are rich in ascorbic acid compared to the dark green fruited gynoecious parent and hybrids. This is similar to the observations of Krishnendu and Nandini (2016) who reported that the light green fruits of bitter gourd carry a high amount of ascorbic acid compared to the dark green fruits. On the contrary, Dhillon *et al*. (2016) observed high levels of phytonutrients in the dark green fruits of bitter gourd. The results pertaining to iron and calcium are in agreement with other investigators (Aboa *et al*., 2008; Goo *et al*., 2016; Tan *et al*., 2016), indicating that the bitter gourd is a good dietary source of these minerals.

Physiological loss in weight. A comparative analysis of shelf life in terms of physiological loss in weight is depicted in Table 2. Ten percent loss in weight was regarded as an indication of the end of shelf life (Ganesan *et al*., 2004). In the present study, the marketability of fruits was almost lost after 4 days of storage. Awide range of values was encountered for physiological loss in weight (20.35 to 35.88 percent after 6 days of storage). The mean value increased significantly in all the treatments with the advancement ofthe storage period. By the end of the 6th day, a maximum weight loss of 35.88 percent was observed in KAU-MCGy-101 and a minimum loss of 20.35 percent was observed in Preethi. On the other hand, Preethi retains the marketability of fruits longer than all the other parents and hybrids studied. The Physiological loss in weight was minimum for KAU-MCGy-101 × Priyanka (24.41 %) when compared to other hybrids and the maximum was for KAU-MCGy-101 × Preethi (31.83 %). The other hybrids MC 133 × KAU-MCGy-101, Priyanka × KAU-MCGy-101, Preethi × KAU-MCGy-101 and KAU-MCGy-101 × MC 133 recorded 25.45, 25.67, 26.87 and 27.13 percent weight loss respectively at the end of 6th day. Hence, in the present study, Preethi and KAU-MCGy-101 × Priyanka exhibited maximum shelf life among the parents and hybrids, respectively.

Bitter gourd fruits are intermediate in perishability (Islam and Jalaluddin 2019). Several physiological and biochemical changes cause the deterioration of fresh fruits after harvest. The common post-harvest defects, which reduce the marketability of bitter gourd fruits are softening and ripening with the color change. In the present study, Preethi and KAU-MCGy-101 × Priyanka exhibited less physiological loss in weight among the parents and hybrids, respectively. The weight reduction in fruits is largely associated with water loss through respiration and transpiration (Kays, 2011). As water evaporates from the tissue, turgor pressure decreases and the cells begin to shrink and collapse, leading to loss of freshness (Wills *et al*., 1998).



(T1- Preethi × KAU-MCGy-101, T2- Priyanka × KAU-MCGy-101, T3- MC 133 × KAU-MCGy-101, T4- KAU-MCGy-101 × Preethi, T5- KAU-MCGy-101 × Priyanka, T6-KAU-MCGy-101 × MC 133)

Fig. 1. Sensory evaluation of parents and hybrids.

Table 1: Ascorbic acid, calcium and iron in the parents and hybrids.

Treatments	Ascorbic acid (mg/100g fresh weight)	Calcium (mg/100 g dry weight)	Iron (mg/100 g dry weight)
Preethi	122.07^{a}	15.62^{ab}	0.50^{bc}
Priyanka	117.37^{ab}	12.23^{abc}	0.49^{bc}
MC 133	115.68^{ab}	10.84^{bc}	0.47^{c}
KAU-MCGy-101	93.90^{d}	4.82^{d}	0.61^{b}
Preethi × KAU-MCGy-101	95.23^{d}	14.88^{ab}	0.51^{bc}
Priyanka × KAU-MCGy-101	105.63^{bcd}	8.15^{cd}	0.53^{bc}
MC 133 × KAU-MCGy-101	109.95^{bc}	13.42^{abc}	0.87^{a}
KAU-MCGy-101 × Preethi	103.29^{cd}	7.80^{cd}	0.55^{bc}
KAU-MCGy-101 × Priyanka	98.59^{d}	11.65^{abc}	1.00^{a}
KAU-MCGy-101× MC 133	102.95^{cd}	17.05^{a}	0.55^{bc}
CD (0.5 %)	12.03	5.94	0.143
CV (%)	6.59	29.71	13.668
SEd	5.73	2.83	0.068

(Means in the column followed by the same alphabet do not differ significantly by DMRT at 5%)

Table 2: Changes in the physiological loss in weight (%) of Parents and hybrids at different days of storage.

Treatments	Physiological loss in weight (%)		
	Days of storage		
	2	4	6
Preethi	9.06^{cd}	15.46^{b}	20.35^{c}
Priyanka	11.13^{bc}	17.06^{b}	25.11^{b}
MC 133	16.14^{a}	23.78^{a}	33.54^{a}
KAU-MCGy-101	17.18^{a}	23.54^{a}	35.88^{a}
Preethi × KAU-MCGy-101	8.07^{d}	17.78^{b}	26.87^{b}
Priyanka × KAU-MCGy-101	13.02^{b}	18.50^{b}	25.67^{b}
MC 133 × KAU-MCGy-101	7.99^{d}	17.30^{b}	25.45^{b}
KAU-MCGy-101 × Preethi	12.20^{b}	25.31^{a}	31.83^{a}
KAU-MCGy-101 × Priyanka	7.57^{d}	15.50^{b}	24.41^{bc}
KAU-MCGy-101 × MC 133	9.76^{cd}	17.84^{b}	27.13^{b}
CD (0.5 %)	2.43	3.13	4.21
CV (%)	12.65	9.49	8.87
SEd	1.16	1.49	2.02

(Means in the column followed by the same alphabet do not differ significantly by DMRT at 5%)

CONCLUSIONS

Varietal development programs in bitter gourd have focused on traits related to agronomic importance, particularly fruit yield. Even though, varieties/hybrids should possess good sensory attributes, nutritional profile and shelf life. The sensory evaluation of parents and hybrids showed less acceptability of dark green fruited bitter gourd (5.35 to 6.03), which tastes bitter than the white fruited. The popular light green fruited varieties of Kerala, Preethi and Priyanka along with the white fruited MC 133 stand first in the overall acceptability. Similar to the findings of other studies, bitter gourd fruits were rich in ascorbic acid, calcium and iron (Aboa *et al*., 2008; Sorice *et al*., 2014; Dhillon *et al*., 2016; Goo *et al*., 2016; Tan *et al*., 2016). Compared with the parents, ascorbic acid content was less in the hybrids, ranging from95.23 to 109.95mg/100g. Among the hybrids, MC 133 × KAU-MCGy-101 showed a high amount of ascorbic acid (109.95 mg/100g). The light green and white fruits were rich in ascorbic acid compared to the dark green fruits of gynoecious parent and hybrids. The hybrid, KAU-MCGy-101 × MC 133 posesses 17.05mg/100g of calcium. Iron content was found highest in the hybrid KAU-MCGy-101 × Priyanka (1.00 mg/100g). The hybrids also exhibit good shelf life in the terms of physiological loss in weight. Hence, the hybrids resultingfrom the gynoecious and monecious bitter gourd crosses are rich in phytonutrients with good shelf life.

FUTURE SCOPE

Based on the present investigation, the dark green gynoecious hybrids were scored less for overall acceptability. Therefore, probably these hybrids could not beat the market. Hence further breeding programmes have to be carried out to generate white fruited gynoecious hybrids.

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Conflict of Interest. None.

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