

# Estimation of phenotypic divergence in a collection of *Cucumis melo* from Kerala State, Southern India

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## ABSTRACT

A collection of melon (*Cucumis melo* L.) from Kerala state, Southern India, consisting of thirty three accessions was evaluated for 22 quantitative and 14 qualitative characteristics to estimate the phenotypic diversity. The collection showed appreciable phenotypic diversity in fruit related traits. Principal component analysis (PCA) was performed to determine the relationships among the populations. The analysis revealed that the variations in stem hair length, number of nodes per plant on 60th day, fruit shape, fruit length, fruit weight, fruit colour at ripening, fruit rind hardness, flesh colour, flesh firmness, quality of flesh, shelf life, seed colour were the principle characters to discriminate melon accessions evaluated in the present study. When the 33 populations were plotted on the first two principal components, accounting for 49.97% of the total variation, three clusters were identified, accounting for 36 morphological attributes used in the study. The greater part of diversity was accounted for fruit diameter, fruit weight, fruit length and width, fruit cavity length and diameter, seed length and colour. Flesh area of fruit, flesh thickness, leaf size, seed weight, seed index did not account for variation in the first six principal components of the melon collection. Scatter diagram segregated the *acidulus* and *momordica* into different clusters. This evaluation of fruit trait variability can assist geneticists and breeders to identify populations with desirable characteristics for inclusion in various breeding programmes.

**Keywords:** *Cucumis melo*; Genetic Diversity; Phenotypic Traits; Principle Component Analysis

## 1. INTRODUCTION

*Cucumis melo* L. ( $2n = 2x = 24$ ) is an economically important horticultural crop belonging to the family Cucurbitaceae. A great morphological variation exists in fruit characteristics such as size, shape, colour, texture, taste and composition. Therefore, *C. melo* is considered as the most diverse species of the genus *Cucumis* [1-3]. The cultivated varieties include sweet “dessert” melons as well as non-sweet forms that are consumed raw, pickled or cooked. Such a variation provides breeders with a rich genetic resource and thus there is an increased interest in understanding their genetic diversity.

The melon germplasm of the humid tropics of Southern India has been collected and assessed by Fergany *et al.* [4]. They reported that the collected populations belong to two groups: *C. melo* var. *acidulus* Naudin and *C. melo* var. *momordica* (Roxb.) Duthie et Fuller. They also recommended that additional collections of melon genetic resources should be made from Southern India as this could lead to the discovery of genetic diversity not present in the existing world collections of melon.

Poor keeping quality of some melon varieties which produce climacteric fruits limits their wide commercial acceptance and thus long shelf life has become an important character in modern cultivars of melon. Variation exists among *C. melo* varieties [5-8] and studies were carried out in few varieties including *inodorus*, *reticulatus*, *makuwa*, *sacharinus*, *cantalupensis*, *acidulus* and *momordica* [8-14]. Hence, the main objectives of present study were to evaluate the diversity among melon accessions collected from Kerala state, Southern India and to estimate the distribution of shelf life among these populations.

## 2. MATERIALS AND METHODS

### 2.1. Plant Materials and Bio-Agronomic Traits

The present study was carried out to assess the pheno-

typic diversity among thirty three landraces of *C. melo* collected in the Kerala state, Southern India (**Table 1**).

The landraces were evaluated in field trials using a randomized complete-block design in triplicates during December 2012 to March 2013. Each plot consisted of 1 row, 7.5 m long, spaced 2 m apart, with 1.5 m spacing between plants within the row. All characters (quantita-

tive and qualitative characters) were measured in the field and at the normal harvest time for the estimation of phenotypic diversity. The characters selected for the analysis were pertaining mainly to *C. melo* breeding aims and were recorded for all genotypes in triplicates [1,15,16]. The fruit characters studied at maturity included length, diameter, shape, colour, skin and flesh

**Table 1.** Details of melon accessions used in the present study.

| CmKc | Collection Area    | Disriect           | Fruit type       | Shelf life | Cluster               |
|------|--------------------|--------------------|------------------|------------|-----------------------|
| 1    | Pilicode           | Kasargode          | <i>Acidulus</i>  | Very good  | I                     |
| 2    | Pilicode           | Kasargode          | <i>Acidulus</i>  | Very good  | I                     |
| 3    | Pilicode           | Kasargode          | <i>Acidulus</i>  | Very good  | I                     |
| 4    | Pilicode           | Kasargode          | <i>Acidulus</i>  | Very good  | I                     |
| 5    | Vylanthur          | Thrissur           | <i>Momordica</i> | Poor       | III                   |
| 6    | Vylanthur          | Thrissur           | <i>Acidulus</i>  | Very good  | I                     |
| 7    | Kanhangad          | Kasargode          | <i>Acidulus</i>  | Very good  | I                     |
| 8    | Kanhangad          | Kasargode          | <i>Acidulus</i>  | Very good  | I                     |
| 9    | Kanhangad          | Kasargode          | <i>Acidulus</i>  | Very good  | Unclustered accession |
| 10   | Nidumbal           | Thrissur           | <i>Acidulus</i>  | Very good  | I                     |
| 11   | Amallor            | Thrissur           | <i>Acidulus</i>  | Very good  | I                     |
| 12   | Amallor            | Thrissur           | <i>Acidulus</i>  | Very good  | I                     |
| 13   | Kakkanad           | Ernakulam          | <i>Momordica</i> | Poor       | III                   |
| 14   | Mattumal           | Palakkad           | <i>Acidulus</i>  | Very good  | I                     |
| 15   | Mattumal           | Palakkad           | <i>Acidulus</i>  | Very good  | I                     |
| 16   | Alathur            | Palakkad           | <i>Acidulus</i>  | Very good  | I                     |
| 17   | Chevayur           | Kozhikode          | <i>Acidulus</i>  | Very good  | I                     |
| 18   | Kottapadi          | Malappuram         | <i>Acidulus</i>  | Very good  | I                     |
| 19   | Changuvatti        | Malappuram         | <i>Acidulus</i>  | Very good  | I                     |
| 20   | Ettumunoor         | Kottayam           | <i>Acidulus</i>  | Very good  | I                     |
| 21   | Kamallur           | Allapuzha          | <i>Acidulus</i>  | Very good  | I                     |
| 22   | Pathanamthitta     | Patanamthitta      | <i>Acidulus</i>  | Very good  | I                     |
| 23   | Konni              | Kollam             | <i>Momordica</i> | Poor       | II                    |
| 24   | Thiruvananthapuram | Thiruvananthapuram | <i>Momordica</i> | Poor       | II                    |
| 25   | Thiruvananthapuram | Thiruvananthapuram | <i>Momordica</i> | Poor       | II                    |
| 26   | Edacheri           | Wayanad            | <i>Acidulus</i>  | Very good  | I                     |
| 27   | Edacheri           | Wayanad            | <i>Acidulus</i>  | Very good  | I                     |
| 28   | Dharmadam          | Kannur             | <i>Acidulus</i>  | Very good  | I                     |
| 29   | Peravoor           | Kannur             | <i>Acidulus</i>  | Very good  | I                     |
| 30   | Kasargode          | Kasargode          | <i>Acidulus</i>  | Very good  | I                     |
| 31   | Pandalam           | Patanamthitta      | <i>Acidulus</i>  | Very good  | I                     |
| 32   | Kottarkara         | Kollam             | <i>Acidulus</i>  | Very good  | I                     |
| 33   | Thrissur           | Thrissur           | <i>Momordica</i> | Poor       | III                   |

thickness. Traits of fruit size and shape, such as flesh thickness, fruit length and width, placenta length were measured using the drawing ruler. Cotton blue in lacto phenol stain was used for the analysis of pollen viability.

Finally, with an aim to compare together qualitative and quantitative data, a numerical transformation was applied to traits such as flesh and rind color (**Table 2**). A numerical value, ranging from 1 to k (k equal to number of

**Table 2.** Morphological characters measured in *Cucumis melo* collection.

| Character Number | Character code | Character and descriptive values   |
|------------------|----------------|--|
| 1                | Vl             | Vine length at 60th day in cm  |
| 2                | Sh             | Stem hair: 1 (Soft), 2 (Intermediate), 3 (Hard)  |
| 3                | Nb             | Number of branches per plant at 60th day   |
| 4                | Nn             | Number of nodes per plant at 60th day  |
| 5                | Ll             | Leaf length in cm  |
| 6                | Lw             | Leaf width in cm   |
| 7                | Lb             | Leaf blade; 1 (Entire), 2 (Light lobed), 3 (Intermediate lobed)  |
| 8                | Tl             | Tendrill length in cm  |
| 9                | Pv             | Pollen viability in %  |
| 10               | Fp             | Fruits per plant   |
| 11               | Fsh            | Fruit shape: 1 (globular), 2 (flattened), 3 (oblate), 4 (elliptical), 5 (pyriform), 6 (ovate), 7 (elongate)  |
| 12               | Fl             | Fruit length in cm   |
| 13               | Fw             | Fruit width in cm  |
| 14               | Fd             | Fruit diameter in cm   |
| 15               | Fwt            | Fruit weight in cm   |
| 16               | Fcr            | Fruit colour at ripening: 1 (white to green), 2 (white to orange), 3 (light green to yellow), 4 (yellow to orange), 5 (light green to orange)  |
| 17               | Frc            | Fruit rind colouration: 1 (monocoured), 2 (bicoloured with longitudinal strips from base to apex)  |
| 18               | Frs            | Fruit rind surface: 1 (smooth), 2 (cracked)  |
| 19               | Frp            | Fruit rind pattern: 1 (plane), 2 (strips), 3 (dotted)  |
| 20               | Frh            | Fruit rind hardness: 1(soft), 2 (intermediate), 3 (hard)   |
| 21               | Fs             | Fruit suture: 1 (suture), 2 (non suture)   |
| 22               | Fth            | Flesh thickness in cm  |
| 23               | Flc            | Flesh colour: 1(white), 2 (light orange), 3 (green), 4 (light orange), 5 (greenish orange), 6 (orange)   |
| 24               | Ff             | Flesh firmness: 1 (crispy), 2 (intermediate), 3 (grainy)   |
| 25               | Qf             | Quality of flesh: 1 (crispy), 2 (intermediate), 3 (soft)   |
| 26               | FAF            | Flesh area of fruit in %: $(a + b)^2 - (a' + b') \times 100 / (a + b)^2$<br>a = length of whole fruit, a' = length of fruit cavity<br>b = diameter of whole fruit, b' = diameter of fruit cavity |
| 27               | Cl             | Cavity length in cm  |
| 28               | Cd             | Cavity diameter in cm  |
| 29               | Shl            | Shelf life: 1, poor (1 - 2 months); 2,intermediate (3 months); 3, good (4 - 5 months); 4, very good (6 months)   |
| 30               | Spf            | Seeds per fruit  |
| 31               | Sc             | Seed colour: 1(white), 2 (cream), 3 (light brown)  |
| 32               | Sl             | Seed length in cm  |
| 33               | Sw             | Seed width in cm   |
| 34               | Si             | Seed index   |
| 35               | Swt            | Seed weight in grams   |
| 36               | Gd             | Growth duration: 1 (more than 120 days), 2 (90 to 120 days), 3 (less than 90 days)   |

classes), was assigned to each phenotrait, to indicate different degrees of expression. For seed characters, 10 measurements were averaged for each plant.

## 2.2. Statistical Analysis

All the original data were standardized to eliminate the difference in the variance of each character. Principal component analysis (PCA) was performed to generate a cluster diagram. Eigen values and contribution percentage of each principal component axis were calculated using the correlation matrix among thirty six characters for thirty three accessions [17]. All computations were performed using the unscrambler 10 software (CAMO Software India Pvt. Ltd., Bangalore, India) and SPSS 17.0 for MS Windows (SPSS Inc).

## 3. RESULTS AND DISCUSSION

Thirty three accessions of melons collected from Kerala state, Southern India were evaluated to estimate the

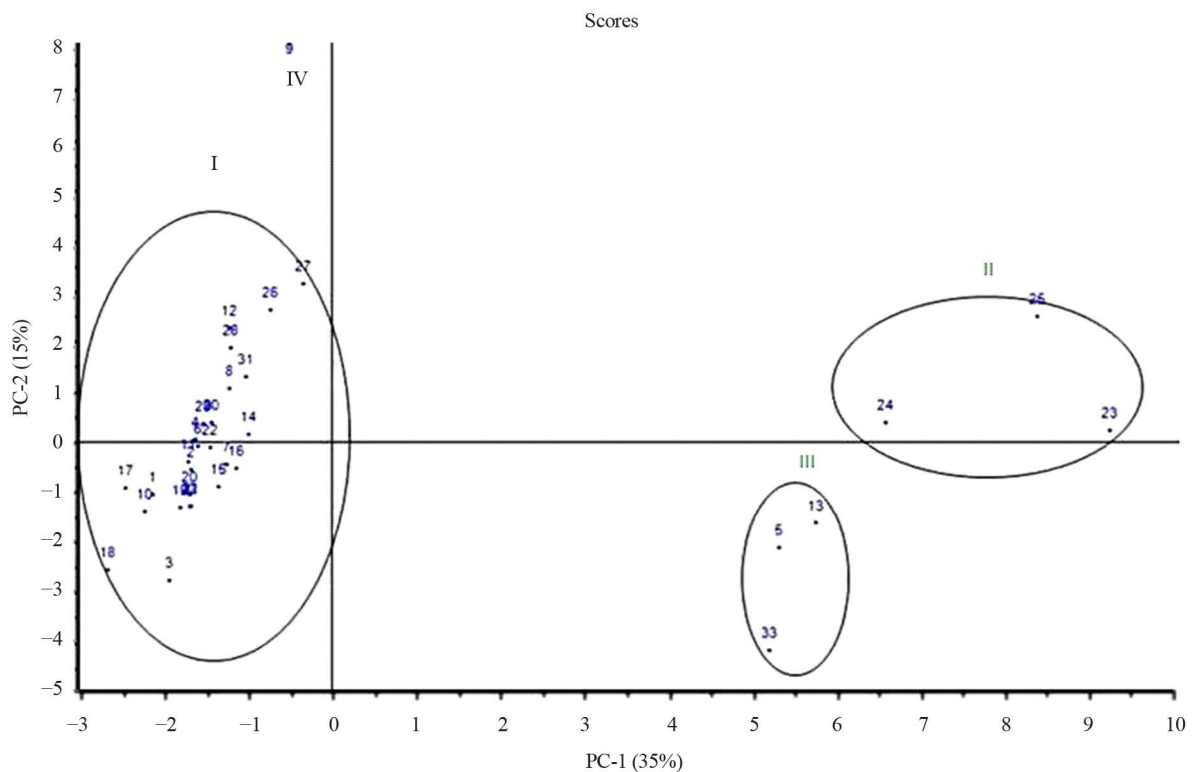
genetic diversity among the melon populations. Thirty six selected qualitative and quantitative characters were assessed in the uniform field trials (**Table 2**). All the melon accessions used in the analysis were monoecious and substantial genetic diversity was observed. These accessions showed a large genetic variability with respect to fruit shape and size. Principal component analysis was used to assess the variability in melon accessions. The percentage of variation explained by the first six components was 35.07, 14.90, 9.10, 6.57, 5.79 and 5.33 respectively, and the principle characters with higher Eigen vectors that delineated the accessions into separate groups in the first six components are represented in the **Table 3**. The variations in stem hair length, number of nodes per plant on 60th day, fruit shape, fruit length, fruit weight, fruit colour at ripening, fruit rind hardness, flesh colour, flesh firmness, quality of flesh, shelf life, seed colour were the important characters for the formation of different clusters. **Figure 1** depicts the formation of three clusters with one un-clustered melon landrace. By these

**Table 3.** Contribution percentage and major characters associated with the first principle components of 33 melon accessions and their Eigen vector.

| Principle component                    | 1          | 2          | 3           | 4            | 5           | 6          |
|--|------------|------------|-------------|--------------|-------------|------------|
| Explained proportion of variation (%)  | 35.07      | 14.90      | 9.10        | 6.57         | 5.79        | 5.33       |
| Cumulative proportion of variation (%) | 35.07      | 49.97      | 59.07       | 65.64        | 71.43       | 76.76      |
| Eigen vector                           |            |            |             |              |             |            |
| Vl                                     | 0.1941308  | 0.3854465  | -0.6465489  | 0.1627286    | 0.09019072  | -0.0867000 |
| Sh                                     | -0.9686255 | 0.1757309  | 0.03016858  | 0.03681153   | 0.1206224   | 0.08627229 |
| Nb                                     | 0.2316808  | 0.2728379  | 0.2949748   | 0.2125249    | 0.3891021   | -0.6061266 |
| Nn                                     | 0.01770082 | 0.2052537  | 0.3517672   | -0.07458628  | 0.3291233   | -0.7096581 |
| Ll                                     | -0.1688125 | -0.2735105 | -0.5529157  | 0.4031258    | 0.232549    | -0.1618984 |
| Lw                                     | 0.1007167  | -0.3312536 | -0.09961649 | -0.005759506 | 0.4643296   | -0.1944669 |
| Tl                                     | 0.2230351  | 0.28338    | -0.4395817  | 0.03696718   | 0.5926297   | -0.0230449 |
| Pv                                     | 0.2668421  | 0.2517732  | 0.0665976   | -0.1027278   | 0.1960052   | 0.1466913  |
| Fp                                     | -0.3765168 | -0.3617526 | 0.3858287   | 0.394814     | 0.03369923  | 0.0822719  |
| Fsh                                    | 0.5391971  | -0.0540669 | -0.4160905  | -0.1364919   | 0.3445447   | 0.09465964 |
| Fl                                     | 0.7227173  | 0.308144   | 0.3233948   | -0.06559674  | 0.170721    | 0.3318942  |
| Fw                                     | 0.1537337  | 0.7595731  | 0.2415445   | -0.2481305   | 0.01015097  | -0.0214247 |
| Fd                                     | 0.04803415 | 0.8598647  | -0.1049251  | -0.1545179   | 0.07193942  | 0.06991526 |
| Fwt                                    | 0.2628347  | 0.7860266  | 0.1906711   | -0.11744     | -0.00634643 | -0.0315025 |
| Fcr                                    | -0.9686255 | 0.1757309  | 0.03016858  | 0.03681153   | 0.1206224   | 0.08627229 |
| Frrh                                   | -0.9686255 | 0.1757309  | 0.03016858  | 0.03681153   | 0.1206224   | 0.08627229 |
| Fth                                    | 0.05059452 | 0.1882358  | -0.7923409  | -0.06250334  | -0.04250038 | 0.08531409 |
| Flc                                    | 0.9686255  | -0.1757309 | -0.03016858 | -0.03681153  | -0.1206224  | -0.0862722 |
| Ff                                     | 0.9686255  | -0.1757309 | -0.03016858 | -0.03681153  | -0.1206224  | -0.0862722 |

Continued

|     |            |             |             |              |             |            |
|-----|------------|-------------|-------------|--------------|-------------|------------|
| Qf  | 0.9686255  | -0.1757309  | -0.03016858 | -0.03681153  | -0.1206224  | -0.0862722 |
| FAF | -0.3263147 | 0.1537797   | -0.1432286  | -0.5821441   | -0.07895434 | -0.210587  |
| Cl  | 0.6670699  | 0.2680832   | 0.4493805   | 0.02985854   | 0.03566362  | 0.2570127  |
| Cd  | 0.2118728  | 0.7323623   | -0.08459914 | -0.01454906  | 0.1111293   | 0.3136823  |
| Shl | -0.9686255 | 0.1757309   | 0.03016858  | 0.03681153   | 0.1206224   | 0.08627229 |
| Spf | 0.1499597  | 0.384278    | -0.3905573  | 0.5643572    | -0.3008645  | 0.04569659 |
| Sc  | 0.9051051  | -0.1046764  | -0.08269551 | 0.0444922    | -0.02368167 | -0.0326795 |
| Sl  | 0.5496318  | 0.5316715   | 0.1352246   | 0.4556467    | 0.0162517   | 0.02770174 |
| Sw  | -0.0274061 | 0.6619      | -0.00583967 | 0.3822937    | -0.4315375  | -0.315695  |
| Si  | 0.5580416  | -0.2469485  | 0.1362616   | -0.000254083 | 0.5087599   | 0.3873413  |
| Swt | 0.1028545  | -0.09773537 | 0.2895683   | 0.6930479    | 0.1978223   | 0.1617651  |
| Gd  | 0.9686255  | -0.1757309  | -0.03016858 | -0.03681153  | -0.1206224  | -0.0862722 |



**Figure 1.** Cluster diagram constructed on the basis of the first two principle component axes, which contain 50% of the total variation.

components, accessions showing large variation in vine length (101 cm to 220 cm), number of branches on 60th day (12 to 20), number of nodes on 60th day (25 to 43), tendril length (24 cm to 51 cm), fruit shape (ovate to oblate), fruit length (15 cm to 43 cm), fruit width (7 cm to 12 cm), stem hair length, fruit colour at ripening, seed colour, larger fruit diameter with medium growth duration (within 120 days) were grouped into a larger cluster in the left and the collections in this cluster were mainly

*acidulus* (Figure 1). Accessions with longer vine length and leaf length, larger fruit length, heavy fruit weight, light green to yellow fruit colour, soft rind, light orange flesh colour, grainy and intermediate flesh, poor shelf life (1 - 2 months), light brown seeds, short growth duration (within 90 days) were on the right of the scatter diagram, and these accessions on the right of the scatter diagram were *momordica* (Figure 1). Cluster 3 included landraces which showed almost similar characters as that of

the landraces grouped in cluster 2 with heavy fruit weight, light green to yellow fruit colour, soft rind, grainy and intermediate flesh, light orange flesh colour, moderate fruit length, poor shelf life (1 - 2 months), light brown seeds, short growth duration (within 90 days). These accessions on the right of the scatter diagram were *momordica* (**Figure 1**). The unclustered landrace CmKc-9 had long vein length, higher number of nodes on 60th day, smaller leaf size, higher fruit width, heavy fruit weight, medium growth duration (within 120 days). This

landrace included the *acidulus*. The range for primary branches per plant was from twelve to twenty in *acidulus* which was almost similar to the branch profile of the *momordica*. The minimum and maximum vein length and number of nodes per plant was almost same in both the varieties. A detailed description of the melon fruits used in the study is given in **Table 4** and mean trait values of each cluster for their quantitative characters are mentioned in **Table 5**. The range of variability of phenotypic characters in terms of minimum

**Table 4.** Fruit traits of melon accessions.

| Analysis code number | Fruits/plant | Fruit colour          | Fruit shape | Weight (g) | Aroma          | Flesh colour |
|----------------------|--------------|-----------------------|-------------|------------|----------------|--------------|
| 1                    | 3            | Light green to orange | Oblate      | 750        | Mild but sweet | White        |
| 2                    | 3            | Light green to orange | Oblate      | 1000       | Mild but sweet | White        |
| 3                    | 4            | Light green to orange | Ovate       | 550        | Mild but sweet | White        |
| 4                    | 3            | Light green to orange | Oblate      | 1225       | Mild but sweet | White        |
| 5                    | 2            | Light green to yellow | Elongate    | 1250       | Strong         | Light orange |
| 6                    | 3            | Light green to orange | Oblate      | 800        | Mild but sweet | White        |
| 7                    | 2            | Light green to orange | Elongate    | 1000       | Mild but sweet | White        |
| 8                    | 2            | Light green to orange | Elliptical  | 1000       | Mild but sweet | White        |
| 9                    | 2            | Light green to orange | Elliptical  | 2000       | Mild but sweet | White        |
| 10                   | 3            | Light green to orange | Oblate      | 370        | Mild but sweet | White        |
| 11                   | 3            | Light green to orange | Ovate       | 900        | Mild but sweet | White        |
| 12                   | 2            | Light green to orange | Oblate      | 1500       | Mild but sweet | White        |
| 13                   | 2            | Light green to yellow | Elongate    | 1000       | Strong         | Light orange |
| 14                   | 3            | Light green to orange | Elongate    | 1225       | Mild but sweet | White        |
| 15                   | 2            | Light green to orange | Elongate    | 755        | Mild but sweet | White        |
| 16                   | 3            | Light green to orange | Elongate    | 900        | Mild but sweet | White        |
| 17                   | 3            | Light green to orange | Oblate      | 570        | Mild but sweet | White        |
| 18                   | 4            | Light green to orange | Oblate      | 750        | Mild but sweet | White        |
| 19                   | 2            | Light green to orange | Elliptical  | 1000       | Mild but sweet | White        |
| 20                   | 2            | Light green to orange | Oblate      | 1000       | Mild but sweet | White        |
| 21                   | 2            | Light green to orange | Ovate       | 800        | Mild but sweet | White        |
| 22                   | 4            | Light green to orange | Ovate       | 900        | Mild but sweet | White        |
| 23                   | 2            | Light green to yellow | Elongate    | 1200       | Strong         | Light orange |

**Table 5.** Mean trait values used in *Cucumis melo* cluster identification.

| Traits | Cluster I     | Cluster II     | Cluster III    | Unclustered accession |
|--------|---------------|----------------|----------------|-----------------------|
| VI     | 153.0 ± 41.46 | 44.75 ± 506.4  | 147.6 ± 34.195 | 210                   |
| Sh     | 3.00 ± 0.00   | 1.000 ± 0.000  | 1.000 ± 0.000  | 3                     |
| Nb     | 16.50 ± 2.68  | 313.7 ± 590.84 | 17.33 ± 2.08   | 21                    |
| Nn     | 33.65 ± 5.19  | 39.16 ± 8.207  | 32.66 ± 5.68   | 38                    |
| Ll     | 11.73 ± 2.28  | 26.20 ± 18.51  | 11.66 ± 2.19   | 9.8                   |

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|     |                 |                  |                 |       |
|-----|-----------------|------------------|-----------------|-------|
| Lw  | 17.84 ± 2.51    | 30.31 ± 14.38    | 18.20 ± 1.00    | 13.9  |
| Tl  | 38.73 ± 8.21    | 42.00 ± 10.39    | 40.33 ± 9.60    | 49    |
| Pv  | 96.69 ± 7.14    | 100.0 ± 0.000    | 100.0 ± 0.00    | 100   |
| Fp  | 2.576 ± 0.757   | 2.000 ± 0.000    | 2.000 ± 0.000   | 2     |
| Fsh | 4.961 ± 1.611   | 7.000 ± 0.000    | 7.000 ± 0.000   | 4     |
| Fl  | 21.80 ± 5.982   | 52.00 ± 7.810    | 23.16 ± 8.51    | 23    |
| Fw  | 8.80 ± 1.288    | 10.73 ± 1.553    | 7.30 ± 2.13     | 12    |
| Fd  | 30.68 ± 5.712   | 34.20 ± 2.662    | 25.26 ± 3.65    | 43.3  |
| Fwt | 814.6 ± 372.421 | 1335.0 ± 212.5   | 483.3 ± 448.14  | 2.000 |
| Fcr | 5.000 ± 0.000   | 3.000 ± 0.000    | 3.000 ± 0.000   | 5     |
| Frs | 2.000 ± 0.000   | 4.000 ± 0.000    | 3.000 ± 0.000   | 1     |
| Frp | 2.192 ± 0.401   | 2.000 ± 0.000    | 1.33 ± 0.57     | 2     |
| Frh | 2.000 ± 0.000   | 1.000 ± 0.000    | 1.000 ± 0.000   | 2     |
| Fth | 2.242 ± 0.441   | 2.300 ± 0.346    | 2.26 ± 0.40     | 2.5   |
| Flc | 1.000 ± 0.000   | 2.000 ± 0.000    | 2.000 ± 0.000   | 1     |
| Ff  | 1.000 ± 0.000   | 3.000 ± 0.000    | 3.000 ± 0.000   | 1     |
| Qf  | 1.000 ± 0.000   | 2.000 ± 0.000    | 2.000 ± 0.000   | 1     |
| FAF | 98.1 ± 0.988    | 96.14 ± 5.21     | 97.75 ± 0.88    | 96.55 |
| Cl  | 19.65 ± 5.698   | 43.43 ± 14.165   | 22.86 ± 10.41   | 25    |
| Cd  | 16.64 ± 2.319   | 492.0 ± 79.170   | 14.60 ± 0.87    | 22.6  |
| Shl | 4.000 ± 0.000   | 1.000 ± 0.000    | 1.000 ± 0.000   | 4     |
| Spf | 446.6 ± 123.7   | 492.0 ± 79.170   | 503.0 ± 136.96  | 848   |
| Sc  | 2.000 ± 0.000   | 3.000 ± 0.000    | 2.66 ± 0.57     | 2     |
| Sl  | 9.000 ± 0.000   | 0.966 ± 0.057    | 9.00 ± 0.00     | 1     |
| Sw  | 4.000 ± 0.000   | 4.000 ± 0.000    | 4.000 ± 0.000   | 0.5   |
| Si  | 2.250 ± 0.000   | 2.416 ± 0.144    | 2.250 ± 0.000   | 2     |
| Swt | 1151.1 ± 182.8  | 1224.0 ± 303.464 | 1142.6 ± 160.31 | 1202  |
| Gd  | 2.000 ± 0.000   | 3.000 ± 0.000    | 3.000 ± 0.000   | 2     |

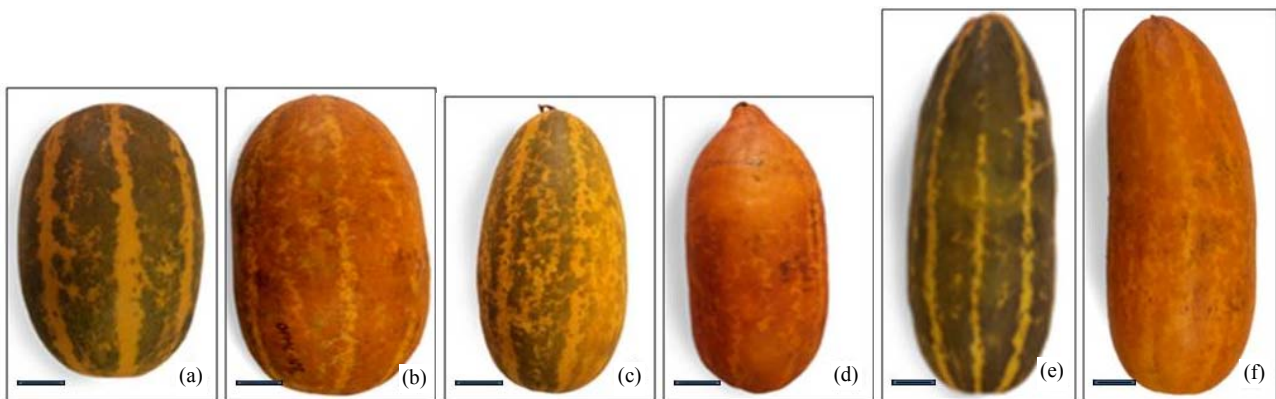
and maximum and mean values are presented in **Table 6**. Morphological variation was most apparent in fruit length which varied from 15 cm to 43 cm per fruit in *acidulus* whereas in *momordica* it was from 15 cm to 57 cm per fruit. Fruit colour was also quite similar ranging from light green to yellow or orange (**Figure 2**). The fruit colour of the accessions, CmKc-5, CmKc-13, CmKc-23, CmKc-24, CmKc-25 and CmKc-33 was mainly light green to yellow which were grouped in cluster 2 and 3 which included mainly *momordica* (**Figure 3**). The fruits of *acidulus* were generally ovate to oblate in shape except in CmKc-8, but those of *momordica* were elongated except in CmKc-3 which was ovate. The average fruit weight of the collections varied greatly. The fruit weight

varied from 420 g to 1250 g per fruit in *acidulus*, in *momordica* it varied from 200 g to 1580 g per fruit with CmKc-9 gaining the maximum fruit weight of 2000 g per fruit. The flesh of the fruits was generally white to light orange in color and crispy to grainy in nature. The flesh colour was white in *acidulus* and it was light orange in *momordica* (**Table 4**). Most of the *momordica* landraces had a strong odour at maturity except for CmKc-3 which had a mild and sweet odour. The fruits of *acidulus* were non climacteric, very firm and did not crack at maturity (**Figure 2**) and these fruits are used for cooking purpose in Kerala. The fruits of *momordica* were, climacteric, soft and cracked at maturity (**Figures 3(e)-(f)**), hence had very low shelf life and these fruits are also used for

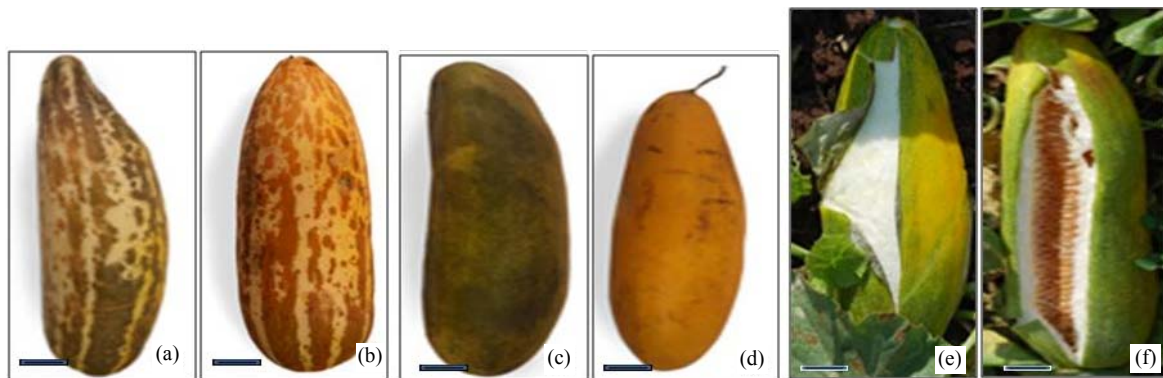
**Table 6.** Variability in some quantitative characters of *acidulus* and *momordica* landraces.

| Trait | <i>Cucumis melo</i> var. <i>acidulus</i> |                |                 | <i>Cucumis melo</i> var. <i>momordica</i> |                |                  |
|-------|--|----------------|-----------------|---|----------------|------------------|
|       | Cluster I                                |                |                 | Cluster II                                |                |                  |
|       | Minimum values                           | Maximum values | Mean $\pm$ SD   | Minimum values                            | Maximum values | Mean $\pm$ SD    |
| Vl    | 101                                      | 220            | 153 $\pm$ 41.46 | 176                                       | 210            | 187 $\pm$ 19.3   |
| Sh    | 3  | 3              | 3.00 $\pm$ 0.00 | 1   | 1              | 1.00 $\pm$ 0.00  |
| Nb    | 12                                       | 20             | 16.5 $\pm$ 2.68 | 14  | 23             | 18.3 $\pm$ 4.50  |
| Nn    | 25                                       | 43             | 33.6 $\pm$ 5.19 | 30  | 42             | 36.3 $\pm$ 6.02  |
| Ll    | 9.7                                      | 18.9           | 11.7 $\pm$ 2.28 | 10.1                                      | 10.8           | 10.4 $\pm$ 0.36  |
| Lw    | 10.7                                     | 20.1           | 17.8 $\pm$ 0.49 | 18.2                                      | 18.9           | 18.6 $\pm$ 0.37  |
| Tl    | 24                                       | 51             | 38.7 $\pm$ 8.21 | 30  | 48             | 42.0 $\pm$ 10.3  |
| Pv    | 75                                       | 100            | 96.6 $\pm$ 7.14 | 100                                       | 100            | 100.0 $\pm$ 0.00 |
| Fp    | 1  | 4              | 2.57 $\pm$ 0.75 | 2   | 2              | 2.00 $\pm$ 0.00  |
| Fsh   | 3  | 7              | 4.96 $\pm$ 1.61 | 7   | 7              | 7.00 $\pm$ 0.00  |
| Fl    | 15                                       | 43             | 21.8 $\pm$ 5.98 | 43  | 57             | 52.0 $\pm$ 7.81  |
| Fw    | 7  | 12             | 8.80 $\pm$ 1.28 | 9   | 12             | 10.7 $\pm$ 1.55  |
| Fd    | 17                                       | 40             | 30.6 $\pm$ 5.71 | 31  | 34             | 34.2 $\pm$ 2.66  |
| Fwt   | 370                                      | 1500           | 922 $\pm$ 285.2 | 1200                                      | 1580           | 1335 $\pm$ 212   |
| Fcr   | 5  | 5              | 5.00 $\pm$ 0.00 | 3   | 3              | 3.00 $\pm$ 0.00  |
| Frs   | 1  | 1              | 1.00 $\pm$ 0.00 | 4   | 4              | 4.00 $\pm$ 0.00  |
| Frp   | 2  | 3              | 2.19 $\pm$ 0.40 | 2   | 2              | 2.00 $\pm$ 0.00  |
| Frh   | 2  | 2              | 2.00 $\pm$ 0.00 | 1   | 1              | 1.00 $\pm$ 0.00  |
| Fth   | 1.4                                      | 2.5            | 2.62 $\pm$ 2.06 | 1.9                                       | 2.5            | 2.30 $\pm$ 0.34  |
| Fle   | 1  | 1              | 1.00 $\pm$ 0.00 | 2   | 2              | 2.00 $\pm$ 0.00  |
| Ff    | 1  | 1              | 1.00 $\pm$ 0.00 | 3   | 3              | 3.00 $\pm$ 0.00  |
| Qf    | 1  | 1              | 1.00 $\pm$ 0.00 | 2   | 2              | 2.00 $\pm$ 0.00  |
| FAF   | 95                                       | 99             | 98.1 $\pm$ 0.98 | 90  | 99             | 96.1 $\pm$ 5.21  |
| Cl    | 13                                       | 40             | 19.6 $\pm$ 5.69 | 31  | 59             | 43.3 $\pm$ 14.1  |
| Cd    | 12                                       | 20             | 16.6 $\pm$ 2.31 | 15  | 26             | 20.1 $\pm$ 5.52  |
| Shl   | 4  | 4              | 4.00 $\pm$ 0.00 | 1   | 1              | 1.00 $\pm$ 0.00  |
| Spf   | 221                                      | 948            | 458 $\pm$ 153   | 410                                       | 568            | 492 $\pm$ 79.1   |
| Sc    | 2  | 2              | 2.00 $\pm$ 0.00 | 3   | 3              | 3.00 $\pm$ 0.00  |
| Sl    | 0.9                                      | 0.9            | 0.90 $\pm$ 0.00 | 0.9                                       | 1              | 0.96 $\pm$ 0.57  |
| Sw    | 0.4                                      | 0.4            | 0.40 $\pm$ 0.00 | 0.4                                       | 0.4            | 0.40 $\pm$ 0.00  |
| Si    | 0.25                                     | 2.25           | 2.17 $\pm$ 0.39 | 2.25                                      | 2.50           | 2.41 $\pm$ 0.14  |
| Swt   | 100                                      | 158            | 1151 $\pm$ 182. | 1003                                      | 1570           | 1224 $\pm$ 303   |
| Gd    | 2  | 2              | 2.00 $\pm$ 0.00 | 3   | 3              | 3.00 $\pm$ 0.00  |





**Figure 2.** Variability in fruits of *Cucumis melo* var. *acidulus* landraces: (a) Tender oblate fruit of CmKc-3 landrace (Bar = 2.66 cm); (b) Ripe fruit of CmKc-3 landrace (Bar = 3.21 cm); (c) Tender fruit of CmKc-14 landrace (Bar = 4.92 cm); (d) Ripe fruit of CmKc-22 landrace (Bar = 5.04 cm); (e) Tender elongated fruit of CmKc-15 landrace (Bar = 3.5cm); (f) Ripe fruit of CmKc-27 landrace (Bar = 3.26 cm).



**Figure 3.** Variability in fruits of *Cucumis melo* var. *momordica* landraces: (a) Tender plane fruit of CmKc-5 landrace (Bar = 4.95 cm); (b) Ripe fruit of CmKc-13 landrace (Bar = 5.4 cm); (c) Tender fruit of CmKc-24 landrace (Bar = 5.07 cm); (d) Ripe fruit of CmKc-23 landrace (Bar = 5.78 cm); (e) Peeled fruit of CmKc-25 landrace (Bar = 3.17 cm); (f) Fruit cracking in CmKc-33 landrace (Bar = 3.4 cm).

cooking before maturity. The seeds of *acidulus* and *momordica* were medium sized, white in colour and maximum seed length was 0.9 and 1.0 cm respectively. The present survey of morpho-metric analysis of Kerala landraces of melon revealed considerable variability especially with fruit characteristics. The landraces belonged to two varieties, *acidulus* and *momordica* which possessed non sweet fruits which are consumed as cooked vegetables. These observations support the views of Fergany *et al.* [4], Manohar and Murthy [14] that South Indian melon landraces comprises of *acidulus* and *momordica*. The data on shelf-life and its correlation with other characteristics is presented in **Table 7**. Fruit shape, fruit weight, flesh colour, quality of flesh, flesh firmness were highly correlated with shelf-life of melon fruits. Accessions with good shelf-life belong to *acidulus* variety and these accessions were characterized by fruits possessing firm skin, non-climacteric, non-juicy, crisp with white flesh. The fruits of such accession could be stored more than six months without loss of quality. As-

**Table 7.** Correlation coefficients between shelf life and other characters.

| Character        | Shelf life |
|------------------|------------|
| Fruit shape      | 0.31087    |
| Fruit colour     | 0.16896    |
| Fruit weight     | 0.37343    |
| Flesh colour     | 0.33142    |
| Flesh thickness  | 0.18398    |
| Quality of flesh | 0.33142    |
| Flesh firmness   | 0.57446    |
| Rind hardness    | 0.21542    |
| 100 seed weight  | 0.15917    |
| Growth duration  | 0.16923    |

essment of shelf-life among melon accessions was carried

out in *C. melo* var. *sacharinus* (Hami-melon) [18], and selected accessions have been used for breeding programme.

#### 4. CONCLUSION

It was reported that melon germplasm (*acidulus* and *momordica*) of Southern India possess resistance to Cucumber mosaic virus, Zucchini yellow mosaic virus, Powdery mildew (races 1, 2, 3 and 5), *Fusarium* wilt (races 1 and 2), *Aphis gossypii* and leafminer [4]. The landraces collected from Kerala state showed increased shelf-life. However, these land races should be assessed for disease resistance characteristics by using molecular markers. These landraces need to be analyzed for their ability to be used as bred cultivars for commercial breeding purpose.

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## APPENDIX

Abbreviations: CmKc-*Cucumis melo* Kerala collection, PCA-Principle Component Analysis