CHARACTERIZATION OF TRADITIONAL MANGO (*Mangifera indica* L.) VARIETIES OF SOUTHERN KERALA

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DECLARATION

I hereby declare that this thesis entitled "**Characterization of traditional mango (*Mangifera indica* L.) varieties of southern Kerala**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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CERTIFICATE

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Dedicated to
My Beloved
Parents & Husband

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LIST OF ABBREVIATIONS

µ	micron
µl	microlitre
µM	micromolar
Acc.	accession
AFLP	amplified fragment length polymorphism
bp	base pair
DNA	deoxy ribonucleic acid
dNTPs	deoxy nucleotides
EDTA	ethylene diamino tetra acetic acid disodium salt
IBPGR	International Board for Plant Genetic Resources
IPGRI	International Plant Genetic Resources Institute
ISSR	Inter simple sequence repeats
mM	millimolar
ng	nanogram
PCR	polymerase chain reaction
pM	picomolar
PVP	poly vinyl pyrollidone
RAPD	random amplified polymorphic DNA
RFLP	restriction fragment length polymorphism
SCAR	sequence characterized amplified region
SSR	simple sequence repeats
Tris HCl	tris (hydroxy methyl) aminomethane hydrochloride
TSS	total soluble solids
VNTR	variable number of tandem repeats
IDH	isocitrate dehydrogenase
LAP	leusine aminopeptidase
PGI	phosphoglucose isomerase
PG	polygalacturonase
TPI	triose phosphate isomerase

Introduction

1. INTRODUCTION

Mango (*Mangifera indica* L.) is the most important fruit crop of India and it has been cultivated in India for over 4000 years. Mango is cultivated in an area of 1.6 million ha. India ranks first among the mango producing countries in the world, with an annual production of 10.78 million tonnes (CMIE, 2005). There are at least 1000 named cultivars in India (Kumar *et al.*, 2001). Mango is considered as the national fruit of India.

In south India, over 350 varieties are being cultivated (Naik, 1963). Currently, mango is cultivated in an area of 85,428 ha with a production of 3,84,190 tonnes (FIB, 2006) in Kerala. Previously, there were vast areas of land under mango cultivation in Kerala. Vellari manga, Karpooram manga, Chenka Varikka, Moovandan, Kotookonam Varikka, Chandrakaran, Koonan, Kalkandamanga, Karakka manga, Chappikudiyan and Kilichundan are some of the traditional mango varieties of Kerala. The importance of these mango varieties to the people of Kerala is indicated by the multitude of uses of the various parts of the trees. The tree is valued for its timber, leaves as a substitute for toothbrush, tender fruits for pickling and culinary purposes, ripened fruits for table purpose, juice extraction and also for certain culinary preparations. Thus mango fruits form an integral part of food preparations of Kerala and hence it finds place in all the homesteads. However, due to the changes in socio-economic situation and land use pattern and the shrinking homesteads, the area under mango cultivation has been reduced. Urbanisation and industrialisation paved way to large scale destruction of mango germplasm. Moreover, there was a shift in the preference of people towards new varieties and grafts. This has resulted in the genetic erosion of traditional mango germplasm of the state. In southern Kerala, (particularly, Trivandrum, Kollam, Pathanamthitta and Alappuzha districts), there has been more than 15 per cent reduction in area from 2000-01 to 2003-04 (FIB, 2006). Many of

our traditional varieties have become extinct. The remaining few varieties are confined to homesteads and avenues. This is an alarming situation. Therefore, there is an urgent need to catalogue and conserve at least the available traditional genetic resources, which are on the verge of extinction. Apart from this, the nomenclature of *Mangifera* sp. and mango cultivars is complicated by the use of synonyms. Proper assessment of existing genetic diversity is important in view of the emerging patent rules. Efforts in this regard are not appreciable. However, in North and Central Kerala, attempts have been made to collect, maintain and conduct variability studies in mango varieties (Radha and Manjula, 2000; Naik *et al.*, 2000).

In the present study, an attempt has been made with the objective to characterize the traditional mango varieties of southern Kerala (Thiruvananthapuram, Kollam, Pathanamthitta and Alappuzha districts) based on vegetative, floral and fruit characters and random amplified polymorphic DNA (RAPD) profiles and to document the traditional knowledge associated with the varieties.

RAPD is a quick, reliable and widely accepted molecular marker. It is simple to perform and is preferable to experiments where the genotypes of a large number of individuals are to be determined at a few genetic loci. The RAPD technique has high potential for the identification and management of mango germplasm (Kumar *et al.*, 2001). The grouping of the varieties based on morphological characters and molecular profile and identification of varieties with specific qualities were done. Selected characters were correlated and the dependence among various qualitative/ qualitative and quantitative characters was studied. Also, the traditional knowledge associated with the varieties/ accessions were documented which will be helpful for further trait specific studies.

Review of Literature

2. REVIEW OF LITERATURE

Mango has a long history of cultivation in India for over 4000 years. It is believed to have originated in the Indo-Burma region. The cultivation of mango is so widespread in India that it has earned the reputation of being the apple of tropics (Lal *et al.*, 1986).

Mukherjee (1985) identified several diverse genotypes possessing useful horticultural characteristics that could be utilized for mango breeding. However, the known genetic diversity has hardly been exploited. The nomenclature of *Mangifera* sp. and mango cultivars has been complicated by the widespread use of synonyms (Lakshminarayana, 1980). There are ninety six cultivars of mango having more than one name as per Pandey (1984). The different regions of the country have their own commercial varieties, as a particular variety of mango does not perform equally well under different sets of climatic conditions (Sharma *et al.*, 2002).

Description of varieties prevalent in different regions of India has been attempted by a number of workers. The earliest description of mango varieties using scientific and botanical terminology was made by Maries (1902). Wester (1920) provided a descriptive list of Indian mangoes. Attributes of vegetative and reproductive organs such as tree habit, leaf colour both at emergence and maturity, panicle length, flower size, colour and pattern of veins on the petals and detailed descriptions of fruits were used as basis for varietal characterization by Mukherjee (1948). Naik and Gangolly (1950) described 335 varieties of south Indian mangoes. Although very large collections of diverse cultivated *Mangifera indica* are being conserved in gene banks at several centres in India, very less variability of wild forms is represented in these collections (Yadav and Rajan, 1993).

Kerala enjoys typical humid tropical climate conditions and natural mango gene pool consists mainly of the seedling races of local types, predominantly grown in homesteads and as avenue trees. The occurrence of specific varieties showing polyembryony such as Chandrakaran, Goa, Kurukkan, Mylepelian, Olour, Vellaikolamban, Muvandan etc. has been reported (Singh, 1990).

Radha and Manjula (2000) located 12 distinct polyembryonic types of mango in a survey conducted in the central part of Kerala. The vegetative characters (leaf shape, size, colour etc.) and floral characters (inflorescence position, shape, size, colour, flower characters etc.) exhibited by these types showed great variation. Review of research work on the variability of mango in morphological and quality characters as well as in molecular aspects in different growing conditions has been presented in this chapter. Literature pertaining to these aspects in cashew and spondias, members of Anacardiaceae family to which mango belongs is also reviewed.

2.1 VARIATION IN VEGETATIVE CHARACTERS

Form or outline of the general appearance of tree was popularly considered to provide a valuable basis for the classification of mango varieties (Naik and Gangolly, 1950).

2.1.1 Plant Height

Approximate height of 80 mango trees described by Radha and Manjula (2000) ranged from 10 to 35 m.

2.1.2 Plant Habit

Tree habit along with other characters was used as the basis for varietal characterization by Mukherjee (1948). According to Morton (1987), the mango tree is erect, 10 to 30m high, with a broad, rounded canopy which may, with age, attain 30 to 38m in width, or a more upright,

oval, relatively slender crown. Based on plant habit, the 12 polyembryonic mango varieties described by Radha and Manjula (2000) were classified into erect, intermediate and spreading types. Accordingly, varieties, Kotta Manga was erect and Puliyan and Nalla Nadan were intermediate. Nadan Manga, Kolambu manga, Muvandan, Chappikudiyan, Gomanga, Vatta manga and Kilichundan were classified as spreading types.

2.1.3 Leaf Characters

Classification and nomenclature of South Indian mangoes were attempted by Naik and Gangolly (1950). In this classification, pose of leaf, shape of leaf, leaf tip, margin, thickness, smell of crushed leaves and the colour of mature and emerging leaves have been described.

Leaf characters form an important criterion in identification of varieties. Descriptors are provided for leaf shape, tip and margin (IBPGR, 1989). Aroma of crushed leaf has a direct correlation with fruit flavour (Majumder and Sharma, 1990). Samanta *et al.* (1999) observed broad range of variation for leaf length, number of leaves per twig and chlorophyll a and b contents among the 25 types of mango grown in West Bengal. Leaf characters including pose of the leaf, shape, size, tip, margin, length of petiole, aroma of young leaf and colour of young and old leaves were described by Radha and Manjula (2000). Wide variations were observed among the types in these characters.

Colour of new flushes was observed by Davenport and Nunez-Elizea (1977). The emerging vegetative structures are usually green but may be sometimes bronze red or shades of red, which depends on cultivars. They are considered mature when they turn dark green, which occurs after two or three months.

2.2 INFLORESCENCE CHARACTERS

Hartless (1913) was the first worker to emphasise the importance of floral characters in classifying mango varieties. Floral characters included in the description of South Indian mangoes by Naik and Gangolly (1950) were shape, hairiness and sex ratios. Inflorescence characters were also used in describing mango varieties. These included shape, colour, hairiness and flowering intensity (IBPGR, 1989). Inflorescence characters like percentage of hermaphrodite flowers, length and breadth of inflorescence, density of flowers, colour of rachis, shape of inflorescence and hairiness and flower characters like type of flower, diameter of flower, nature of disc and number of stamens of selected varieties and hybrids of mango were studied by Anila (2002).

According to the reports by Chacko (1984), flower buds are borne generally in terminal buds of shoots produced during the previous season. Even though mango inflorescence is primarily terminal, axillary and multiple panicles may also arise from axillary buds according to Chadha and Pal (1986).

Kalyanasundaram (1976) reported that Neelum had the highest percentage of perfect flowers (62 %) and Mulgoa, the least (5 %). Wide variations were observed between cultivars in the number of flowers per inflorescence (1431-3962) and fruit set per inflorescence (0.33-1.39 %) (Schohefield and Oag, 1986). Uthaiah *et al.* (1988) observed that the variety Mallika recorded the highest percentage of hermaphrodite flowers per panicle with low sex ratio of 1.03. Majumdar and Sharma (1990) reported that sex ratio varied from 0.74 per cent in Rumani to 69.8 per cent in Langra. The sex ratio is also reported to be influenced by environmental conditions. The lowest ratio of hermaphrodite to male flowers was observed in Kesar (Dod *et al.*, 1998). Inflorescence and flower characters including the position of inflorescence, shape, size, sex ratio and characters of individual flowers were studied (Radha and

Manjula, 2000). Percentage of bisexual flowers, which is an important factor determining the initial fruit set, varied from 16.6 to 60. Asif *et al.* (2002a) investigated the total flower number and proportion of male to female flowers in mango cultivars Anwar Rataul, Dashehari and Langra. The highest percentage of hermaphrodite flowers (37.7 %) was recorded in Zardalu (Hoda *et al.*, 2003).

Hussein *et al.* (1989) evaluated three varieties both in their on and off years for the distribution of flowers on the panicle and flower production per panicle during the spring, summer and autumn growth cycles of 1986 and 1987 under Assiut conditions. The highest percentage of flowers occurred at the panicle apex in Hindi Bisinnara and Pairi and at the basal region in Golek. The latter had the highest percentage flowers per panicle. Flowering and fruiting behaviour of different varieties of mango under hot and dry climatic condition of Akola during 1996-97 was studied by Dod *et al.* (1999). The highest number of panicles per square metre was observed in cultivar Kesar.

Though the south Indian mango varieties attain a physiological status for flowering earlier than the North Indian cultivars, such manifestation is suppressed on the latter by the prevailing low temperatures resulting in late flowering (Yadav and Singh, 1985). Gunjate *et al.* (1977) observed that under Konkan condition, fruit bud differentiation started on August 20th and continued till the end of October. Flowering started on December 1st. The flowering and maturity time of Harumanin, Common Sabre, Kensington, Mulgoa and Neelum have been described by Schohefield (1986). Variation in flowering season was observed among the twelve polyembryonic varieties studied by Radha and Manjula (2000). Four were early (November-December), five were mid season (January-February) and three were late season types (after March). Occurrence of secondary flowering was seen frequently in four types, which helps in the availability of fruits during off-seasons. Studies on the floral character of

mango cultivars and hybrids, under agro climatic conditions of Orissa were conducted by Chandra *et al.* (2001). The date of flowering and duration of flowering days varied distinctly in different mango cultivars and hybrids.

The flowering laterals m^{-2} was a major contributor to final plant yield. Flowering and fruiting behaviour studied in ten cultivars by Dod *et al.* (1998) revealed that Kesar exhibited the earliest panicle emergence followed by Dashehari under Akola conditions. The highest number of panicles per square metre was observed in Dashehari. Majumdar and Sharma (1990) observed that the flowering time in mango was closely linked with the time of flower bud initiation, which varied with cultivars and location where it was grown. Flowering period extended for a shorter duration of two to three weeks. Low temperature extended it and high temperature shortened it. Shanmughavelu *et al.* (2002) reported that wide variation occurred in the duration of flowering from tree to tree in cashew and on an average a tree completed flowering in 32 days.

Pandey and Kishore (1987) reported that one of the most important factors affecting the regularity of flowering is variety. Most varieties from northern India flower in alternate years, while those from the south tend to flower every year but produce poor quality fruit.

Variation in the size of inflorescence among mango varieties was studied by a number of workers (Narayanaswamy, 1982; Chadha and Pal, 1986; Schohefield and Oag, 1986; Thimmappaiah and Suman, 1987; Uthaiah *et al.*, 1988). The length and breadth of inflorescence in five varieties of mango ranged from 21.33 to 34.36 cm and 18.11 to 32.83 cm respectively (Narayanaswamy, 1982). Chadha and Pal (1986) reported that wide variation occurred in inflorescence length, the range being from a few centimetres to 60 cm. Schohefield and Oag (1986) studied the inflorescence size, flower number, flower sex and fruit set in Bangalora, Batavi, Common, Glenn, Irwin and Kensington. Wide variations were

observed between cultivars in the number of flowers per inflorescence (1431 to 3962) and fruit set per inflorescence (0.33 to 11.39%). Panicle size in mango varied from 11.25 to 42.20 cm according to Thimmappaiah and Suman (1987). Varieties having longer panicles produced largest number of flowers consisting of mostly male flowers. They also opined that the role of perfect flowers was only secondary and indirect on yield. Under coastal Karnataka conditions, Uthaiah *et al.* (1988) observed that the length of flower panicle ranged from 12.4 to 38.6 cm. The length and breadth of the panicles and number of flowering laterals m^{-2} showed distinct variation among the mango cultivars (Chandra *et al.*, 2001). Evaluation of the ecological groups of mango cultivars for flowering and fruiting under Bihar conditions was carried out by Hoda *et al.* (2003). The maximum panicle length (20.5 cm) was recorded in Bangalora, followed by Zardalu and Mallika.

The variability in fruit set in twenty six important mango cultivars was studied by Kumar *et al.* (1998) under Lucknow conditions. The results indicated that overall barren panicles were more in Fernandin (42.75 %), Baneshan (42.7 %) and Alphonso (40.34 %). The percentage of fruit bearing panicles was maximum in Chausa (97 %) and minimum in Fernandin. Fruits per panicle (after forty days of fruit set) were maximum in Kishanbhog (2.47 %) followed by Amrapali. It was the lowest in Vanraj (0.26 %), Nisar Pasand and Alphonso.

Singh and Bhagat (1989) made comparative studies on the floral biology of early and late cultivars of mango. Date and duration of panicle emergence and anthesis, time and rate of anthesis, number of flowers per panicle and sex ratio, time of dehiscence of anthers, receptivity of stigma, size and viability of pollen grains and fruit set were measured for the four cultivars. The early cultivars Gulabkhas and Mithua gave slightly superior values compared to the two late cultivars Sukul and Sipia. Anther dehiscence, pollen viability and pollen germination of three mango

cultivars with different fruit set characters was studied by Jutamanee *et al.* (2000). The cultivars studied were Khiew Sawoey which naturally had low fruit set, Nam Dok Mai with moderate fruit set and Choke Anan with high fruit set. The results showed that Choke Anan had the highest anther dehiscence of 74.46 per cent whereas Khiew Sawoey and Nam Dok Mai showed anther dehiscence of only 14.95 and 20.06 per cent, respectively. All cultivars had high pollen viability (81.33%-91.29%) with germination of 24.1 to 32.51 per cent. Poor dehiscing of anthers is a factor causing low fruit set in Nam Dok Mai and Khiew Sawoey. An electron microscopic observation of the pollen grains of mango cultivars Neelum, Kalepad and its hybrid was conducted by Prakashkumar and Suresh (2002). Considering pollen ornamentation, the primary character of both Neelum and Kalepad showed a striate- pitted pattern while the hybrid was with striate- reticulate ornamentation. Though the primary character of both Neelum and Kalepad was similar, characters of the lirae (secondary character) of both these varieties were found to be distinctly different.

Flower bud development, anthesis and anther dehiscence in cashew selections under Chintamani conditions were studied by Shivanandam *et al.* (1986). Duration of flowering, male and bisexual flower production, number of flowers per panicle, number of bisexual flowers per panicle and flower sex ratio were studied in 16 accessions at Ullal, Karnataka (Hanamashetti *et al.*, 1986). Variation was observed in all characters. and it is considered that there is scope for breeding varieties with a short, synchronized flowering period and high yield. Masawe *et al.* (1996) observed differences in the number of flower types both between clones and between the different sides of cashew tree canopy. Experiments were conducted in Bhubaneswar, during 1996-2002 on 13 cashew cultivars by Lenka *et al.* (2003). NRCC-2 exhibited the shortest period and duration of flowering (59 days). The flowering behaviour of five species of *Spondias* and several unnamed varieties of *S. purpurea* were briefly described by Popenoe (1980).

2.3 FRUIT CHARACTERS

Fruit characters including fruit skin colour, weight, shape, beak, sinus, shoulders, apex, fibre in pulp, per cent of pulp, per cent of peel, per cent of stone, fruit quality parameters like TSS, acidity, reducing and total sugars stone characters like stone weight, length and width of 12 polyembryonic mango varieties were studied by Radha and Manjula (2000).

2.3.1 Fruit Morphological Characters

2.3.1.1 Fruit Shape

The shape of the fruit including the presence/absence of beak is considered as the most important character of mango fruits (Gangolly and Ranjith, 1957). The common fruit shapes reported in mango are roundish, ovate, oblong, cordate and reniform with a number of shapes intermediate between these. According to Manay and Shadksharaswamy (1995), the mango fruit is a large drupe in varied shape, size, colour and flavour. They also reported that the shapes are normally round, oval or oblong and the size ranges from plum sized ones to giants (more than 22 cm long).

2.3.1.2 Fruit Size

In a study conducted under Akola conditions, it has been observed that cultivar Pune Pairi exhibited maximum fruit breadth and Mallika had the highest length (Jadhao *et al.*, 1998). Physico-chemical analysis of different varieties under Kerala conditions had been reported by Radha and Nair (1998). Imam Pasand recorded the highest fruit weight and Kalpady produced the smallest fruits. The lowest fruit breadth of 2.48 cm was observed in Aman Prince and the highest (11.10 cm) was observed in Pansera cultivars. Puttu and Nauratna showed fruit thickness in the range 1.63 to 2.8 cm (Kumar and Brahmachari, 2004).

Gowda *et al.* (1994) compared the mango hybrids Arka Aruna (H10), Arka Puneet (H13), Arka Anmol (H17-3) and H51 with commercial

cultivars Alphonso and Totapuri to assess their physico-chemical characteristics. Arka Puneet and Arka Anmol were comparable with Alphonso for fruit weight, volume and breadth. Arka Aruna had higher fruit weight, volume and breadth. Ten mango varieties of Bihar were subjected to physico-chemical analysis (Syamal and Mishra, 1987). The highest mean fruit weights were recorded for Fazli (506 g), Langra (310 g) and Paharpur Sinduria (293 g) and the lowest fruit weight for Mithwa (125 g). Physico-chemical characteristics of seven mango cultivars, over two years, under the sub mountainous regions of Himachal Pradesh were studied by Jagmohan *et al.* (1989). Mallika produced the highest fruit weight (464.4 and 312.6 g) and fruit volume (427 and 295 ml). In a study conducted under Akola conditions, it has been observed that cultivar Pune Pairi exhibited the highest fruit weight (Jadhao *et al.*, 1998). Twenty mango cultivars were evaluated by Hoda *et al.* (2003a). Fajri produced the heaviest fruits (450.98 g). An evaluation of morphological characters of fruits of four cultivars (Alphonso, Prior, Muvandan and Neelum) and two hybrids (Ratna (Neelum x Alphonso) and H-151 (Kalepad x Neelum)) of mango were made under Kerala conditions (Anila and Radha, 2003). Ratna fruits had the maximum length, breadth, weight, volume and circumference.

The physico-chemical characters of cashew apples of 16 high-yielding types were studied during 1977-78 in Trichur (Chandran and Damodaran, 1985). K 10-2 ranked first with regard to mean weight, length, diameter, length: diameter ratio and apple juice content. Haldankar *et al.* (1986) investigated the physico-chemical characteristics of the cashew apple of five varieties of cashew grown in Maharashtra. Vengurla 3 had the largest and heaviest apples and Vengurla 2 the smallest and lightest. The fruit characteristics of five species of *Spondias* and several unnamed varieties of *S. purpurea* were briefly described by Popenoe (1980).

2.3.1.3 Fruit Flesh Characters

Langra had the highest pulp/stone ratio, ascorbic acid, TSS and sugar contents and the lowest total acidity (Syamal and Mishra, 1987). Pulp contents of thirteen mango varieties investigated by Desai and Dhandar (2000) depending on fruit size, varied from 67.56% (Bemcorado) to 83.21% in RC-MS-1 (Bemcorado selection). Fruit pulp was prominently orange in early varieties, Mankurad & Furtado, and mid-late variety - RC-MS-1 (Bemcorado selection), and also in Bardez Mussarat, a late variety, which indicated a source for higher carotenoid contents. Rai *et al.* (2001) reported that the percentage of edible pulp was high in Alphonso, Fazli, Mallika, Amrapali and Langra Maldah.

Jagmohan *et al.* (1989) reported that Mallika had the highest pulp yields (70.1 and 74.2%) among the seven mango cultivars studied over two seasons in Himachal Pradesh. Pulp percentage of some less popular mango varieties in coastal Karnataka ranged from 49.5 per cent (Kala Hapus) to 80.1 per cent (Kalangharas). Banarasi Bath had the highest edible to non-edible ratio (3.31) (Uthaiah, 1990). Physico-chemical characteristics of nineteen mango varieties grown in West Bengal were studied by Mitra and Mitra (2001). The higher pulp weight and lower stone weight in Misti Bhog, Mocha and Panja indicated that these cultivars are suitable for processing. Mallika recorded the greatest average pulp (68 %) content among the twenty mango cultivars in Bihar studied by Hoda *et al.* (2003a).

2.3.1.4 Fruit Skin Characters

Gowda and Ramanjaneya (1994) studied the physico-chemical characteristics of eleven mango varieties and reported that the peel and stone contents were the lowest in Suvarnarekha. Fruit of Mussarat (Bardez and Salcette types), Fernandin and Bemcorado Selection had attractive skin colour of crimson to dark red, blushed on shoulders as observed by Desai and Dhandar (2000). Evaluation of mango genotypes for their fruit

characters was conducted during 1997 and 1998 in Bihar by Singh and Singh (2003). Hathi Jhula produced the highest peel percentage (22.83%).

2.3.1.5 Stone Characters

The form, size and shape of seed or stone and also the texture and position of the fibre provide useful information for varietal identification (Gangolly and Ranjith, 1957). Fruits of seven mango cultivars were analysed (Jagmohan *et al.*, 1989) for biochemical characters over two seasons (1983 and 1984) in Himachal Pradesh. The largest stone weight was recorded in Dashahari (16.8 and 17.0 %). Character association study of 19 pickle type mangoes by Jha *et al.* (2001) revealed that stone weight was significantly and positively correlated with fruit weight. Kumar and Brahmachari (2004) evaluated fifty mango cultivars for stone characteristics in a trial conducted in Bihar. The lowest stone percentage (5.51 %) was observed in cv. Pansera. The lowest breadth of 2.48 cm was observed in Aman Prince and the highest (11.10 cm) was observed in Pansera cultivars Puttu and Nauratna which showed fruit thickness in the range 1.63 to 2.8 cm. Anila and Radha (2003) evaluated the physical and morphological characters of fruits of four cultivars (Alphonso, Prior, Muvandan and Neelum) and two hybrids (Ratna (Neelum x Alphonso) and H-151 (Kalepad x Neelum)) of mango under Kerala conditions. The minimum contribution of stone to fruit weight was in Ratna and the maximum in Muvandan.

2.3.2 Fruit Quality

Majumdar and Sharma (1990) reported that the composition of mango fruit in general differed with the cultivar and stage of maturity.

Srivastava *et al.* (1987) evaluated fifteen mango varieties in Madhya Pradesh. The varieties with the best quality characters were Langra, Mallika, Dashehari and Alphonso. Langra had the highest ascorbic acid, TSS and sugar contents, and the lowest total acidity among the ten

mango varieties of Bihar studied by Syamal and Mishra (1987). Fruits of seven mango cultivars were analysed (Jagmohan *et al.*, 1989) for biochemical characters over two seasons (1983 and 1984) in Himachal Pradesh. The total soluble solids content was the highest in Alphonso (21.7 % in both seasons) and the reducing sugar content was the highest in Dashehari (2.7 and 2.9 %).

The physico-chemical nature of Neelum, Bride of Russia, Anupam, Langra, Kesar and Nisar Pasand has been studied by Teotia *et al.* (1972). Neelum had the highest vitamin C content, whereas Nisar Pasand had the highest TSS and sugar content. The earliest ripening variety, Bride of Russia having an attractive reddish blush on its shoulder, exhibited minimum acidity (0.243 %). In a study conducted at Bangladesh on mango cultivars, it was seen that the vitamin C content ranged from 12.91 mg per 100 g in Dashehari to 28.08 mg per 100 g in Koa Pahari (Samad *et al.*, 1975). Joshi and Shiralkar (1977) observed a decrease in ascorbic acid and phenolic contents with the development of fruits. Goncalves *et al.* (1998) and Attri and Singh (1999) reported the physico-chemical characteristics of mango varieties grown in Brazil and Andaman and Nicobar Islands respectively. Among the nineteen mango varieties of West Bengal studied by Mitra and Mitra (2001), the highest total soluble solids (22.66^0B) and sugar/acid ratio (226.6) and the lowest titrable acidity (0.1 %) were recorded for Misti Bhog. Lata Bombai showed the highest total sugar (16.23 %), while Lohajang had the greatest ascorbic acid (104.66 mg/100 g). The highest reducing sugar content (6.2 %) was observed in Mohan Bhog. Hoda *et al.* (2003a) evaluated twenty mango cultivars planted in Sabour during 1980 for fruit quality in 1997/99. Mallika recorded the greatest total carotenoid (4.95 mg per 100g) contents. The highest contents of TSS, total sugar, reducing sugar and ascorbic acid were recorded for Dashehari.

Chandran and Damodaran (1985) investigated the physico-chemical characters of cashew apples of 16 high-yielding types during 1977-78 in Trichur. M 6/1 had the highest TSS percentage, specific gravity and sugar, whereas K 27-1 was superior in ascorbic acid content. Physico-chemical characteristics of the cashew apple of five varieties of cashew grown in Maharashtra were studied by Haldankar *et al.* (1986). Vengurla 5 had the highest moisture content, the highest soluble solids content, the lowest pH and the highest percentage acidity.

Gowda and Ramanjaneya (1994) studied the physico-chemical characteristics of eleven mango varieties and reported that the fibre content was the least in Dashehari. Langra, Mulgoa, Dashehari and Alphonso possessed very viscous pulp/juice. The pulp of some mangoes are fibrous throughout while the fibre may be absent or very little in others and the flesh may also be firm, soft or juicy, sub acid or sweet and richly sweet smelling (Manay and Shadaksharaswamy, 1995) . Kumar and Kumar (2000) studied the pulp characters of 101 varieties. Twenty-two cultivars had fibreless pulp. Pulps of Baramasia and Sukul cultivars were much fibrous, while the rest had some or less fibre. Pulps of 48 cultivars were soft, 44 were firm and the remaining nine were loose.

One hundred and fifty four mango cultivars were evaluated for their productivity (tree height upon reaching maturity and fruit bearing index) and fruit quality (including average weight, shape of fruit, colour and texture of pulp, colour of flesh and fruit covering and fibre content) (Avilan *et al.*, 2001). A scale of one to three was used for various attributes. Haden, Kent, Irwin, Davis-Haden and Tommy Atkins which were selected in Florida and are now found world wide and Araque and Rangel, found in Venezuela are some of the cultivars selected for their superior quality. Nine mango varieties were analysed for their total (TDF), insoluble (IDF) and soluble (SDF) dietary fibre contents by enzymatic and gravimetric method of AOAC (Ramulu *et al.*, 2003). The TDF and IDF

contents were low in Panchadarakalasa (1.3 and 0.5 g %) and high in Banganapalli (3.0 and 1.5 g%), respectively. The SDF content was low in Dashehari (0.7 g%) and high in Eruman (1.6 g%). The SDF as % TDF ranged between 46.9% in Dashehari and 61.5% in Panchadarakalasa, but most of the mango varieties had around 50% of their TDF as SDF.

Chandran and Damodaran (1985) investigated the physico-chemical characters of cashew apples of 16 high-yielding types during 1977-78 in Trichur. Vengurla 37-3 stood first in ether extractives and BLA-273 in crude fibre content. Ten cultivars grown in Thrissur were assessed (Kumar and Aravindakshan, 1985) for physico-chemical characters. Cultivars noted for high TSS (14.13%) were Sawantwadi and BLA-256-1, for high reducing sugar (14.16%) K-27-1, and for ascorbic acid, BLA-1 (328.19 mg /100 g) and M-6-1 (321.81 mg /100 g). Acidity in the range 0.39-0.42% is considered highly desirable for processing; cultivars within this range were K-27-1, BLA-139-1, BLA-1 and Sawantwadi.

2.3.3 Organoleptic Qualities

According to Herrington (1991), sensory evaluation technology is a method using skilled management and trained panelists to provide information on the acceptability of the product profile, consumer acceptability and consistency.

Jain *et al.* (1996) reported that mango varieties Amrapali and Taimuria recorded the highest organoleptic score for mango nectar and RTS drink. Ten small fruited mango cultivars were assessed by Ahmad *et al.* (1989) for whole fruit weight, percentages of pulp, skin and stone, sugar content (%) and organoleptic properties. The cultivar Kalia produced the longest fruits (214.8 g) with high sugar content (20.3 %) and was compared to Rani Pasand with respect to organoleptic quality. Jadhao *et al.* (1998) observed that Kesar was the sweetest followed by Dashehari.

2.3.4 Specific Gravity

The weight to volume relationship, which is specific gravity, has been suggested as a dependable index of maturity in many mango cultivars like Haden (Harkin and Cobin, 1950), Dashehari (Gangwar and Tripathi, 1973) and Alphonso (Thangaraj and Irulappan, 1991). However, variation in specific gravity between varieties is known to exist.

2.3.5 Fruit Yield

A positive relationship was observed between the percentage of perfect flowers and number of fruits carried to maturity per panicle (Naik and Rao, 1943).

According to Srivastava *et al.* (1987), Neelum, Langra and Bangalora were the highest yielding in Madhya Pradesh. Correlation studies of 15 different characters in cultivar Langra indicated that the number of fruits per square metre could be considered as the most effective parameter for predicting the yield followed by the yield of secondary branches, number of fruits per panicle and number of panicles per square metre (Baghel *et al.*, 1988). Comparison of 21 varieties and 12 Mexican selections of mango in Central Veracruz was done by Santos and Mosqueda (1989). Considerable variation was found among the genotypes studied, overall mean yields ranging from 5.6 kg/tree (0.39 t ha^{-1}) for Florigon to 63 kg/tree (4.35 t ha^{-1}) for Haden. Fruits of seven mango cultivars were analysed (Jagmohan *et al.*, 1989) for yield characters over 2 seasons (1983 and 1984) in Himachal Pradesh. Yields were the highest in *cv.* Mallika (3/7 and 8.5 kg $plant^{-1}$) over two seasons. Ram and Rajput (1999) reported that under the same conditions, Dashehari fruits could be harvested from the first week of June, whereas Langra fruits were ready for harvest only by the second week of June, indicating varietal variation. Barui and Ghosh (2002) investigated the performance of ten mango cultivars of semiarid regions of West Bengal in 1995 -1998. Himsagar produced the highest fruit yield (73.9 kg) and fruit quality. . Experiments

were conducted in Bhubaneswar, during 1996-2002 on 13 cashew cultivars by Lenka *et al.* (2003). H 320 gave the highest cumulative yield (31.48 kg per plant) at 7 consecutive harvests.

Viswanath *et al.* (1999) reported that varieties Bangalora and Neelum exhibited regular bearing habit while Baramasi produced fruit in two seasons when grown in Oman. Results of a study on path coefficient analysis for some quantitative characters in mango (Das *et al.*, 2001) revealed that the number of fruits per tree and fruit weight had the maximum direct effects on fruit yield.

Study conducted by Forshey and Elfving (1977) on the relationships between yield components and yield trends revealed that fruit yield was positively related to fruit numbers but negatively related to fruit size in apple. Natural variability produced wide range in fruit numbers, fruit weight and yield in Dashehari mango (Rajput *et al.*, 1999).

Variation in fruit setting and subsequent drop were evaluated among three commercial mango cultivars *viz.*, Anwar Rataul, Dashehari and Langra under local conditions in Faisabad, Pakistan. The highest fruit set was observed in all the cultivars on eastern side of the plant. Langra recorded the highest number of fruit set (119.9). Fruit drop per cent was high on all the cultivars in the first 15 days after the initial fruit set with maximum drop in Anwar Rataul (96.25 %). On the other hand, Dashehari showed the highest fruit retention of 1.6 per cent until maturity and was suggested as the best cultivar among the three (Asif *et al.*, 2002).

2.4 MOLECULAR MARKERS

Molecular markers are genotypic markers (Bretting and Widrlechner, 1995) and they are used to study the differences among strains at molecular level. They constitute biochemical constituents (secondary metabolites in plants) and macromolecules (protein, DNA).

Biochemical markers have been used since long for the characterization of variation in a plant, now considered to be inappropriate as universal markers (Cooke, 1984). Molecular markers have been shown to be useful for diversity assessment in a number of plant species (Waugh and Powell, 1992) Molecular markers are direct manifestations of genetic content (Weising *et al.*, 1995). They serve as reliable indices of genetic variation. In the past decade, molecular markers have very rapidly complemented the classical strategies.

The genetic markers are used for clonal identification, linkage mapping, population diversity, taxonomy, evolutionary studies, determining the genetic fidelity during micro propagation and germplasm conservation (Bretting and Widrlechner, 1995).

2.4.1 Isozymes

Numerous attempts have been made to use isozyme polymorphism as genetic markers in mango. Gan *et al.* (1981) observed considerable variation within vegetatively propagated mango cultivars based on polymorphism of four enzymes from leaf tissues. Enzyme polymorphism was used by Degani *et al.* (1990) to differentiate among mango cultivars and to identify parentage of certain modern mango cultivars. Schnell and Knight (1992) successfully differentiated zygotic from nucellar seedlings using isocitrate dehydrogenase (IDH), leusine aminopeptidase (LAP), phosphoglucose isomerase (PGI), polygalacturonase (PG) and triose phosphate isomerase (TPI). Degani *et al.* (1992) demonstrated that there are two distinct zones of PGI activity in mango (PGI1 and PGI2) and suggested that four alleles control the PGI2 banding. Truscott *et al.* (1993) characterized 88 mango cultivars on the basis of isozymes. The outcross origin of some cultivars was supported by zygograms. Frequency and characteristics of zygotic seedlings from polyembryonic mango cultivars was determined by Degani *et al.* (1993) using isozymes as genetic markers. Mango seeds were produced by open-pollination of 'Turpentine'

and '13–1', respectively, and by 'Turpentine' caged with '13–1'. Leaf extracts of the resultant seedlings were electrophoretically analyzed for isozymes of isocitrate dehydrogenase, phosphoglucose isomerase, phosphoglucomutase and triosephosphate isomerase. Based on this analysis, 22%, 20% and 13% of the seed progeny from open-pollinated '13–1' and 'Turpentine', and from 'Turpentine' caged with '13–1', respectively, contained zygotic embryos. Among the zygotic progeny of open-pollinated '13–1', 37% were identified as originating from out crossing. Within each progeny population, the mean weight of zygotic seedlings was higher than that of nucellar seedlings. Eiadthong *et al.* (1998) investigated the isozyme polymorphisms of mango cultivars in Thailand. Polymorphism was observed in all enzyme systems examined and intra cultivar variation of the same cultivar name collected from different locations was confirmed based on banding patterns. No correlation between the polyembryonic and monoembryonic groups was found. Banding patterns of three enzyme systems allowed classification of Thai cultivars into fourteen groups. True hybrids derived from the embryo were identified from within the progenies of some controlled crosses by putative diaphorase (DIA-C) and IDH-A gene loci (Jintanawongse and Changtragoon, 2000).

The enzyme coding loci do not constitute a random sample of genes and they are not randomly dispersed throughout the genome. Electrophoresis will detect only portion of the actual variability present in amino acid sequences (Maxon and Maxon, 1990). Some isozyme variants are not selectively neutral (De Michele *et al.*, 1991). Moreover, isozymes are unstable markers during plant development and standardization of sampling procedures is sometimes difficult. Therefore, the isozymes have been replaced by DNA based molecular markers (Anolles and Trigiano, 1997).

2.4.2 DNA markers

With the advent of molecular biology techniques, DNA based markers have replaced enzyme markers in germplasm identification and characterization as well as in gene tagging. Because of its plasticity, ubiquity and stability, DNA is the ideal molecule for such analysis (Caetano-Anolles *et al.,* 1991). Various types of molecular markers are utilized to evaluate DNA polymorphism and are generally classified as hybridization based markers and polymerase chain reaction (PCR) based markers (Joshi *et al.*, 1999).

2.4.2.1 Hybridisation based DNA Markers

The hybridization based DNA marker techniques utilize labeled nucleic acid molecules as hybridization probes (Anolles *et al.*, 1991). Probe molecules range from synthetic oligonucleotides to cloned DNA. Some of the important hybridization based DNA techniques are restriction fragment length polymorphism (RFLP), hypervariable sequences and variable number of tandem repeats (VNTRs).

2.4.2.1.1 Restriction Fragment Length Polymorphism (RFLP)

RFLP analysis involves digesting the genomic DNA with restriction enzymes, separating the fragments electrophoretically and then preferentially visualizing fragments containing particular homologous sequences by hybridizing them to a specific DNA probe (Deverna and Alpert, 1990; Walton, 1990). Eiadthong *et al.* (1998) classified 13 *Mangifera* species collected in Thailand into two groups by RFLP analysis of a particular region of ctDNA. The first group consisted of M. indica and M. *sylvatica*, and the second group consisted of *M. caloneura, M. cochinchinensis, M. collina, M. flava, M. foetida, M. gedebe, M. griffithii, M. macrocarpa, M. oblongifolia, M. odorata, and M. pentandra.* Molecular mapping of mango cultivars 'Alphonso' and 'Palmer' was done by Chunwongse *et al.* (2000) using 197 RFLP markers derived from the

Pst I genomic library of *cv.* Nang Klang Wan together with 650 loci of AFLP markers segregating for each parental loci corresponding to a pseudo-testcross scheme. Ravishankar *et al.* (2004) used RAPD and chloroplast DNA RFLP to examine whether the monoembryonic and polyembryonic types of mango have a common or different genetic base. The cultivars got clearly grouped into two based on embryo types, indicating that these two types have a different genetic base.

2.4.2.2. Polymerase Chain Reaction (PCR) based DNA marker techniques

These are fingerprinting techniques that use an *in vitro* enzymatic reaction to specifically amplify a multiplicity of target sites in one or more nucleic acid molecules (Anolles and Trigiano, 1997).

Among the PCR based marker techniques, the important ones are amplified fragment length polymorphism, microsatellites, sequence characterized amplified region and random amplified polymorphic DNA.

2.4.2.2.1. Amplified Fragment Length Polymorphism (AFLP)

Amplified Fragment Length Polymorphism is based on PCR amplification of restriction fragments generated by specific restriction enzymes and oligonucleotide adapters of few neucleotide bases (Vos *et al.*, 1995). Gui *et al.* (2000) studied the polymorphism and segregation patterns of AFLP markers in the F_1 progenies from two mango cultivars (Keitt X Tommy) using 14 primer combinations. The polymorphism of the AFLP markers in the F_1 population was high, and the average frequency of the segregation loci was 37.16%. AFLP information was used for identification of mango cultivars, for studying the genetic relationships among 16 mango cultivars grown at the Volcani Centre, Israel and seven mango rootstocks and for the construction of a genetic linkage map (Kashkush *et al.*, 2001). Six AFLP primer combinations produced 204 clear bands and there were 34 bands for each combination. Hybrid status

of Kuwini, *Mangifera odorata* Griff. was verified by amplified fragment length polymorphism (Teo *et al.*, 2002). All the *M. odorata* samples additively inherit bands specific to *M. indica* and *M. foetida*, which strongly suggested the hybrid origin. The results of AFLP analysis confirmed the hybrid status of taxa in some Malesian plants including those belonging to genus Mangifera (Kiew *et al.*, 2003).

Eiadthong *et al.* (2000) confirmed the usefulness of AFLP for studying phylogenetic relationships among fourteen *Mangifera* species in Thailand.

AFLP is considered to be a powerful, reliable and rapid assay with potential application in genome fingerprinting and marker-assisted breeding (Thomas *et al.*, 1995; Vos *et al.*, 1995).

2.4.2.2.2. Minisatellites and micro satellites

Micro satellites consist of tandemly arranged di-, tri- and tetra nucleotide repeats, which are hypervariable and ubiquitously distributed throughout eukaryotic genomes. Micro satellite DNA markers, which can be directly amplified by PCR, have been developed using the unique sequences that flank micro satellites (Litt and Luty, 1989; Tantz, 1989; Weber and May, 1989). Mini- and microsatellites are based on a variable number of tandem repeats (VNTR) and result in a higher level of polymorphism. Minisatellites create multi-band patterns which are quite useful for identification purposes but rather unsuitable for linkage analysis. Minisatellites were used to identify mango (*Mangifera indica*) cultivars and rootstocks and to assess genetic relatedness between them (Lavi *et al.*, 1998). Duval *et al.* (2005) developed microsatellite markers for mango using a genomic library enriched for $(GA)_n$ and $(GT)_n$ dinucleotide repeats. Twenty-eight primer pairs produced polymorphic amplification products for a diversity sample including 15 mango cultivars and two accessions from the related species *Mangifera laurina* and *Mangifera applanata.*

2.4.2.2.3. Random amplified polymorphic DNA (RAPD)

Amplification of genomic DNA by polymerase chain reaction (PCR) with single oligonucleotides of arbitrary sequence can produce genotype specific DNA products which can be separated on agarose gel (Williams *et al.*, 1990). The RAPD assay has been used for cultivar identification in many crops like rice (Fukoka *et al.*, 1992), cocoa (Wilde *et al.*, 1992), apple (Koller *et al.*, 1993), banana (Bhat *et al.*, 1995), mango (Adato *et al.*, 1995; Schnell *et al.*, 1995) and citrus (Lious *et al.*, 1996).

The genetic diversity of Kensington mangoes was investigated using RAPD analysis. However, there was very little evidence of significant genetic variation within Kensington Pride selections. Fifteen of the selections were identical in all 107 markers. Only 2 selections, WEAN2 and ML2N1, differed by more than 5%. These plants provided the best options for use in genetic improvement of the Kensington Pride mango (Bally *et al.*, 1996).

Schnell *et al.* (1993) studied phylogenetic relationships among nine *Mangifera* species using RAPDs. When the two subsections of the genus (subgenera Mangifera and Limus) were analysed separately, the classification closely agreed with traditional taxonomic relationships. Twenty-five accessions of mango were examined by Schnell *et al.* (1995) with RAPD genetic markers using 80 decamer random primers. A maternal half-sib (MHS) family was included among the 25 accessions to see if genetic relationships could be detected. RAPD data were used to generate simple matching coefficients, which were analysed phenetically and by means of principal coordinate analysis (PCA). The MHS clustered together in both the phenetic and the PCA while the randomly selected accessions were scattered with no apparent pattern.

Using RAPD markers, Valenzuela *et a*l. (1997) classified mango genotypes into groups according to their geographical origin. Eighteen commercial mango cultivars, traditionally grown in western, southern,

northern and eastern parts of India, were selected to assess genetic relatedness (Ravishankar *et al.*, 2000). Cluster analysis clearly showed two groups - the first consisting of western, northern and eastern mango cultivars and the second group consisting of southern cultivars. From the analysis of results, it appears that the majority of mango cultivars originated from a local mango genepool and was domesticated later. RAPD analysis was carried out in 29 Indian mango cultivars comprising popular landraces and some advanced cultivars (Karihaloo *et al.*, 2003). A UPGMA dendrogram showed the majority of the cultivars from northern and eastern regions of India clustering together and separate from southern and western cultivars. Analysis of molecular variance revealed that 94.7% of the genetic diversity in mango existed within regions. However, differences among regions were significant; northern and eastern regions formed one zone and western and southern regions formed another zone of mango diversity in India.

Fifty mango cultivars, chosen from a number of south Indian institutes were screened using RAPD markers with decamer primers of arbitrary sequence (Kumar *et al.*, 2001). Out of the eighty primers screened, ten were selected which gave 139 clear and bright fragments. A dendrogram based on Jaccard's coefficient of similarity implied a moderate degree of genetic diversity among the cultivars. The hybrids which had one parent in common were placed together. In the cluster, alternate bearers and regular bearers formed separate groups and the members of each group were very closely linked. Another analysis based on Pearson's coefficient of similarity revealed a high degree of genetic diversity. In both the analyses, Mulgoa was found to be very distinct. This study showed clearly that cultivars from South India possess a high degree of genetic diversity.

Souza and Lima (2004) examined forty mango genotypes of the Embrapa Meio-Norte mango collection for RAPD markers with 32 random

primers. Initially the genotypes were grouped into two distinct groups (J=0.36): one formed by 'Mallika' and 'Amrapali' and another comprised of the other genotypes, which was subdivided into other two groups (J=0.41), one formed by 'Manzanilo', 'Van Dyke' 'Palmer' and 'Keitt', and the other including the remaining genotypes. This latter group was still split in two other groups (J=0.54), one including 'Edward', 'Winter', 'Alfa Emprapa 142', 'Kensington' and the advanced breeding selection CPAC 98/86 ('Beta') and the other, including 'Santa Alexandrina', 'Sensation', 'Glenn', 'Irwin' and all 25 Rosa's genotypes. In Rosa's group, the similarity coefficient ranged from 0.55 to 0.98, indicating a reasonable amount of genetic variation within this cultivar. Bootstrap consistency test, however, indicated that only three groups ('Mallika' and 'Amrapali', 'Van Dyke', 'Palmer' and 'Keitt', and 'Irwin' and 'Glenn') were really diverged.

The application of molecular markers for parentage analysis of commercial mango hybrids has been studied by Anuj *et al.* (2004). Primarily, three different Single Primer Amplification Reaction (SPAR) methods, RAPD, Inter-Simple Sequence Repeat (ISSR) and Directed Amplification of Minisatellite DNA (DAMD), have been used for establishing parent-hybrid relationship in three commercially important mango hybrids that were developed using Neelum as one of the parents, and their respective parents. Hybrid Ratna was genetically closer to its male parent Alphonso while reciprocal hybrids Amrapali and Mallika were closer to Neelum. One RAPD and two DAMD primers revealed Neelum-specific bands present in all three hybrids and Neelum exclusively.

Samal *et al.* (2004) assessed the genetic relationship of twenty varieties of cashew by using RAPD markers. Cluster analysis clearly showed that 20 varieties of cashew grouped into 2 major clusters based on similarity indices. The variety Vengrula-2 has very close similarity (85%) with variety VRI-3.

DNA fingerprinting of Indian cashew varieties using RAPD and ISSR techniques was done by Archak *et al.*(2003).

2.5 TRADITIONAL KNOWLEDGE

Traditional knowledge is said to be the wisdom developed by people over many generations for proper utilization of their lands, natural resources and environment; it is reflected in their life styles, innovations and practices (Jain, 2005). Tribal communities have developed their own knowledge base about the flora, fauna and mineral wealth of their region (Sahai, 2003). The technology pertaining to the medicinal uses of plants and animals belongs to them.

Traditionally, different parts of mango have been put to a multitude of uses. Mango seed kernel powder mixed with honey was used to cure diarrhoea and vomiting. Ripe fruit skin of variety, Varikka was used as an ingredient in the ayurvedic preparation, 'Ragakhandavam', useful for increasing body strength (Nair, 1996). Tender leaves of mango were chewed by the tribals as remedy for rise in blood sugar level (Divakar and Geetha, 2003). Ash produced by burning mango leaves was applied to wounds as antiseptic.

Fruits of each traditional mango variety possess a unique taste (Nair, 1996 a). Based on the taste, they were used to prepare different items like pickle, chutney, mango curry, mango curd, mango chips etc. Ripe fruits of the variety, Chandrakkaran were sqeezed and its juice mixed with cooked rice and eaten.

Materials and Methods

3. MATERIALS AND METHODS

Investigations were carried out at the Department of Pomology and Floriculture and the Department of Plant Biotechnology, College of Agriculture, Vellayani during June 2003 to December 2005 for characterising traditional mango (*Mangifera indica* L.) varieties of southern Kerala. The materials and methods tried for the research work are described in this chapter.

3.1 LOCATING THE TREES

Advertisement about the study was given in different mass media like newspapers, television and All India Radio in order to locate the traditional mango varieties of Thiruvananthapuram, Kollam, Pathanamthitta and Alappuzha districts. Response was obtained in the form of letters and phone calls. Accordingly, field visits were made to locate the trees.

3.2 LIST OF VARIETIES

Names, synonyms and location of the fifty traditional mango varieties / accessions located were tabulated.

3.3 MORPHOLOGICAL CHARACTERISATION

Field visits were made in order to locate the trees, conduct survey and to collect research materials. Morphological characters were observed and recorded during the first visit. The standard descriptor prescribed by IBPGR (1989) was used as guideline to describe the vegetative, floral and fruit characters. Traditional knowledge associated with the varieties was also recorded.

3.3.1 Vegetative characters

The following details were collected during the first visit:

3.3.1.1 Age of the trees

The age of the trees were recorded as reported by the farmers.

3.3.1.2 Tree habit

Trees located were grouped as erect, intermediate or spreading based on the canopy characters.

3.3.1.3 Tree height

The height of trees was measured using measuring pole and expressed in metres.

3.3.1.4 Leaf characters

Mature leaves were collected and the following observations were made:

1.Leaf shape (oblong lanceolate / lanceolate / elliptic oblong)

2.Leaf tip (obtuse/ acute/ acuminate)

3.Leaf margin (flat/ wavy/ folded/ crinkled)

4.Leaf length (cm)

5.Leaf width (cm)

6.Petiole length (cm)

The colour of young leaves (light green / yellowish green / light green with brown tinch / purple / reddish brown) were also visually observed and recorded.

3.3.2 Floral characters

During the time of flowering, a second visit was made to these locations. Inflorescences were collected and observations were made and classified into the following categories:

3.3.2.1 Inflorescence characters

1. Position of inflorescence (terminal/ axillary/ both)

2. Shape of inflorescence (conical/ pyramidal/ broadly pyramidal)

3. Density of flowers in the inflorescence (laxly/ densely flowered)

4. Inflorescence length (cm)

5. Inflorescence colour (crimson / deep pink/ red / cream / light yellow/ light green / Green, cream or light yellow with light red or pink or crimson flowers)

6. Hairiness of inflorescence (absent / puberulous / pubescent)

7. Leafy bracts (absent / present)

8. Percentage of hermaphrodite flowers in an average inflorescence

3.3.2.2 Flower characters

1. Flower diameter (mm)

2. Flower type (pentamerous / tetramerous / both)

3. Nature of disc (swollen, lobed, broader than ovary / narrow, often reduced or absent)

4. Number of stamens

3.3.2.3 Season of flowering **(early / intermediate / late)**

The trees were classified as early flowering if flowering started in November - December, as intermediate if flowering started in January - February and late if it was after March.

3.3.2.4 Regularity of flowering **(extremely irregular / irregular/ intermediate / regular)**

The trees were classified as regular if it flowered at least once in every year, intermediate if flowering occurred at least once in most of the years, irregular if flowering occurred in alternate years alone or once in

three years, extremely irregular if flowering occurred once in more than three years or without a regular pattern.

3.3.2.5 Secondary flowering **(rare / intermediate/ frequent)**

Occurrence of secondary flowering was classified as rare if secondary flowering was absent or occurred once in a year, intermediate if it occurred twice and frequent if it occurred three or more times in a year.

3.3.2.6 Pollen characters

1. Pollen size (μ)

Size of pollen was measured using stage and ocular micrometers.

2. Pollen fertility (%)

Pollen characters were studied by acetocarmine staining method. In the staining method, anthers from mature flower buds were taken and slides were prepared using acetocarmine glycerine ester (acetocarmine 50 % + glycerin 50 %). The pollen grains were observed through high power (10 x X 45 x) of the microscope. Uniformly stained and plumpy pollens were fertile and unstained and shrunken pollens were sterile. Number of fertile and sterile pollens was counted and the average counts of six fields were taken and expressed as percentage.

3.3.3 Fruit characters

During fruiting season, a third visit was made to these locations and fruits were collected. The following characters were studied and classified into the following categories:

3.3.3.1 ***Fruit morphological characters***

3.3.3.1.1 Fruit shape

1.Fruit shape (oblong / elliptic / roundish)

2.Basal cavity (absent / present)

3.Beak type (absent / point / prominent / mammiform)

4.Sinus type (absent /shallow / deep)

5.Groove (absent / present)

6.Shoulders (level / dorsal higher than ventral)

7.Slope of shoulders (sloping abruptly / ending in a long curve / rising and then rounded)

8.Apex (acute / obtuse)

3.3.3.1.2 Fruit size

1.Fruit length (cm)

2.Fruit breadth (cm)

3.Fruit thickness (cm)

4.Fruit weight (g)

5.Fruit volume (ml) measured as volume of water displaced by the fruit

3.3.3.1.3 Specific gravity

Specific gravity was calculated as the ratio of the weight of single fruit to its volume.

3.3.3.1.4 Stalk insertion

The mode of attachment of the stalk to the fruit was observed as being vertical or oblique.

3.3.3.1.5 Skin characters

1. Fruit skin colour

2. Fruit skin thickness (thin / medium thick / thick / very thick)

3. Skin texture (smooth / rough)

4. Skin weight (g)

3.3.3.1.6 *Flesh characters*

1. Pulp weight (g)

2. Flesh texture (firm / soft / juicy)

3. Adherence of skin to pulp (absent / present)

4. Fibre in pulp (absent / present)

5. Flesh content (ratio of pulp to skin + stone)

3.3.3.1.7 *Stone characters*

1.Length (cm)

2.Breadth (cm)

3.Weight (g)

4.Veins (level with surface / depressed / elevated)

5.Pattern of venation (parallel / forked)

6.Fibre (absent / present)

7.Length of fibres (mm)

3.3.3.2 Maturity period (early / intermediate / late)

Based on maturity period the trees were classified as early if the fruits attained maturity by February, as intermediate if it was by March to May and as late if it was by June onwards.

3.3.3.3 Yield

Number of fruits produced per tree per year as reported by the farmers was recorded.

3.3.3.4 Storage life of fruits (days)

Number of days up to which ripe fruits can be stored with out spoilage based on the information provided by farmers was recorded. The

mango varieties were classified into three based on the storage life as short (<2.5 days), intermediate (2.5 to 7 days) and long (≥7 days).

3.4 QUALITY CHARACTERS

Fruit pulp was weighed and analysed for various quality parameters.

3.4.1 Acidity

Titrable acidity was estimated as per cent anhydrous citric acid using the procedure standardized by Ranganna (1977).

3.4.2 Ascorbic acid content

Amount of ascorbic acid in mg per 100g of fruit was estimated using the volumetric method (Sadasivam and Manikam, 1992).

3.4.3 Total carotenoids

The estimation of total carotenoids present in the fruit was done using the procedure described by Jensen (1978) and expressed in mg per 100 g.

3.4.4 Total soluble solids (TSS)

Total soluble solids present in the fruit pulp was measured with the help of Erma hand refractometer (pocket type) and expressed in percentage.

3.4.5 Total sugars and reducing sugars

Total sugars, reducing sugars and non reducing sugars were estimated by the Lane and Eynon method (Saini *et al.*, 2001).

3.4.6 Crude fibre content

Percentage of crude fibre in mango flesh was estimated by the method proposed by Saini *et al.* (2001).

3.4.7 Organoleptic qualities

Organoleptic evaluation was done at the laboratory level by ten judges including a group of teachers and students. The sensory analysis was done using a four point score method. The major quality attributes included in the score were appearance (fruit shape, skin colour), flesh colour, flavour, taste and texture (Appendix I). Scores for overall acceptability was obtained by determining the average mean scores for each character and the fruits of the fifty varieties were ranked based on the overall acceptability.

3.5 STATISTICAL ANALYSIS

The fifty varieties / accessions were grouped into three as pickling table and dual types based on the utility of the fruits. They were grouped into three categories with respect to each character as <Average - Standard deviation, Average - Standard deviation to Average + Standard deviation and > Average + Standard deviation. For the characters like percentage of hermaphrodite flowers, titrable acidity, total carotenoids, crude fibre content and specific gravity, the classification was made by dividing the range of variation into three meaningful groups.

3.5.1 Correlation studies

Correlation among the selected characters was studied.

3.5.2 Dependence among various qualitative characters

Dependence among various qualitative / qualitative and quantitative characters was studied by preparing two way tables corresponding to scores of different pairs of qualitative characters. The dependence was tested by using the Chi square test. Relationships were noted among important traits.

3.5.3 Assessment of similarity between the accessions

Similarity was worked out for all the fifty accessions by making use of 24 characters (twenty morphological and four physico-chemical characters).

Quantitative characters were codified to qualitative characters by looking into their range of variation. The similarity values for all the pairs were counted and similarity index was worked out. Based on this similarity index, dendrogram was constructed (Krzanowski, 1988). Association between the various accessions was found out from the dendrogram.

3.6 MOLECULAR CHARACTERISATION

3.6.1 Extraction of DNA

Tender leaves were collected during the subsequent visits for DNA extraction. DNA was extracted using hexadecyl trimethyl ammonium bromide (CTAB) method (Dellaporta *et al.*, 1983) with slight modification (Anuj *et al.*, 2004). Two gram of fresh leaves were ground to a fine powder in liquid nitrogen. Poly vinyl pyrrolidone (PVP, 100 mg) was added to this and the powder was transferred to 10 ml pre-heated (60°C) extraction buffer (containing 2 % w/v CTAB, 1.4 M NaCl, 20 mM EDTA, 0.1 % β-mercapto ethanol and 100 mM Tris pH 8.0) and incubated at 60°C for one hour with occasional shaking. The homogenate was cooled to room temperature and extracted with 10 ml of chloroform: isoamyl alcohol (24 : 1, v/v), centrifuged at 10,000 rpm and the clear aqueous phase separated. To this, 2.5 ml of 5 M NaCl and 10 ml of ethanol were added, mixed and stored at -20°C overnight to precipitate the DNA. The mixture was centrifuged at 10000 rpm for 10 minutes (4^0C) and the supernatant decanted retaining the pellet. The pellet was washed twice with 70 per cent v/v ethanol and then air-dried. The dried pellet was resuspended in 1.0 ml TE (10 mM Tris, 1 mM EDTA, pH 8.0) buffer. Contaminating RNA was removed by digestion with RNase (10 µg /ml) for 30 minutes at 37°C. The DNA was further purified by extracting with an equal volume of phenol followed by an equal volume of phenol chloroform 1: 1 (v/v) and finally with an equal volume of chloroform. The DNA was precipitated by the addition of one volume of isopropanol and centrifuged at 10,000 rpm for five minutes. The final pellet was dissolved in 100 µl

TE and stored in an ultra freezer (Sanyo ultra low) at –85°C. DNA concentrations were determined using a UV-Vis spectrophotometer and the quality checked by electrophoresis on one per cent agarose gel.

3.6.2 Quantification of DNA

DNA quantification was carried out with the help of UV- Vis spectrophotometer (Spectronic Genesis 5). The spectrophotometer was calibrated at 260 nm and 280 nm wave length using TE buffer, in which DNA was dissolved. The optical density (O.D) of the DNA sample dissolved in the buffer was recorded at both 260 nm and 280 nm.

Since an O.D of 1.0 at 260 nm represent 50 μgml^{-1} of DNA, the quantity of DNA in the sample was estimated by employing the following formula :

Amount of DNA (μgml^{-1}) = A_{260} x 50 x dilution factor

(where, A_{260} = absorbance at 260nm)

The quality of DNA could be judged from the ratio of the O.D values recorded at 260 nm and 280 nm. A ratio between 1.8 and 2.0 indicates good quality of DNA.

3.6.3 RAPD Analysis

Initially, primers from OP-A and OP-B kits supplied by Operon Inc., CA, USA were screened for RAPD reactions with the DNA of Velutha Muvandan variety. The primers OPS-11 and OPS-12 which were identified by Bally *et al.* (1996) to be useful in mango DNA amplification were also used for screening. On the basis of this screening, primers resulting in discrete well separated bands on agarose gels were selected for amplification of the different mango DNAs. All RAPD reactions were carried out in 25µl volumes and contained 50ng template DNA, 10 picomoles of RAPD primer, 200 µM each dNTP, 2.5mM Mg^{2+} ion concentration in suitable 1x assay buffer supplied along with the enzyme and 0.5 units of thermostable *Taq* DNA polymerase(Bangalore Genei, Bangalore). The amplification reactions were carried out using a

Programmable Thermal Cycler (PTC 100, MJ Research Inc.) which was programmed to include pre-denaturation at 94^{0}C for one minute, followed by 45 cycles of denaturation at 94^{0}C for one minute, annealing at 35^{0}C for one minute and extension at 72^{0}C for one minute. The final cycle allowed an additional five minute period of extension at 72^{0}C. Finally the products of amplification were cooled to 4.0°C until attended.

The PCR products along with standard molecular weight marker (100 bp DNA ladder) supplied by US Biochemicals were analysed by electrophoresis through 1.4 per cent agarose gel in 1x TAE buffer stained with ethidium bromide (0.5µg/ml concentration) at constant voltage of 50V. It was visualized on a UV transilluminator (Appligene oncor, France) and photographs taken using gel documentation system (Biorad, USA). The RAPD bands were represented as '1' (for presence) and '0' (for absence) and recorded. The PCR was repeated at least twice in order to check the reproducibility. The amplification products of those primers alone, which could produce amplification for most of the varieties were used for further analysis.

3.6.4 Data analysis

The reproducible bands were scored for their presence (1) or absence (0) for the mango varieties studied. A genetic similarity matrix was constructed using the Jaccard's coefficient method (Jaccard, 1908).

$Sij = a / (a+b+c)$

where,

a : number of bands present in both the varieties in a pair.

b : number of bands present in the first variety but not in the second one.

c : number of bands present in the second variety but not in the first.

Based on the similarity coefficient, a dendrogram was constructed with the help of software package 'NTSYS' (Version 2.02). Association

between the accessions was found out from the dendrogram. Grouping of the accessions in RAPD based dendrogram and that in morphological and quality characters based dendrogram were compared with each other.

Results

4. RESULTS

The results of the investigations carried out for characterizing the traditional mango (*Mangifera indica* L.) varieties of southern Kerala are presented in this chapter.

4.1 LOCATING THE TREES

Advertisement about the study was given in different mass media like newspapers, television and All India Radio in order to locate the traditional mango varieties of Trivandrum, Kollam, Pathanamthitta and Alappuzha districts. Response was obtained in the form of letters and phone calls which helped in locating the trees. Periodic field trips were conducted to these localities in order to take observations and collect the research materials.

4.2 LIST OF VARIETIES

The list of varieties/accessions, synonyms, place of collection and district were tabulated (Table 1). Fifty varieties were located in the four districts of southern Kerala, Trivandrum (17), Kollam (10), Pathanamthitta (6) and Alappuzha (17). The fifty varieties / accessions were grouped into three as pickling (32%), table (34%) and dual (34%) types based on the utility of the fruits (Table 2).

4.3 MORPHOLOGICAL CHARACTERISATION

4.3.1 Vegetative characters

4.3.1.1 Age of the trees

Age of the trees varied from ten to seventy five years.

Table 1. List of traditional mango varieties / accessions collected from southern Kerala

Acc. No.	Local name	Synonyms	Location	District
1	Karutha Muvandan		Mavelikkara	Alappuzha
2	Natumavu Type-1	–	Karunagapally	Kollam
3	Vellari Type-1	–	Kalliyoor	Trivandrum
4	Kalkanda Vellari	–	Manacaud	Trivandrum
5	Vazhapazhithi	–	Kalliyoor	Trivandrum
6	Pulichi	–	Plamoottukada	Trivandrum
7	Natumavu Type-2	–	Eara	Alappuzha
8	Chadayamangalam Local	–	Chadayamangalam	Kollam
9	Komanga	–	Vallikkal	Pathanamthitta
10	Puliyan	–	Cherthala	Alappuzha
11	Natumavu Type-3	–	Parakode	Pathanamthitta
12	Manacaud Local-1	–	Manacaud	Trivandrum
13	Kalluketty	–	Vayalar	Alappuzha
14	Natumavu Type-4	–	Mavelikkara	Alappuzha
15	Natumavu Type-5	–	Vayalar	Alappuzha
16	Eara Local	–	Eara	Alappuzha
17	Muthalamookkan	–	Karunagapally	Kollam
18	Nedungolan	Karpooram	Chadayamangalam	Kollam
19	Vellari Type-2	–	Paripally	Kollam
20	Kolambi	–	Chadayamangalam	Kollam
21	Perakka manga	Preor	Eara	Alappuzha
22	Kasthuri	–	Kalliyoor	Trivandrum
23	Inamanga	–	Varkala	Trivandrum
24	Panchasara Varikka	–	Plamoottukada	Trivandrum
25	Kappa manga	–	Adoor	Pathanamthitta
26	Kandiyoor Local	–	Kandiyoor	Alappuzha
27	Thenga manga	–	Chiranikkal	Pathanamthitta
28	Mylapore manga	Thekkathai Varikka	Plamootukada	Trivandrum
29	Koli manga	–	Mavelikkara	Alappuzha
30	Kundara manga	Kalluketty	Thykkal	Alappuzha
31	Neendakara manga	–	Cherthala	Alappuzha

Continued..

Table 1. Continued

Acc. No.	Local name	Synonyms	Place of collection	District
32	Neenda Karpooram	—	Parakode	Pathanamthitta
33	Karpooram manga	—	Eara	Alappuzha
34	Cheriya Kilichundan	—	Chadayamangalam	Kollam
35	Valiya Kilichundan	Thamboru	Karunagapalli	Kollam
36	Velutha Muvandan	Vellamkolli	Eara	Alappuzha
37	Kotookonam Varikka	Varikka, Chenka Varikka, VellayaniVarikka	Vellayani	Trivandrum
38	ChampaVarikka	—	Ambalathara	Trivandrum
39	Kallu Varikka	—	Vellayani	Trivandrum
40	Vellamkolli	—	Karunagapally	Kollam
41	Vellayani Local	—	Vellayani	Trivandrum
42	Thali	—	Manacaud	Trivandrum
43	Karpoora Varikka	—	Plamoottukada	Trivandrum
44	Kota manga	—	Cherthala	Alappuzha
45	Karimbu mavu	—	Parakode	Pathanamthitta
46	Mavelikkara Local	—	Mavelikkara	Alappuzha
47	Kizhakkan Thali	—	Paripally	Kollam
48	Ponnadan manga	—	Cherthala	Alappuzha
49	Manacaud Local-2	—	Manacaud	Trivandrum
50	Ambalathara Local	—	Ambalathara	Trivandrum

Table 2. Classification of traditional mango varieties / accessions collected from southern Kerala based on utility of fruits

Acc. No.	Pickling types	Acc. No.	Table types	Acc. No.	Dual types
1	Karutha Muvandan	17	Muthalamookkan	34	Cheriya Kilichundan
2	Natumavu Type-1	18	Nedungolan	35	Valiya Kilichundan
3	Vellari Type-1	19	Vellari Type-2	36	Velutha Muvandan
4	Kalkanda Vellari	20	Kolambi	37	Kotookonam Varikka
5	Vazhapazhithi	21	Perakka manga	38	Champa Varikka
6	Pulichi	22	Kasthuri	39	Kallu Varikka
7	Natumavu Type-2	23	Inamanga	40	Vellamkolli
8	Chadayamangalam Local	24	Panchasara Varikka	41	Vellayani Local
9	Komanga	25	Kappa manga	42	Thali
10	Puliyan	26	Kandiyoor Local	43	Karpoora Varikka
11	Natumav Type-3	27	Thenga manga	44	Kotamanga
12	Manacaud Local-1	28	Mylapore manga	45	Karimbu mavu
13	Kalluketty	29	Kolimanga	46	Mavelikkara Local
14	Natumav Type-4	30	Kundara manga	47	Kizhakkan Thali
15	Natumavu Type-5	31	Neendakara manga	48	Ponnadan manga
16	Eara Local	32	Neenda Karpooram	49	Manacaud Local-2
	--	33	Karpooram manga	50	Ambalathara Local
No. of varieties	16 (32%)		17 (34%)		17 (34%)

4.3.1.2 Tree habit

Based on the habit, the fifty accessions/ varieties were grouped into three-erect, intermediate and spreading (Table 3 and 4). Nineteen varieties (38%) were erect, 15 (30%) were intermediate and 16 (32%) spreading.

4.3.1.3 *Tree height*

Tree height varied from 4.50 m to 30.00 m.

4.3.1.4 *Leaf characters*

Leaf characters were observed and tabulated (Table 5).

1. Leaf shape

Three leaf shapes were observed, oblong lanceolate, lanceolate and elliptic lanceolate (Plate 1). The highest percentage of trees had lanceolate leaves (50%), followed by elliptic lanceolate (36%) and the least (14%) had oblong lanceolate leaves. The leaf shape of 56.25 per cent of pickling type mango varieties was elliptic lanceolate, while, 82.35 percent of table varieties had lanceolate leaves. In dual purpose varieties, 47.06 per cent and 41.18 per cent of varieties possessed elliptic lanceolate and lanceolate leaves, respectively (Table 6).

2. Leaf tip

Three types of leaf tips could be observed, obtuse, acute and acuminate (Plate 2). Leaves of 54, 28 and 18 percentage of varieties had acuminate, acute and obtuse tips respectively (Table 7). Of the pickling types, 56.25 per cent accessions had acuminate tips, while 31.25 per cent had acute tips. In table varieties, the corresponding figures were 58.82 and 17.65. Obtuse tips were observed in 23.53 per cent. Among the dual types, 47.06, 35.29 and 17.65 per cent possessed acuminate, acute and obtuse tips, respectively.

Table 3. Vegetative characters of the traditional mango varieties/ accessions collected from southern Kerala

Acc. No.	Age of the tree (years)	Tree height (m)	Tree habit
1. Pickling types			
1	35	5.00	Intermediate
2	20	9.00	Erect
3	30	6.00	Spreading
4	75	30.00	Erect
5	35	12.00	Intermediate
6	40	8.00	Intermediate
7	20	15.00	Erect
8	10	20.00	Spreading
9	30	18.00	Erect
10	28	9.00	Erect
11	20	9.00	Spreading
12	50	9.50	Erect
13	30	10.70	Erect
14	10	6.00	Spreading
15	40	13.50	Spreading
16	20	12.00	Spreading
Average	30.81	12.04	
SE	4.02	1.59	
2. Table types			
17	25	5.50	Spreading
18	50	7.50	Spreading
19	30	12.00	Spreading
20	45	5.00	Erect
21	25	7.50	Intermediate
22	15	14.00	Erect
23	20	6.00	Intermediate
24	18	4.50	Intermediate
25	35	15.00	Erect
26	15	4.50	Intermediate
27	28	9.00	Erect
28	12	12.00	Erect
29	35	15.00	Erect
30	35	18.00	Spreading
31	25	20.00	Intermediate
32	45	9.00	Spreading
33	35	12.00	Spreading
Average	29.00	10.38	
SE	2.73	1.18	

Table 3. Continued..

Acc. No.	Age of the tree (years)	Tree height (m)	Tree habit
3. Dual types			
34	30	10.00	Intermediate
35	15	7.50	Spreading
36	20	12.00	Intermediate
37	25	7.50	Intermediate
38	35	8.00	Intermediate
39	20	7.50	Erect
40	30	9.00	Intermediate
41	50	15.00	Erect
42	35	8.00	Erect
43	30	10.50	Erect
44	15	6.00	Erect
45	25	9.00	Spreading
46	50	12.00	Intermediate
47	40	9.00	Spreading
48	30	12.00	Spreading
49	15	6.30	Intermediate
50	10	18.00	Erect
Average	28.24	9.49	
SE	2.81	0.79	
Overall average	29.32	10.61	
SE	1.78	0.70	

SE- Standard error of mean

Table 4. Tree habit of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Erect	7 (43.75 %)	6 (35.29 %)	6 (35.29 %)	19 (38.00%)
Intermediate	10 (62.50 %)	11 (64.71%)	7 (41.18 %)	28 (56.00%)
Spreading	6 (37.50 %)	6 (35.29%)	4 (23.53 %)	16 (32.00%)

Table 5. Leaf characters of traditional mango varieties / accessions collected from southern Kerala

Acc. No	Leaf shape	Young leaf colour	Leaf tip	Leaf margine
1. Pickling types				
1	EL	Reddish brown	Acuminate	Flat
2	EL	Light green	Acuminate	Flat
3	EL	Light green with brown tinge	Acute	Flat
4	OL	Light green with brown tinge	Obtuse	Wavy
5	EL	Light green with brown tinge	Acute	Wavy
6	EL	Light green with brown tinge	Acuminate	Folded
7	L	Yellowish green	Acuminate	Flat
8	EL	Light green with brown tinge	Acute	Wavy
9	OL	Yellowish green	Acuminate	Folded
10	L	Light green with brown tinge	Acute	Wavy
11	EL	Light green	Acuminate	Flat
12	EL	Light green	Acuminate	Wavy
13	L	Light green	Acuminate	Wavy
14	EL	Light green	Acuminate	Wavy
15	OL	Light green	Acute	Wavy
16	L	Light green with brown tinge	Obtuse	Wavy
2. Table types				
17	OL	Purple	Acute	Flat
18	L	Light green with brown tinge	Acuminate	Flat
19	L	Light green	Acuminate	Wavy
20	L	Yellowish green	Acuminate	Wavy
21	L	Light green with brown tinge	Obtuse	Flat
22	L	Reddish brown	Acuminate	Flat
23	L	Light green	Acuminate	Wavy
24	EL	Light green with brown tinge	Obtuse	Wavy
25	L	Light green with brown tinge	Acute	Folded
26	L	Light green with brown tinge	Acuminate	Wavy
27	L	Yellowish green	Obtuse	Flat
28	L	Purple	Obtuse	Folded
29	L	Light green	Acuminate	Wavy
30	OL	Light green with brown tinge	Acute	Folded
31	L	Light green with brown tinge	Acuminate	Wavy
32	L	Reddish brown	Acuminate	Crinkled
33	L	Light green	Acuminate	Flat

Continued..

Table 5. Continued.

Acc. No.	Leaf shape	Young leaf colour	Leaf tip	Leaf margine
3. Dual types				
34	EL	Reddish brown	Acute	Flat
35	OL	Light green with brown tinge	Acute	Crinkled
36	L	Light green	Acuminate	Folded
37	L	Light green with brown tinge	Acuminate	Folded
38	EL	Light green with brown tinge	Acute	Flat
39	L	Light green	Obtuse	Flat
40	OL	Light green with brown tinge	Acuminate	Wavy
41	EL	Light green	Acuminate	Flat
42	L	Reddish brown	Acuminate	Flat
43	EL	Light green with brown tinge	Acuminate	Wavy
44	EL	Light green	Acuminate	Wavy
45	EL	Yellowish green	Acuminate	Flat
46	L	Yellowish green	Obtuse	Wavy
47	L	Reddish brown	Acute	Folded
48	EL	Light green with brown tinge	Acute	Flat
49	EL	Reddish brown	Acute	Wavy
50	L	Light green	Obtuse	Wavy

L- Lanceolate, **EL**- Elliptic lanceolate, **OL**- Oblong lanceolate

Table 6. Leaf shape of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Elliptic lanceolate	9 (56.25 %)	1 (5.88 %)	8 (47.06 %)	18 (36.00 %)
Lanceolate	4 (25.00 %)	14 (82.35 %)	7 (41.18 %)	25 (50.00 %)
Oblong lanceolate	3 (18.75 %)	2 (11.76 %)	2 (11.76 %)	7 (14.00 %)

Table 7. Leaf tip of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Acuminate	9 (56.25 %)	10 (58.82 %)	8 (47.06 %)	27 (54.00 %)
Acute	5 (31.25 %)	3 (17.65 %)	6 (35.29 %)	14 (28.00 %)
Obtuse	2 (12.5%)	4 (23.53 %)	3 (17.65 %)	9 (18.00 %)

3. Leaf margin

Wavy, flat, folded and crinkled leaf margins were observed in 44, 36, 16 and 4 per cent of trees (Plate 3 and Table 8). Leaf margins were flat in 31.25, 35.29 and 41.18 per cent of pickling, table and dual type varieties and wavy in 56.25, 41.18 and 35.29 per cent, respectively. Acc. No.s 32 and 35 alone had crinkled margins.

4. Leaf length

Average leaf length ranged from 13.65 cm in Acc.No.35 to 31.08 cm in Acc. No.13. There was significant variation in leaf length between the varieties. Average leaf length of all the fifty varieties was 20.65 cm. The average length of pickling, table and dual groups, were respectively, 20.68, 21.55 and 19.71 cm. The average leaf length was the highest in table type (Table 9 to 11).

5. Leaf width

Average leaf width was the highest in Acc.No.30 (7.77 cm) and the lowest in Acc.No.45 (3.42 cm). The overall leaf width was 5.29. The variation in leaf width between the fifty varieties was significant. The average leaf length of pickling, table and dual varieties, were 20.68, 19.71 and 21.55 cm, respectively (Table 9 to 11).

6. Petiole length

The average petiole length ranged from 1.53 cm in Acc. No. 48 to 5.73 cm in Acc. No. 13. The mean petiole length of the fifty accessions was 3.28 cm. There was significant variation in petiole length between the varieties. Pickling, table and dual varieties had average petiole length of 3.37, 3 and 3.46 cm, respectively (Table 9 to 11).

Table 8. Leaf margine of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Flat	5 (31.25 %)	6 (35.29 %)	7 (41.18 %)	18 (36.00 %)
Wavy	9 (56.25 %)	7 (41.18 %)	6 (35.29 %)	22 (44.00 %)
Folded	2 (12.5%)	3 (17.65 %)	3 (17.65 %)	8 (16.00 %)
Crinkled	0	1 (5.88 %)	1 (5.88 %)	2 (4.00 %)

Table 9. Leaf characters of pickling type traditional mango varieties / accessions collected from southern Kerala

Acc. No.	Leaf length (cm)	Leaf width (cm)	Petiole length (cm)
1	17.23	3.87	2.43
2	21.17	5.12	3.40
3	15.37	3.47	2.67
4	18.43	6.15	3.00
5	18.95	5.07	3.07
6	20.12	4.98	4.83
7	21.57	4.87	4.22
8	15.27	3.43	3.37
9	16.27	4.65	2.60
10	18.70	3.72	2.90
11	18.03	6.08	2.70
12	20.27	5.02	3.73
13	31.08	6.08	5.73
14	26.73	5.38	2.88
15	27.47	6.83	3.08
16	24.17	7.75	3.33
Average	20.68	5.15	3.37
CD	2.17	0.68	0.77
SE	1.14	0.30	0.22

Table 10. Leaf characters of table type traditional mango varieties / accessions collected from southern Kerala

Acc. No.	Leaf length cm)	Leaf width(cm)	Petiole length (cm)
17	24.65	6.05	3.40
18	22.00	5.88	3.35
19	19.60	4.98	2.35
20	20.87	6.77	5.05
21	23.62	6.18	3.70
22	26.67	6.20	4.42
23	23.60	6.45	3.67
24	23.50	5.50	2.95
25	16.30	4.93	2.65
26	24.18	5.95	4.78
27	14.38	3.80	2.30
28	16.83	4.72	3.58
29	22.70	5.20	3.20
30	27.40	7.77	3.38
31	21.30	5.43	4.20
32	19.67	4.77	2.13
33	19.13	4.52	3.67
Average	21.55	5.59	3.46
CD	2.14	0.64	0.99
SE	0.87	0.23	0.20

Table 11. Leaf characters of dual purpose traditional mango varieties / accessions collected from southern Kerala

Acc. No.	Leaf length (cm)	Leaf width(cm)	Petiole length(cm)
34	18.35	3.88	2.53
35	13.65	5.95	2.00
36	18.93	4.85	2.72
37	20.77	5.32	4.75
38	26.75	5.5	2.93
39	18.67	5.07	3.35
40	25.02	6.45	3.90
41	20.02	5.17	3.23
42	21.23	5.50	3.77
43	18.85	3.43	2.12
44	21.05	5.08	2.12
45	15.43	3.42	1.95
46	16.30	6.47	2.5
47	21.57	5.38	3.58
48	13.77	3.45	1.53
49	22.73	6.32	4.52
50	21.98	5.78	3.57
Average	19.71	5.12	3.00
CD	2.20	0.53	0.87
SE	0.87	0.25	0.23

Plate 1. Leaf shape types of mango varieties.
a. oblong lanceolate b. lanceolate c. elliptic lanceolate

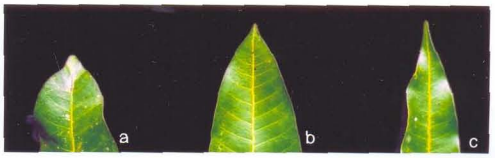


Plate 2. Leaf tip types of mango varieties
a. obtuse b. acute c. acuminate

Plate 3. Leaf margin types of mango varieties
a. flat b. wavy c. folded d. crinkled

7. Young leaf colour

Forty per cent of the accessions had light green young leaves with brown tinge. Light green and reddish brown leaves were produced by 30 and 14 per cent of the accessions. Two accessions produced purple and and six produced yellowish green leaves. (Table12.).

4.3.2 Floral characters

The data on different floral characters are presented (Table 13.).

4.3.2.1 Inflorescence characters

The variability in inflorescence characters were studied (Tables 14 to 20 and Plate 4).

1. Position of inflorescence.

Inflorescences were borne in terminal (84%), axillary (2%) or both (14%) the positions of shoots in different varieties (Table 14).

2. Shape of inflorescence

Inflorescence shape varied between varieties (Plate 5). Fifty two per cent produced pyramidal while 30 and 18 per cent produced broadly pyramidal and conical inflorescences, respectively. Inflorescence length of pickling, table and dual purpose types was medium (16-28 cm) in 62.5, 82.35 and 58.82 per cent (Table 15).

3. Density of flowers in the inflorescence.

The density of flowers in the flowers was classified as per IBPGR descriptor as laxly and densely. Ninety per cent of trees fell into the group, densely flowered, whereas 10 per cent into laxly flowered group. All the table type varieties were densely flowered. Among the pickling types, Acc. No. 16 alone was laxly flowered. The Acc. No.s 36, 38, 44 and 50 which are dual types were also laxly flowered (Table 16).

Table 12. Young leaf colour of traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Reddish brown	1 (6.25%)	2 (11.76%)	4 (23.53 %)	7 (14.00 %)
Purple	0	2 (11.76%)	0	2 (4.00%)
Light green with brown tinge	7 (43.75 %)	7 (41.18 %)	6 (35.29 %)	20 (40.00 %)
Light green	6 (37.5 %)	4 (23.53 %)	5 (29.41%)	15 (30 .00%)
Yellowish green	2 (12.5%)	2 (11.76%)	2 (11.76%)	6 (12.00%)

Table 13. a. Floral characters of the traditional mango varieties/ accessions collected from southern Kerala

Acc. No	Position	Shape	Density	Hairiness	Length (cm)
Pickling types					
1	Terminal	P	Densely	Puberulous	27.00
2	Terminal	P	Densely	Pubescent	31.50
3	Terminal	BP	Densely	Pubescent	12.00
4	Terminal	P	Densely	Pubescent	30.00
5	Terminal	BP	Densely	Pubescent	15.00
6	Terminal	BP	Densely	Pubescent	13.00
7	Terminal	P	Densely	Puberulous	26.00
8	Both	P	Densely	Pubescent	22.00
9	Terminal	P	Densely	Pubescent	17.00
10	Terminal	C	Densely	Glabrous	26.00
11	Both	P	Densely	Pubescent	19.50
12	Terminal	P	Densely	Pubescent	29.67
13	Terminal	P	Densely	Pubescent	26.00
14	Terminal	P	Densely	Pubescent	21.00
15	Terminal	P	Densely	Glabrous	23.00
16	Terminal	BP	Laxly	Pubescent	21.00
	Average				22.48
	SE				1.51

C - Conical; P- Pyramidal; BP - Broadly pyramidal

Continued...

Table 13. a. Continued..

Acc. No.	Position	Shape	Density	Hairiness	Length (cm)
Table types					
17	Both	BP	Densely	Pubescent	19.50
18	Terminal	BP	Densely	Pubescent	13.50
19	Terminal	C	Densely	Puberulous	25.00
20	Terminal	P	Densely	Pubescent	23.25
21	Terminal	BP	Densely	Pubescent	23.60
22	Terminal	BP	Densely	Pubescent	16.50
23	Terminal	BP	Densely	Pubescent	20.50
24	Terminal	P	Densely	Pubescent	23.00
25	Terminal	P	Densely	Pubescent	18.00
26	Terminal	P	Densely	Pubescent	21.00
27	Terminal	BP	Densely	Pubescent	17.00
28	Both	P	Densely	Pubescent	18.00
29	Terminal	P	Densely	Pubescent	17.00
30	Terminal	C	Densely	Pubescent	21.50
31	Terminal	BP	Densely	Pubescent	16.00
32	Terminal	P	Densely	Pubescent	41.00
33	Terminal	BP	Densely	Pubescent	19.00
	Average				20.79
	SE				1.47
Dual types					
34	Both	BP	Densely	Pubescent	21.50
35	Terminal	P	Densely	Pubescent	33.50
36	Both	C	Laxly	Pubescent	30.00
37	Terminal	P	Densely	Pubescent	28.00
38	Terminal	P	Laxly	Pubescent	18.00
39	Terminal	P	Densely	Pubescent	18.50
40	Terminal	P	Densely	Puberulous	25.50
41	Terminal	P	Densely	Pubescent	15.50
42	Axillary	C	Densely	Puberulous	15.00
43	Terminal	C	Densely	Pubescent	21.00
44	Terminal	C	Laxly	Pubescent	20.50
45	Terminal	P	Densely	Pubescent	28.00
46	Terminal	BP	Densely	Pubescent	29.75
47	Terminal	BP	Densely	Puberulous	22.30
48	Terminal	P	Densely	Pubescent	21.00
49	Both	C	Densely	Pubescent	20.50
50	Terminal	C	Laxly	Pubescent	27.00
	Average				23.27
	SE				1.31
Overall average					22.17
	SE				0.82

Table 13. b. Floral characters of the traditional mango varieties/ accessions collected from southern Kerala

Acc. No.	Inflorescence colour	Percentage of hermaphrodite flowers
	Pickling types	
1	Light green with red and yellow flowers	45.00
2	Light green	28.19
3	Red	25
4	Light pink rachis with green and red flowers	61.54
5	Yellowish green	21.05
6	Light green with few light pink flowers	13.68
7	Light green	76.40
8	Pink rachis and crimson flowers	30.00
9	Light green with light crimson rachis	23.33
10	Light green	37.30
11	Pink rachis red and yellow flowers	40.00
12	Light pink rachis with pink and yellow flowers	48.59
13	Light green	58.00
14	Light green	45.00
15	Light yellow	28.70
16	Crimson rachis, green flowers with red patches	96.00
	Table types	
17	Light green with red flowers	32.00
18	Light pink rachis with cream and pink flowers	47.5
19	Light green with red flowers	41.56
20	Light green	57.50
21	Light green with few red flowers	37.50
22	Light crimson rachis with cream flowers	10.00
23	Cream	53.09
24	Light green with a few crimson flowers	33.33
25	Light green with a few red flowers	33.33
26	Crimson	65.00
27	Light red rachis light brown and yellow flowers	60.00
28	Crimson	33.35
29	Yellow	40.00
30	Crimson	26.19
31	Crimson rachis with green and a few pink flowers	36.00
32	Light green	66.67
33	Light green	12.00

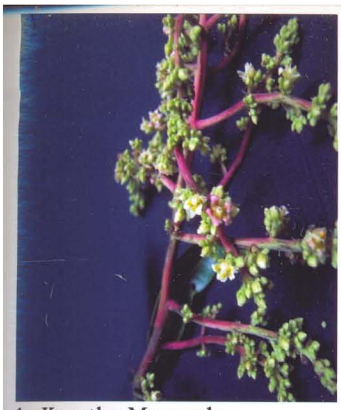
Continued...

Table 13. b. Continued..

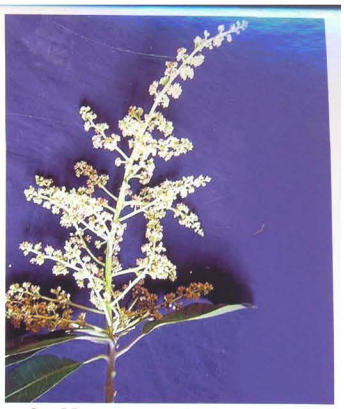
Acc. No.	Inflorescence colour	Percentage of hermaphrodite flowers
	Dual purpose types	
34	Crimson	90.57
35	Crimson	81.85
36	Light green with pink blush	8.38
37	Crimson rachis green cream and pink flowers	38.10
38	Light crimson rachis with cream flowers	45.50
39	Light green	37.00
40	Crimson rachis with yellow and crimson flowers	12.00
41	Cream with few pink flowers	73.39
42	Crimson with green flowers	66.67
43	Light green	20.00
44	Green with few crimson flowers	32.86
45	Green with yellow and red flowers	33.33
46	Light green	80.00
47	Crimson rachis with cream and pink flowers	54.55
48	Light green	37.32
49	Crimson rachis with green and pink flowers	19.05
50	Cream with light pink blush	16.67
	Average	42.20
	SE	3.04

Table 14. Position of inflorescence of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Axillary	0	0	1 (5.88 %)	1 (2.00 %)
Terminal	14 (87.5 %)	15 (88.24 %)	13 (76.47 %)	42 (84.00 %)
Both	2 (12.5%)	2 (11.76%)	3 (17.65 %)	7 (14 .00%)

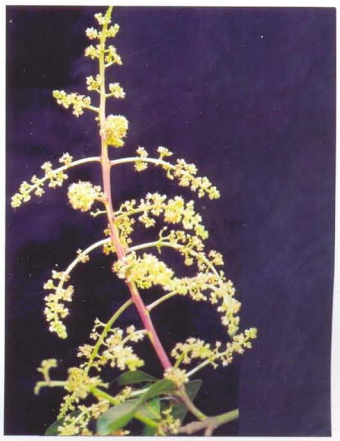


1. Karutha Muvandan



2. Natumavu Type-1

3. Vellari Type-1



4. Kalkanda Vellari

5. Vazhapazhithi

6. Pulichi

Plate 4. Variability in inflorescence of mango varieties

7. Natumavu Type-2

8. Chadayamangalam Local

9. Komanga

10. Puliyan

11. Natumavu Type-3

12. Manacaud Local-1

Plate 4. Continued

13. Kalluketty

14. Natumav Type-4

15. Natumavu Type-5

16. Eara Local

17. Muthalamookkan

18. Nedungolan

Plate 4. Continued

19. Vellari Type-2

20. Kolambi

21. Perakka manga

22. Kasthuri

23. Inamanga

24. Panchasara Varikka

Plate 4. Continued

25. Kappa manga

26. Kandiyoor Local

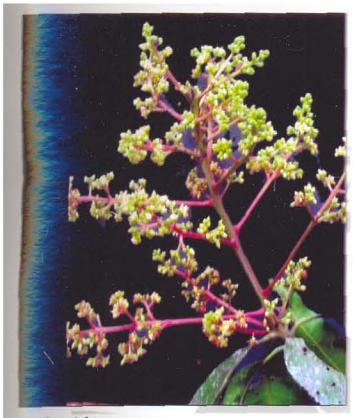
27. Thenga manga

28. Mylapore manga

29. Kolimanga

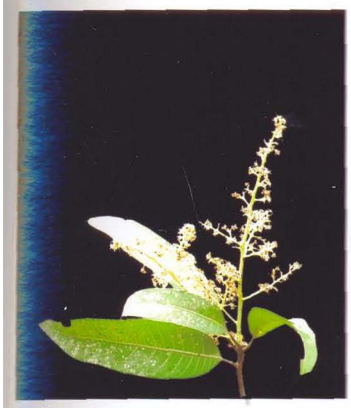
30. Kundara manga

Plate 4. Continued



31. Neendakara manga

32. Neenda Karpooram



33. Karpooram manga

34. Cheriya Kilichundan

35. Valiya Kilichundan

36. Velutha Muvandan

Plate 4. Continued

37. Kotookonam Varikka

38. ChampaVarikka

39. Kallu Varikka

40. Vellamkolli

41. Vellayani Local

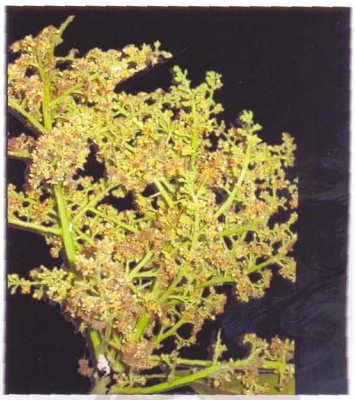
42. Thali

Plate 4 Continued

43. Karpoora Varikka

44. Kotamanga

45. Karimbu mavu



46. Mavelikkara Local

47. Kizhakkan Thali

48. Ponnadan manga

Plate 4. Continued

49. Manacaud Local-2

50. Ambalathara Local

Plate 4. Continued

Plate 5. Inflorescence shape types of mango varieties : 1. Broadly pyramidal 2. Pyramidal 3. Conical

4. Inflorescence length

The length ranged from 12 cm in Acc. No. 3 to 41 cm in Acc. No.32. Majority (62.5, 82.35 and 58.82 per cent) of the pickling, table and dual types produced medium sized inflorescences. The average length of inflorescences of pickling, table and dual types was 22.48, 20.79 and 23.27, respectively. Average inflorescence length of all the varieties was 22.17 cm (Table 17).

5. Inflorescence colour

The inflorescence colour ranged from light green to crimson The highest per cent (43.75, 47.06 and 41.18) of pickling, table and dual types possessed predominantly cream, yellow and crimson flowers respectively (Table 18).

6. Hairiness of inflorescence

Eighty four per cent of the trees had hairy (pubescent) inflorescence and 12 per cent slightly hairy (puberulous) ones. No hairs were found (glabrous) in Acc. No. 10 and Acc. No.15 (Table 19).

7. Leafy bracts

Leafy bracts were present in all the fifty accessions.

8. Percentage of hermaphrodite flowers.

The highest value was observed in Acc. No. 16 (96%). The least percentage of hermaphrodite flowers was observed in Acc. No.36 (8.38%). The average percentage of hermaphrodite flowers of all the accessions was 42.2. In all the three utility groups, majority (81.25, 76.47 and 41.18%, respectively in pickling, table and dual types) of the accessions possessed medium per cent (21-64%) of hermaphrodite flowers (Table 20).

Table 15. Inflorescence shape of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Conical	2 (12.5%)	2 (11.76%)	5 (29.41 %)	9 (18.00 %)
Pyramidal	10 (62.50 %)	7 (41.18 %)	9 (52.94%)	26 (52 .00%)
Broadly pyramidal	4 (25.00 %)	8 (47.06 %)	3 (17.65 %)	15 (30 .00%)

Table 16. Density of flowers of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Densely	15 (93.75 %)	17 (100 %)	13 (76.47 %)	45 (9.00 %)
Laxly	1 (6.25%)	0	4 (23.53 %)	5 (10.00 %)

Table 17. Inflorescence length of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Short (≤16cm)	3	2 (11.76%)	2 (11.76%)	7 (14.00 %)
Medium (16- 28 cm)	10 (62.5 %)	14 (82.35 %)	10 (58.82 %)	34 (68.00 %)
Long (≥ 28cm)	3	1 (5.88%)	5 (29.41 %)	9 (18 .00%)

Table 18. Inflorescence colour of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Crimson, deep pink and red	4 (25 .00%)	4 (23.53 %)	7 (41.18 %)	15 (30.00 %)
Cream or light yellow or light green	7 (43.75 %)	5 (29.41 %)	6 (35.29 %)	18 (36.00 %)
Green, cream or light yellow with light red or pink or crimson flowers	5 (31.25 %)	8 (47.06 %)	4 (23.53 %)	17 (34.00 %)

4.3.2.2 Flower characters

The flower characters of the different mango varieties were recorded (Table 21) and summarized (Tables 22 to 24).

1. Flower diameter (mm)

The flower diameter varied from 3.5mm in Acc. No. 9 to 7.50 mm in Acc.No.35. The average diameter of all the accessions was 5.32 mm. Fifty four per cent of the accessions had diameter between 4.50 and 6.00 mm (Table 22).

2. Flower type

All the varieties produced pentamerous flowers. In addition, six varieties produced tetramerous and five produced hexamerous flowers. Acc. No.12 and Acc. No. 49 produced all the three types (Table 23).

3. Nature of disc

In 41 varieties, the disc was swollen, lobed and broader than ovary. Narrow disc was observed in nine varieties (Table 24).

4. Number of stamens

All the varieties had five stamens, out of which only one to two were fertile.

4.3.2.3 Season of flowering

Flowering season in mango extended from November to March in different varieties. It was reported to be highly influenced by the weather conditions. It varied according to the availability of rain. However, season of flowering was classified into three-early (Nov-Dec), intermediate (Jan-Feb) and late (after March). Twenty one varieties were early flowering types and the rest were intermediate. None of the varieties studied were late (Table 25 and 26).

Table 19. Hairiness of inflorescence of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Pubescent	12 (75.00 %)	16 (94.12 %)	14 (82.35 %)	42 (84.00 %)
Puberulous	2 (12.5 %)	1 (5.88%)	3 (17.65 %)	6 (12.00 %)
Glabrous	2 (12.5 %)	0	0	2 (4.00%)

Table 20. Percentage of hermaphrodite flowers of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Less (<21 %)	1 (6.25 %)	2 (11.76 %)	5 (29.41 %)	8 (16.00 %)
Medium (21-64 %)	13 (81.25 %)	13 (76.47 %)	7 (41.18 %)	33 (66.00 %)
More (>64 %)	2 (12.5 %)	2 (11.76 %)	5 (29.41 %)	9 (18.00 %)

Table 21. Flower characters of the traditional mango varieties/ accessions collected from southern Kerala

Acc. No.	Flower diameter (mm)	Type of flower	Nature of disc
	Pickling types		
1	5.0	Pentamerous	Swollen, lobed broader than ovary
2	6.6	Pentamerous Tetramerous	Swollen, lobed broader than ovary
3	4.0	Pentamerous	Swollen, lobed broader than ovary
4	5.0	Pentamerous	Swollen, lobed broader than ovary
5	4.75	Pentamerous Hexamerous	Swollen, lobed broader than ovary
6	7.0	Pentamerous	Swollen, lobed broader than ovary
7	4.5	Pentamerous	Swollen, lobed broader than ovary
8	4.5	Hexamerous Pentamerous	Swollen, lobed broader than ovary
9	3.5	Pentamerous	Swollen, lobed broader than ovary
10	6.0	Pentamerous	Narrow, often reduced or absent
11	5.0	Pentamerous	Narrow, often reduced or absent
12	5.5	Pentamerous Tetramerous Hexamerous	Narrow, often reduced or absent
13	5.0	Pentamerous	Swollen, lobed broader than ovary
14	5.0	Pentamerous	Swollen, lobed broader than ovary
15	5.0	Tetramerous Pentamerous	Narrow, often reduced or absent
16	6.5	Pentamerous	Swollen, lobed broader than ovary

Table 21. Continued..

Acc. No.	Flower diameter (mm)	Type of flower	Nature of disc
	Table types		
17	6.2	Pentamerous Tetramerous	Swollen, lobed broader than ovary
18	5.5	Pentamerous	Swollen, lobed broader than ovary
19	5.0	Pentamerous	Swollen, lobed broader than ovary
20	6.0	Pentamerous Hexamerous	Swollen, lobed broader than ovary
21	5.0	Tetramerous Pentamerous	Swollen, lobed broader than ovary
22	5.0	Pentamerous	Swollen, lobed broader than ovary
23	6.8	Pentamerous	Swollen, lobed broader than ovary
24	4.5	Pentamerous	Swollen, lobed broader than ovary
25	5.0	Pentamerous	Swollen, lobed broader than ovary
26	5.0	Pentamerous	Swollen, lobed broader than ovary
27	5.0	Pentamerous	Swollen, lobed broader than ovary
28	4.0	Pentamerous	Swollen, lobed broader than ovary
29	6.7	Pentamerous	Swollen, lobed broader than ovary
30	5.0	Pentamerous	Swollen, lobed broader than ovary
31	5.0	Pentamerous	Swollen, lobed broader than ovary
32	5.0	Tetramerous Pentamerous	Narrow, often reduced or absent
33	5.0	Pentamerous	Swollen, lobed broader than ovary
	Dual purpose types		
34	5.7	Tetramerous Pentamerous Hexamerous	Swollen, lobed broader than ovary
35	7.5	Pentamerous	Swollen, lobed broader than ovary
36	5.0	Pentamerous	Swollen, lobed broader than ovary
37	6.0	Pentamerous	Swollen, lobed broader than ovary
38	5.5	Pentamerous	Swollen, lobed broader than ovary
39	5.6	Pentamerous	Swollen, lobed broader than ovary
40	5.7	Pentamerous Hexamerous	Swollen, lobed broader than ovary
41	4.0	Pentamerous	Swollen, lobed broader than ovary
42	5.0	Pentamerous	Swollen, lobed broader than ovary
43	4.0	Pentamerous	Swollen, lobed broader than ovary
44	6.0	Pentamerous	Swollen, lobed broader than ovary
45	5.5	Hexamerous Pentamerous	Narrow, often reduced or absent
46	6.0	Pentamerous	Swollen, lobed broader than ovary
47	5.5	Pentamerous	Swollen, lobed broader than ovary
48	4.0	Pentamerous	Narrow, often reduced or absent
49	6.0	Pentamerous	Swollen, lobed broader than ovary
50	6.2	Tetramerous Pentamerous	Swollen, lobed broader than ovary

Table 22. Flower diameter of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
≤4.5 mm	4 (25.00 %)	2 (11.76 %)	3 (17.65 %)	9 (18.00 %)
4.5-6.0mm	8 (50.00 %)	11 (64.71 %)	8 (47.06 %)	27 (54.00 %)
≥ 6 mm	4 (25.00 %)	4 (23.53 %)	6 (35.29 %)	14 (28.00 %)

Table 23. Type of flowers of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Tetramerous Pentamerous Hexamerous	1 (6.25 %)	0	1 (6.25 %)	2 (4.00%)
Tetramerous Pentamerous	2 (12.50 %)	3 (17.65 %)	1 (5.88 %)	6 (12.00 %)
Pentamerous Hexamerous	2 (12.5 0%)	1 (5.88 %)	2 (11.76 %)	5 (10.00%)
Pentamerous	11 (68.75 %)	13 (76.47 %)	13 76.47 %)	37 (74.00%)

Table 24. Nature of disc of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
B	12 (75.00 %)	14 (82.35 %)	15 (88.24 %)	41 (82.00 %)
N	4 (25.00 %)	3 (17.65 %)	2 (11.76 %)	9 (18.00 %)

B-Disc broader than ovary; N-Disc narrow often reduced or absent

4.3.2.4 Regularity of flowering

Majority of the varieties (43 varieties) were regular bearing. These varieties produced fruits every year. Seven accessions were intermediate in bearing habit. Acc. No. 26 was an alternate bearer. Acc. No 31was irregular in bearing habit (Table 27).

4.3.2.5 Secondary flowering

Frequent secondary flowering was exhibited by four varieties (Acc. No.s 3, 42, 47 and 50). These accessions showed secondary flowering three or more times in a year. Secondary flowering was intermediary in Accessions 8, 9, 17 and 34. Rest of the varieties flowered only once a year (Table 28).

4.3.2.6 Pollen characters

1. Pollen size

Pollen size varied from 19.18 (Acc. 22) to 34.18 micron (Acc. 34) (Table 29 and 30).

2. Pollen fertility

Pollen fertility percentage varied from 47.92 to 100. The lowest value was recorded in Acc. 3 and the highest in Acc.8, Acc. 36, Acc 37 and Acc. 48 (Table 31). Percentage of fertile pollen was high in 56.25, 70.59 and 47.06 per cent of pickling, table and dual type mango accessions, respectively.

4.3.3 Fruit characters

4.3.3.1 Fruit morphological characters

The variability in fruit morphological characters were observed (Plate 6).

4.3.3.1.1 Fruit shape

Fruit shape and related characters were observed and recorded (Table 32).

Table 25. Flowering and related characters of the traditional mango varieties / accessions collected from southern Kerala

Acc. No.	Season of flowering	Regularity of flowering	Secondary flowering
1	Intermediate	Regular	Absent
2	Intermediate	Regular	Absent
3	Intermediate	Regular	3 to 4 times
4	Early	Regular	Once (Sept.)
5	Intermediate	Regular	Absent
6	Intermediate	Regular	Once (Sept.)
7	Early	Regular	Absent
8	Intermediate	Regular	Twice (Aug, Nov)
9	Intermediate	Intermediate	Twice (Aug, April)
10	Early	Intermediate	Absent
11	Early	Regular	Absent
12	Intermediate	Intermediate	Absent
13	Early	Regular	Rarely once
14	Early	Regular	Absent
15	Intermediate	Regular	Absent
16	Early	Regular	Absent
17	Intermediate	Regular	Twice (Sept, Nov)
18	Intermediate	Regular	Absent
19	Intermediate	Regular	Once (Sept.)
20	Early	Regular	Absent
21	Early	Regular	Once (Sept.)
22	Intermediate	Regular	Absent
23	Early	Regular	Absent
24	Intermediate	Regular	Absent
25	Intermediate	Regular	Absent
26	Early	Intermediate	Absent
27	Intermediate	Regular	Absent
28	Early	Regular	Absent
29	Intermediate	Regular	Absent
30	Intermediate	Intermediate	Absent
31	Intermediate	Irregular	Absent
32	Intermediate	Regular	Once (Aug)
33	Intermediate	Regular	Rarely

Continued...

Table 25. Continued..

Acc. No.	Season of flowering	Regularity of flowering	Secondary flowering
34	Intermediate	Regular	Twice
35	Intermediate	Regular	Absent
36	Early	Regular	Once (Sept)
37	Intermediate	Regular	Once (Sept.)
38	Early	Regular	Absent
39	Intermediate	Intermediate	Absent
40	Early	Regular	Absent
41	Early	Regular	Absent
42	Early	Regular	Twice (Aug, Oct). Few flowers throughout year
43	Intermediate	Intermediate	Absent
44	Intermediate	Regular	Absent
45	Intermediate	Regular	Absent
46	Early	Regular	Absent
47	Early	Regular	Twice. Few flowers through out the year
48	Early	Regular	Absent
49	Early	Regular	Absent
50	Early	Regular	Present. A few flowers through out the year

Table 26. Season of flowering of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Early	7 (43.75 %)	5 (29.41 %)	10 (58.82 %)	22 (44.00 %)
Intermediate	9 (56.25 %)	12 (70.59%)	7 (41.18 %)	28 (56.00%)
Late	0	0	0	0

Table 27. Regularity of flowering of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Regular	13 (81.25 %)	14 (82.35%)	15 (88.24%)	42 (84.00 %)
Intermediate	3	2	2	7 (14.00 %)
Irregular	0	1	0	1

Table 28. Secondary flowering of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Rare	13 (81.25 %)	16 (94.12 %)	13 (76.47 %)	42 (84.00 %)
Intermediate	2 (12.5%)	1 (5.88%)	1 (5.88%)	4 (8.00 %)
Frequent	1 (6.25%)	0	3 (18.75%)	4 (8.00 %)

Table 29. Pollen characters of the traditional mango varieties / accessions collected from southern Kerala

Acc. No.	Pollen Fertility %	Pollen size (μ)
Pickling types		
1	47.92	29.18
2	92.86	25.83
3	94.71	27.50
4	62.73	27.00
5	95.83	32.50
6	67.14	27.25
7	92.38	25.50
8	100.00	27.08
9	90.00	25.00
10	91.67	26.89
11	92.00	25.88
12	93.52	25.83
13	96.00	26.00
14	89.00	32.00
15	89.53	26.89
16	89.52	27.50
Average	86.55	27.36
SE	3.58	0.54

Continued...

Table 29. Continued.

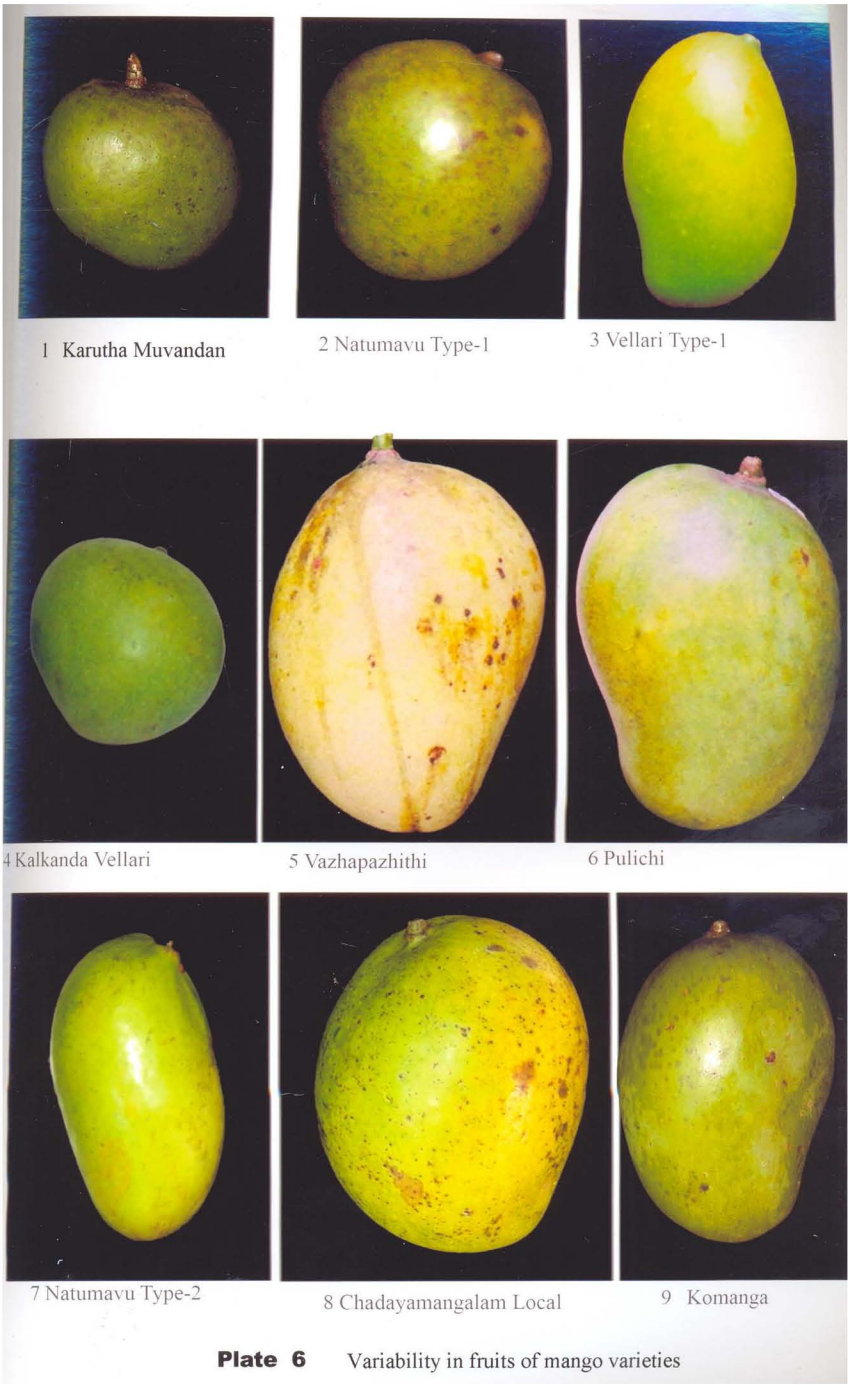
Acc. No.	Pollen fertility percentage	Pollen size (μ)
Table types		
17	93.52	27.50
18	97.41	22.50
19	76.00	30.50
20	93.51	28.13
21	77.91	23.75
22	92.28	19.18
23	98.00	26.00
24	89.00	30.83
25	87.50	27.50
26	98.00	32.00
27	98.00	25.00
28	88.89	25.00
29	94.44	30.00
30	91.17	22.50
31	99.00	26.25
32	90.80	26.25
33	93.57	25.00
Average	91.71	26.35
SE	1.60	0.82
Dual types		
34	83.23	34.18
35	94.72	31.89
36	100.00	31.88
37	100.00	22.50
38	97.00	33.00
39	99.00	27.91
40	88.79	29.38
41	85.26	27.50
42	88.33	25.00
43	85.26	27.50
44	88.76	24.00
45	97.00	27.00
46	98.61	31.00
47	87.43	26.00
48	100.00	22.00
49	79.95	21.67
50	86.08	22.00
Average	91.73	27.32
SE	1.65	0.99
Overall average	90.06	27.00
SE	1.40	0.47

Table 30. Pollen size of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Small (<24μ)	0	4 (23.53 %)	4 (23.53 %)	8 (16.00 %)
Medium (24- 30 μ)	14 (87.5 %)	10 (58.82 %)	8 (47.06 %)	32 (64.00 %)
Large (>30 μ)	2 (12.5 %)	3 (17.65 %)	5 (29.41 %)	10 (20.00 %)

Table 31. Percentage of fertile pollen of the traditional mango varieties/ accessions collected from southern Kerala

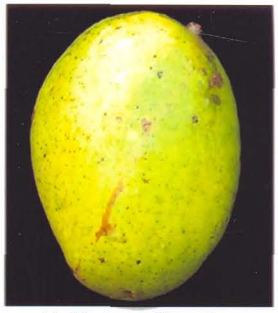
Class	Pickling	Table	Dual	Total
Less (< 80)	3 (18.75%)	2 (11.76 %)	1 (5.88 %)	6 (12.00 %)
Medium (80- 90)	4 (25 %)	3 (17.65 %)	8 (47.06 %)	15 (30.00 %)
More (>90)	9 (56.25 %)	12 (70.59 %)	8 (47.06 %)	29 (58.00 %)



1 Karutha Muvandan
2 Natumavu Type-1
3 Vellari Type-1
4 Kalkanda Vellari
5 Vazhapazhithi
6 Pulichi
7 Natumavu Type-2
8 Chadayamangalam Local
9 Komanga

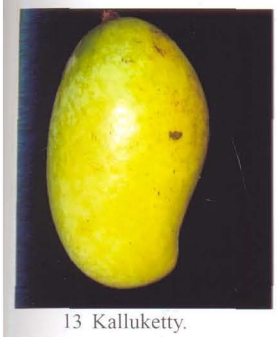
Plate 6 Variability in fruits of mango varieties

10 Puliyan



11 Natumav Type-3

12 Manacaud Local-1



13 Kalluketty.

14 Natumav Type-4

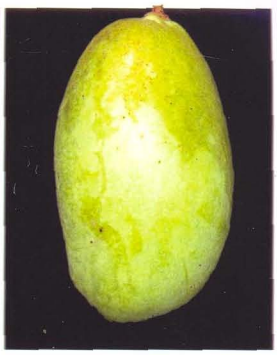
15 Natumavu Type-5

16 Eara Local

17 Muthalamookkan

18 Nedungolan

19 Vellari Type-2



20 Kolambi

21 Perakka manga

22 Kasthuri

23 Inamanga

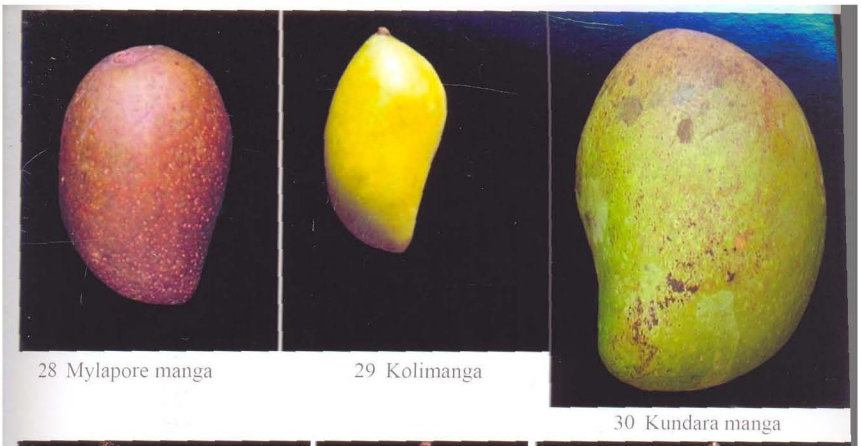
24 Panchasara Varikka

25 Kappa manga

26 Kandiyoor Local

27 Thenga manga

Plate 6 Continued



28 Mylapore manga

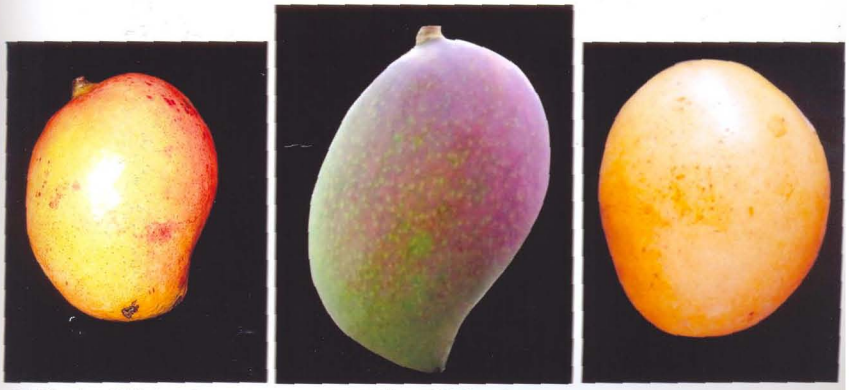
29 Kolimanga

30 Kundara manga

31 Neendakara manga

32 Neenda Karpooram

33 Karpooram manga



34 Cheriya Kilichundan

35 Valiya Kilichundan

36 Velutha Muvandan

Plate 6 Continued

37 Kotookonam Varikka

38 ChampaVarikka

39 Kallu Varikka

40 Vellamkolli

41 Vellayani Local

42 Thali

43 Karpoora Varikka

44 Kotamanga

45 Karimbu mavu

Plate 6 Continued

46 Mavelikkara Local

47 Kizhakkan Thali

48 Ponnadan manga

49 Manacaud Local-2

50 Ambalathara Local

Plate 6 Continued

1. Fruit shape

Four types of fruit shapes were observed, round, oblong, ellipsoid and oblong-ellipsoid (Plate 7). Forty four per cent of the varieties produced round fruits. Oblong and ellipsoid fruits were produced by 36 and 16 per cent varieties respectively (Table 33). The highest per cent each (43.75, 41.18 and 64.70 per cent) of pickling, table and dual types produced round, oblong and round shaped fruits respectively. Accessions 3 and 24 produced oblong ellipsoid fruits.

2. Basal cavity

Fruits were observed for the presence or absence of basal cavity. It was present in 14 varieties and absent in the rest (Table 34 and Fig.1). The basal cavity was present in 23.53 and 41.18 per cent of table and dual types. Among pickling types, Acc. No.s 1, 4, and 16 alone possessed basal cavity.

3. Beak type

Beak type was prominent in Acc. No. 20 and point in 16 varieties. Absence of beak was observed in 33 varieties (Table 35). Point type beak was observed in 18.75, 52.94 and 23.53 per cent of pickling, table and dual types, respectively (Plate 8 and Fig. 2).

4. Sinus type

Sinus was present in 18 varieties. It was deep in Acc. No.s 13, 17, 26, 34 and 35 and shallow in 13 varieties (Table 36 and Fig. 3).

5. Groove

Groove was present only in the accessions 17, 27 and 50 (Table 37 and Fig. 4).

6. Shoulders

Three types of shoulders could be observed in the varieties. Twenty one varieties had ventral shoulder higher than dorsal one while, 15 had

Table 32. Fruit shape characters of the traditional mango varieties / accessions collected from southern Kerala

Acc. No	Fruit shape	Basal cavity	Beak type	Sinus type	Groove	Shoulder	Slope of shoulder	Apex
Pickling types								
1	Round	Present	Absent	Absent	Absent	VH	RR	Acute
2	Round	Absent	Absent	Absent	Absent	VH	RR	Acute
3	Oblong ellipsoid	Absent	Point	Shallow	Absent	L	E	Round
4	Round	Present	Absent	Absent	Absent	VH	RR	Round
5	Oblong	Absent	Absent	Absent	Absent	VH	E	Acute
6	Oblong	Absent	Absent	Shallow	Absent	VH	RR	Acute
7	Ellipsoid	Absent	Absent	Absent	Absent	DH	SA	Acute
8	Oblong	Absent	Absent	Absent	Absent	VH	E	Round
9	Oblong	Absent	Absent	Shallow	Absent	L	RR	Acute
10	Round	Absent	Absent	Absent	Absent	VH	RR	Acute
11	Round	Absent	Absent	Absent	Absent	VH	E	Round
12	Round	Absent	Point	Shallow	Absent	L	E	Acute
13	Ellipsoid	Absent	Point	Deep	Absent	VH	E	Round
14	Oblong	Absent	Absent	Absent	Absent	DH	RR	Acute
15	Ellipsoid	Absent	Absent	Absent	Absent	L	RR	Acute
16	Round	Present	Absent	Absent	Absent	VH	RR	Acute
Table type								
17	Oblong	Present	Point	Deep	Present	VH	RR	Acute
18	Round	Present	Point	Absent	Absent	L	E	Round
19	Ellipsoid	Absent	Absent	Absent	Absent	L	E	Acute
20	Ellipsoid	Absent	Prominent	Shallow	Absent	L	E	Acute
21	Oblong	Absent	Point	Shallow	Absent	VH	E	Round
22	Round	Absent	Absent	Shallow	Absent	VH	RR	Round
23	Oblong	Absent	Absent	Absent	Absent	VH	RR	Round
24	Oblong ellipsoid	Absent	Point	Absent	Absent	VH	E	Round
25	Round	Absent	Absent	Absent	Absent	L	RR	Round
26	Oblong	Absent	Point	Deep	Absent	L	E	Round
27	Round	Present	Absent	Absent	Present	VH	RR	Round
28	Oblong	Absent	Point	Shallow	Absent	L	E	Acute
29	Ellipsoid	Absent	Point	Shallow	Absent	L	E	Acute
30	Oblong	Present	Point	Shallow	Absent	VH	RR	Round
31	Oblong	Present	Point	Shallow	Absent	VH	E	Acute
32	Ellipsoid	Absent	Absent	Absent	Absent	L	E	Acute
33	Oblong	Absent	Absent	Absent	Absent	L	E	Acute

Continued...

Table 32. Continued

Acc. No	Fruit shape	Basal cavity	Beak type	Sinus type	Groov	Shoulder	Slope of shoulder	Apex
Dual purpose types								
34	Oblong	Present	Point	Deep	Absent	L	E	Acute
35	Oblong	Absent	Point	Deep	Absent	VH	RR	Round
36	Round	Present	Absent	Absent	Absent	VH	RR	Round
37	Round	Absent	Absent	Absent	Absent	VH	RR	Round
38	Round	Present	Absent	Absent	Absent	VH	RR	Round
39	Round	Absent	Absent	Absent	Absent	VH	RR	Round
40	Round	Present	Absent	Absent	Absent	VH	RR	Round
41	Oblong	Absent	Absent	Absent	Absent	VH	RR	Round
42	Round	Present	Absent	Absent	Absent	VH	RR	Acute
43	Round	Present	Point	Shallow	Absent	VH	RR	Acute
44	Round	Present	Absent	Absent	Absent	VH	RR	Round
45	Round	Absent	Absent	Absent	Absent	VH	RR	Round
46	Round	Absent	Absent	Absent	Absent	VH	RR	Acute
47	Oblong	Absent	Absent	Absent	Absent	VH	RR	Round
48	Round	Absent	Absent	Absent	Absent	L	RR	Acute
49	Oblong	Absent	Absent	Absent	Absent	VH	RR	Acute
50	Ellipsoid	Absent	Point	Shallow	Present	VH	E	Acute

Shoulders: L: Level; DH: Dorsal higher than ventral; VH: Ventral higher than dorsal
Slope of shoulders: RR: Rising and then rounded; SA: Sloping abruptly; E: Ending in a long curve

Table 33. Fruit shape of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Ellipsoid	2 (12.5%)	5 (29.41 %)	1 (5.88%)	8 (16.00 %)
Oblong	6 (37.50 %)	7 (41.18 %)	5 (29.41 %)	18 (36.00 %)
Oblong ellipsoid	1 (6.25%)	1 (5.88%)	0	2 4.00%)
Round	7 (43.75 %)	4 (23.53 %)	11 (64.70 %)	22 (44.00 %)

Table 34. Basal cavity of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Present	3 (18.75 %)	4 (23.53 %)	7 (41.18 %)	14 (2.00 %)
Absent	13 (81.25 %)	13 (76.47 %)	10 (58.82 %)	36 (72.00 %)

Fig. 1 Presence of basal cavity in the fruits of traditional mango varieties of southern Kerala

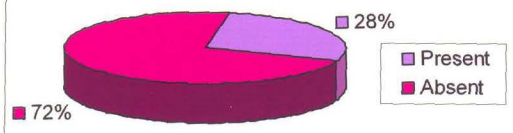


Fig. 2 Presence of basal cavity in the fruits of traditional mango varieties of southern Kerala

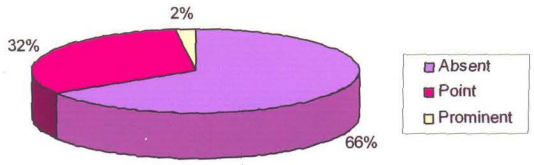
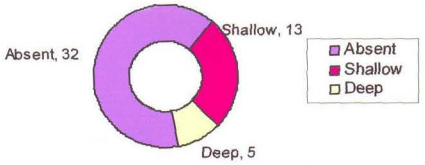


Fig. 3 Fruit sinus type of the traditional *mango* varieties of southern Kerala



level type. The dorsal shoulder was higher than ventral in 14 varieties (Table 38 and Fig. 5).

7. Slope of shoulders

The slope of shoulders was rising and then rounded in thirty varieties and ending in a long curve in 19. In Acc. No. 7 alone, it was sloping abruptly (Table 39, Fig. 6).

8. Apex

Apex of the fruit was acute in 26 and round in 24 varieties (Table 40 and Fig. 7).

4.3.3.1.2 Fruit size

Fruit size characters of the fifty traditional mango varieties/ accessions have been recorded (Table 41 and Fig. 8).

1. Fruit length

Fruit length ranged from 4.4 cm to 18.1 cm (Plate 9). The highest length was observed in Acc, No 17and the lowest in 10 (4.4 cm).There was wide variation in fruit length between the three utility groups. The average fruit length of pickling, table and dual type mango varieties were 7.94, 11.04 and 8.96 cm respectively. Table types had more length compared to the other two groups (Table 42).

2. Fruit breadth

The highest breadth was observed in Acc. No. 17 (12.0 cm) followed by Acc. No. 18 (11.0 cm). The lowest breadth was observed in Acc. No. 10 (3.9 cm). The average fruit breadths of the pickling, table and dual varieties were 6.58, 7.74 and 7.19 cm respectively. The breadth was more for table types compared to the others (Table 43).

Table 35. Beak type of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Absent	13 (81.25 %)	7 (41.18 %)	13 (82.35 %)	33 (66.00 %)
Point	3 (18.75 %)	9 (52.94 %)	4 (23.53 %)	16 (32.00 %)
Prominent	0	1 (5.88%)	0	1 (2.00%)

Table 36. Sinus type of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Absent	11 (68.75 %)	8 (47.06 %)	13 (82.35 %)	32 (64.00 %)
Shallow	4 (25.00 %)	7 (41.18 %)	2 (11.76%)	13 (26.00 %)
Deep	1 (6.25%)	2 (11.76%)	2 (11.76%)	5 (10.00 %)

Table 37. Presence of groove in the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Absent	16 (100.00%)	15 (88.24%)	16 (94.12 %)	47 (94.00 %)
Present	0	2 (11,76%)	1 (5.88%)	3 (6.00%)

Table 38. Shoulder type of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Level with the surface	4 (25.00 %)	6 (35.29 %)	5 (29.41 %)	15 (30.00 %)
Dorsal higher than ventral	0	2 (11.76%)	12 (70.59 %)	14 (28.00 %)
Ventral higher than dorsal	12 (75.00 %)	9 (52.94 %)	0	21 (42.00 %)

Table 39. Slope of shoulders of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Rising and then rounded	9 (56.25 %)	6 (35.29 %)	15 (88.24 %)	30 (60.00 %)
Sloping abruptly	1 (6.25%)	0	0	1 (2%)
Ending in a long curve	6 (37.5 %)	11 (64.71 %)	2 (11.76%)	19 (38.00 %)

Table 40. Fruit apex of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Acute	11 (68.75 %)	8 (47.06 %)	7 (41.18 %)	26 (52.00 %)
Round	5 (31.25 %)	9 (52.94 %)	10 (58.82 %)	24 (48.00 %)

Table 41. Fruit size characters of the traditional mango varieties / accessions collected from southern Kerala

Acc. No.	Length	Breadth	Thickness	Weight	Volume
Pickling types					
1	8.20	8.40	5.90	182.50	187.00
2	5.40	4.80	3.90	45.00	35.00
3	8.90	6.80	5.35	110.00	100.00
4	10.10	9.80	8.80	220.00	217.00
5	9.40	7.10	5.80	175.00	190.00
6	10.10	6.70	6.00	217.50	220.00
7	9.20	5.80	4.30	115.00	110.00
8	9.40	6.60	4.90	155.00	153.00
9	9.10	6.50	4.90	150.00	143.00
10	4.40	3.90	3.55	37.50	30.00
11	7.80	7.20	5.50	172.50	165.00
12	10.30	8.70	6.85	260.00	245.33
13	9.00	5.00	4.50	85.00	69.00
14	7.10	4.20	4.30	65.00	62.00
15	8.60	6.70	6.00	125.00	118.00
16	8.50	7.05	6.40	221.67	200.00
Average	7.94	6.58	5.43	146.04	140.27
SE	0.41	0.40	0.32	16.74	17.05
Table type					
17	18.10	12.00	9.60	826.00	857.75
18	12.50	11.00	7.10	451.00	484.95
19	13.20	7.90	6.00	367.00	360.00
20	11.50	6.80	5.00	223.00	223.00
21	10.00	7.25	6.50	270.00	235.00
22	9.40	7.80	6.80	215.00	210.00
23	7.80	6.20	4.70	194.00	194.00
24	12.50	8.00	6.70	317.00	322.00
25	9.50	8.40	7.10	240.00	242.00
26	8.90	5.70	4.70	116.00	110.00
27	11.70	9.70	9.10	425.00	428.00
28	9.00	6.55	5.05	130.00	128.00
29	8.00	4.40	4.10	109.67	98.00
30	12.00	8.00	8.40	485.00	472.00
31	12.20	7.80	7.40	342.33	346.00
32	10.40	6.45	5.70	203.00	181.67
33	11.05	7.70	6.25	286.00	270.00
Average	11.04	7.74	6.48	305.88	303.67
SE	0.60	0.45	0.38	42.57	45.03

Table 41. Continued.

Acc. No..	Fruit length	Fruit breadth	Fruit thickness	Fruit weight	Fruit volume
Dual purpose type					
34	9.40	7.00	6.10	205.00	203.00
35	12.00	7.90	7.40	251.00	285.00
36	10.00	8.65	6.65	224.80	215.67
37	8.90	7.30	6.30	250.00	252.00
38	8.80	8.50	6.90	215.00	229.00
39	9.30	7.70	6.70	225.00	222.00
40	9.00	8.20	6.10	141.00	140.00
41	10.50	7.80	6.20	245.00	247.00
42	8.00	5.20	4.70	126.00	118.00
43	7.60	7.40	6.10	158.00	168.00
44	7.80	7.20	6.10	150.00	150.00
45	7.00	6.70	5.42	117.50	96.50
46	8.40	6.20	4.60	105.67	81.00
47	9.00	6.80	5.85	157.00	155.00
48	6.10	5.00	4.40	75.00	64.00
49	8.10	6.80	5.90	145.00	150.00
50	12.50	7.80	8.00	380.00	370.00
Average	8.96	7.19	6.08	175.12	185.07
SE	0.41	0.25	0.23	20.27	19.23
Overall average	9.51	7.18	6.01	210.27	211.06
SE	0.31	0.22	0.19	19.32	19.79

Table 42. Fruit length of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Short (≤ 7 cm)	2 (12.5%)	0	2 (11.76%)	4 (8.00 %)
Intermediate (7-12 cm)	14 (87.50 %)	11 (64.71 %)	13 (82.35 %)	38 (76.00 %)
Long (≥ 12 cm)	0	6 (35.29 %)	2 (11.76%)	8 (16.00 %)

Table 43 Fruit breadth of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Narrow (≤6 cm)	5 (31.25 %)	2 (11.76%)	2 (11.76%)	9 (18.00 %)
Intermediate (6-8.5 cm)	9 (56.25 %)	12 (70.59 %)	13 (82.35 %)	34 (68.00 %)
Broad (≥8.5 cm)	2 (12.50%)	3 (17.65 %)	2 (11.76%)	7 (14.00 %)

Fig. 4 Presence of groove in the fruits of traditional mango varieties of southern Kerala

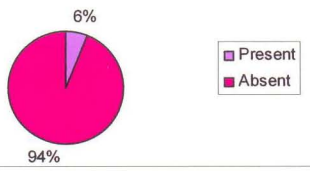
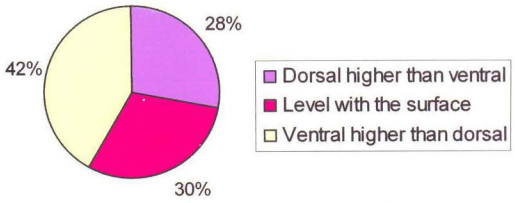


Fig. 5 Fruit shoulder type of the traditional mango varieties of southern Kerala



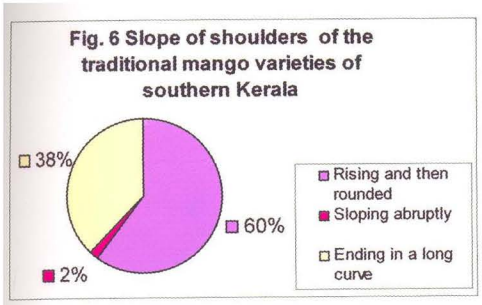


Fig. 6 Slope of shoulders of the traditional mango varieties of southern Kerala
38%
60%
2%
Rising and then rounded
Sloping abruptly
Ending in a long curve

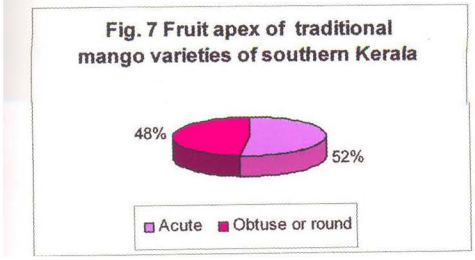
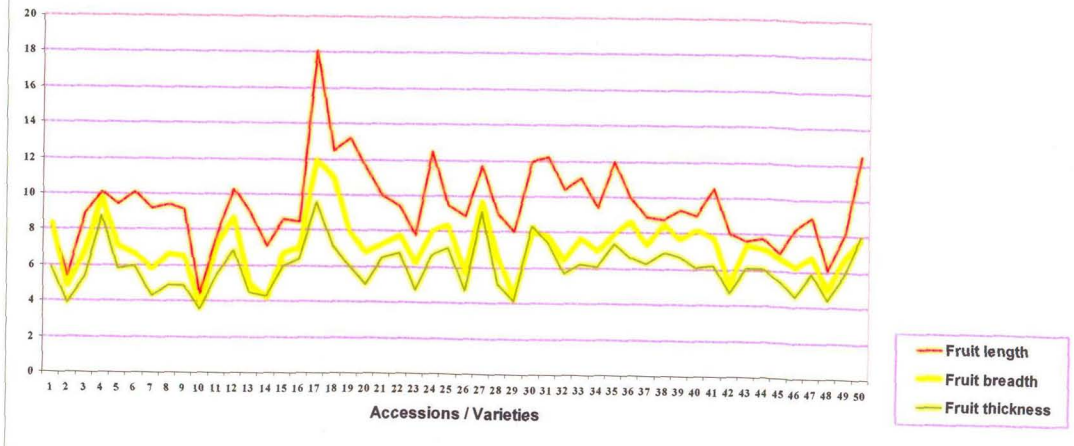


Fig. 7 Fruit apex of traditional mango varieties of southern Kerala
48%
52%
Acute
Obtuse or round

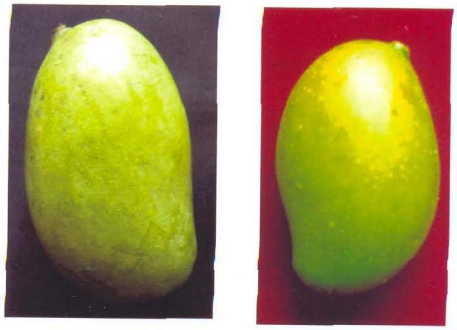
Fig. 8 Fruit size characters of the traditional mango varieties of southern Kerala



1. Round

2. Oblong

3. Ellipsoid



4. Oblong- ellipsoid

Fruit shape types of mango varieties

1. Absent

2. Point

3. Prominent

Plate 8 Beak types of mango varieties

Plate 9 Variability in fruit length of mango varieties

3. Fruit thickness

Fruit thickness varied from 3.55 cm (in Acc. No. 10) to 9.6 cm (in Acc. No. 17). Percentage of fruits having thickness more than 7.00 cm was the highest in table type while those having medium thick and thin fruits were for dual and pickling types, respectively as evident from table 44 .

4. Fruit weight

Fruit weight ranged from 37.5 g to 826.0 g. Acc. No. 17 recorded the highest value followed by Acc. No. 30 (485 g). Acc. No. 10 recorded the lowest weight. The highest per cent of fruits weighing more than 348 g was for table type (Table 45).

5. Fruit volume

The range observed was from 30 ml to 676.1 ml. Pickling type varieties possessed the highest per cent (25%) of fruits with less than 70 ml volume, while, the table types had the highest per cent(29.41%) of fruits with more than 350 ml volume (Table 46).

4.3.3.1.3 Specific gravity

The specific gravity values ranged from 0.88 (Acc. No. 35) to 1.3 (Acc, No. 46). It was greater than 1.10 in 10 varieties and less than 1.1 in 40 varieties (Table 47 and48).

4.3.3.1.4 Stalk insertion

The mode of attachment of the stalk to the fruit was noted as being vertical or oblique. It was vertical in 29 varieties and oblique in 21 (Table 49).

4.3.3.1.5 Skin characters

Skin characters were observed and tabulated (Table 50).

Table 44. Fruit thickness of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Thin (≤4.7cm)	5 (31.25 %)	3 (17.65 %)	3 (17.65 %)	14 (28.00 %)
Medium (4.7-7.0 cm)	10 (62.50 %)	8 (47.06 %)	12 (70.59 %)	30 (60.00 %)
Thick (>7.0 cm)	1 (6.25%)	6 (35.29 %)	2 (11.76%)	9 (18.00 %)

Table 45. Fruit weight of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Light (<80 g)	3 (18.75%)	0	1 (5.88%)	4 (8.00 %)
Medium (80-348 g)	13 (81.25 %)	11 (64.71 %)	15 (88.24 %)	39 (78.00 %)
Heavy (>348 g)	0	6 (35.29 %)	3 (17.65 %)	7 (14.00 %)

Table 46. Fruit volume of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
<70 ml	4 (25.00 %)	0	1 (5.88%)	5 (10.00 %)
70-350 ml	12 (75.00 %)	12 (70.59 %)	15 (88.24 %)	39 (78.00 %)
>350 ml	0	5 (29.41 %)	1 (5.88%)	6 (12.00 %)

Table 47. Specific gravity and stalk insertion of the traditional mango varieties/ accessions collected from southern Kerala

Acc. No.	Specific gravity	Stalk insertion
1	0.98	Vertical
2	1.29	Oblique
3	1.10	Oblique
4	1.01	Vertical
5	0.92	Oblique
6	0.99	Oblique
7	1.01	Oblique
8	1.01	Vertical
9	1.04	Vertical
10	1.25	Oblique
11	1.04	Oblique
12	1.06	Vertical
13	1.23	Oblique
14	1.03	Oblique
15	1.06	Oblique
16	1.11	Vertical
17	0.96	Vertical
18	0.93	Vertical
19	1.02	Oblique
20	1.00	Vertical
21	1.15	Oblique
22	1.02	Vertical
23	1.00	Vertical
24	0.98	Oblique
25	0.99	Vertical
26	1.05	Vertical
27	0.99	Vertical
28	1.01	Vertical
29	1.11	Oblique
30	1.02	Vertical
31	0.98	Oblique
32	1.12	Vertical
33	1.06	Vertical

Continued...

Table 47. Continued...

Acc. No.	Specific gravity	Stalk insertion
34	1.01	Oblique
35	0.88	Vertical
36	1.04	Vertical
37	0.99	Vertical
38	0.94	Vertical
39	1.01	Vertical
40	1.00	Vertical
41	0.99	Oblique
42	1.06	Oblique
43	0.94	Vertical
44	1.00	Oblique
45	1.21	Vertical
46	1.30	Vertical
47	1.01	Vertical
48	1.17	Oblique
49	0.97	Vertical
50	1.03	Oblique
Average	1.04	
SE	0.01	

Table 48. Specific gravity of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
0.88- 1.1	12 (75.00%)	14 (82.35%)	14 (82.35%)	40 (80.00%)
> 1.1	4 (25.00 %)	3 (17.65 %)	3 (17.65 %)	10 (20.00 %)

Table 49. Stalk insertion of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Vertical	6 (37.50 %)	12 (41.18 %)	11 (64.71 %)	29 (58.00 %)
Oblique	10 (62.50 %)	5 (29.41 %)	6 (35.29 %)	21 (42.00 %)

Table 50. Fruit skin characters of the traditional mango varieties/ accessions collected from southern Kerala

Acc. No.	Raw fruit skin colour	Ripe fruit skin colour	Skin texture	Skin Thick-ness (mm)	Skin Weight (g)
	Pickling types				
1	Dark green	Dark green	Smooth	1.59	45.00 (24.66 %)
2	Green	Yellowish green	Smooth	1.21	11.60 (25.78 %)
3	Green	Yellowish green	Smooth	1.40	15.89 (15.13 %)
4	Green	Yellowish green	Smooth	1.40	33.00 (15.00 %)
5	Green	Yellow	Smooth	1.49	31.48 (16.57 %)
6	Green	Yellow	Smooth	0.90	45.00 (20.69 %)
7	Green	Yellowish green	Smooth	1.60	25.00 (29.41 %)
8	Green	Green	Smooth	1.12	35.00 (22.58 %)
9	Dark Green	Dark green	Smooth	0.90	35.00 (21.88 %)
10	Dark Green	Green with black dots	Smooth	1.21	16.50 (37.71 %)
11	Green with black dots	Green with black dots	Smooth	1.06	26.25 (15.22 %)
12	Light Green with white ash like covering	Orange	Smooth	1.01	40.00 (15.38 %)
13	Green	Yellow	Smooth	1.41	11.00 (12.94 %)
14	Green	Yellow	Smooth	1.10	10.00 (15.38 %)
15	Green	Green	Smooth	1.60	30.00 (24.00 %)
16	Green with red blush	Deep orange with red blush	Smooth	0.88	24.00 (10.83 %)
	Average			1.24	27.17
	SE			0.06	2.91

Continued...

Table 50. (continued)

Acc. No.	Raw fruit skin colour	Ripe fruit skin colour	Skin texture	Skin thickness (mm)	Skin Weight (g)
	Table types				
17	Green with white ash like covering	Green with white ash like covering	Rough	1.60	72.00 (8.71 %)
18	Green	Brownish orange with black dots	Smooth	0.96	48.30 (10.71 %)
19	Green with white dots	Yellow	Smooth	1.00	49.00 (13.35 %)
20	Green	Green	Smooth	0.61	35.00 (15.70 %)
21	Green	Yellow	Rough	0.91	30.00 (11.11 %)
22	Dark Green	Green	Smooth	1.35	35.50 (16.51 %)
23	Green	Green	Smooth	1.47	34.00 (17.53 %)
24	Green	Orange	Smooth	1.00	30.00 (9.46)
25	Dark Green	Green	Smooth	1.50	25.00 (10.42)
26	Green with red blush and white ash like covering	Deep orange with red blush	Smooth	0.85	15.00 (12.93 %)
27	Dark Green	Green	Smooth	0.94	38.00 (8.940%)
28	Reddish brown	Brownish red	Smooth	1.33	21.50 (16.54 %)
29	Green	Green	Smooth	0.95	20.00 (18.24 %)
30	Green with red blush	Yellowish green with red patch	Smooth	2.00	44.00 (9.07%)
31	Green with red blush	Yellowish green	Rough	1.00	37.00 (10.81%)
32	Green	Yellowish green	Smooth	1.25	27.50 (13.55 %)
33	Green	Green with red dots	Rough	1.09	32.00 (11.19 %)
	Average			1.17	34.93
	SE			0.08	3.24

Continued...

Table 50. Continued

Acc. No.	Raw fruit skin colour	Ripe fruit skin colour	Skin texture	Skin thickness (mm)	Skin Weight (g)
	Dual types				
34	Green with red blush	Deep orange with red blush	Smooth	1.05	30.00 (14.63 %)
35	Green with red blush	Green with red patch	Smooth	1.50	39.00 (15.54 %)
36	Green with white ash like covering	Yellow	Smooth	1.06	38.00 (16.90 %)
37	Green with red blush	Reddish orange	Smooth	1.20	26.00 (10.40 %)
38	Green with white ash like covering	Green with white ash like covering	Smooth	1.75	30.00 (13.95 %)
39	Green	Green	Smooth	1.42	29.00 (12.89 %)
40	Green	Yellow	Smooth	0.86	20.00 (14.18 %)
41	Green	Green	Smooth	1.21	36.00 (14.69 %)
42	Dark Green	Orange	Smooth	1.18	23.00 (18.25 %)
43	Green with black dots	Orange with black dots	Smooth	0.83	25.00 (15.82%)
44	Green	Yellow	Smooth	1.00	21.25 (14.17%)
45	Green	Orange with yellow and black dots	Smooth	1.37	14.00 (11.91%)
46	Dark Green	Green	Smooth	1.20	24.00 (22.71%)
47	Dark Green	Dark green	Smooth	1.20	20.00 (12.74%)
48	Green	Green	Smooth	0.80	18.00 (24.00 %)
49	Dark Green with white ash like covering	Green	Smooth	1.20	28.00 (19.31%)
50	Green	Green	Smooth	1.15	32.00 (8.42 %)
	Average			1.18	26.66
	SE			0.06	1.72
	Overall Average			1.19	29.64
	SE			0.04	1.62

1. Fruit skin colour

The skin colour of raw fruits was dark green in Acc. No.s 1, 9, 10, 22, 25, 27, 42, 46, 47, and 49. In Acc. No. 28, it was brownish red and light green in the rest of the varieties. Red blush at the shoulder region could be observed in Acc. No.s, 16, 26, 30, 31, 34, 35 and 37. White ash like covering over the skin could be observed in Acc. No. s 17, 26, 36, 38, and 49. Acc. No.3 had white dots on the surface of skin (Table 51).

Ripe fruit skin colour varied from dark green to red in the various varieties. It was red in Acc. No.s 34 and 16 and reddish orange in accessions 37 and 26 (Table 52)

2. Fruit skin thickness

Thickness of fruit skin was the lowest in Acc. No. 20 and the highest in Acc. No.30 (Table 53).

3. Skin texture

Fruit skin was rough textured in Acc. No.s 17, 21, 31 and 33 and smooth in the others. All the fruits with rough skin were table types (Table 54).

4. Skin weight

Skin weight ranged from 10 g (Acc. No. 14) to 72g (Acc. No. 17) (Tables 50 and 55). Percentage contribution of skin weight to the fruit weight varied from 8.42 (Acc. No. 50) to 37.71 (Acc. No. 10) (Fig. 9 to 11).

4.3.3.1.6 Flesh characters

Flesh characters of the varieties were observed (Table 57).

1. Pulp weight

Pulp weight ranged from 14.75g (in Acc. No. 10) to 676.1g (Acc. No. 17) (Table 57). Percentage of pulp in fruit ranged from 33.71 (Acc.

Table 51. Raw fruit skin colour of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Green	15 (93.75 %)	13 (81.25 %)	14 (82.35 %)	42 (84.00)
Red or green with red blush	1 (6.25 %)	4 (23.53 %)	3 (17.65 %)	8 (16.00 %)

Table 52. Ripe fruit skin colour of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Green	6 (37.50%)	9 (52.94 %)	9 (52.94 %)	24 (48.00 %)
Yellow	8 (50.00 %)	5 (29.41 %)	3 (17.65 %)	16 (32.00 %)
Orange & Red	2 (12.5%)	3 (17.65 %)	5 (29.41%)	10 (20.00 %)

Table 53. Skin thickness of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
≤0.9mm	3 (18.75 %)	2 (11.76%)	3 (17.65 %)	8 (16.00 %)
0.9-1.5mm	10 (62.50 %)	12 (70.59 %)	12 (70.59 %)	34 (6.00%)
≥1.5mm	3 (18.75 %)	3 (17.65 %)	2 (11.76%)	8 (16.00 %)

Table 54. Skin texture of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Smooth	16 (100.00%)	13 (82.35 %)	17 (100.00%)	46 (92.00 %)
Rough	0	4 (23.53%)	0	4 (8.00 %)

Table 55. Skin weight of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
≤ 20g	5 (31.25 %)	2 (11.76%)	4 (23.53 %)	11 (22.00 %)
20- 40 g	8 (50.00 %)	11 (64.71 %)	13 (82.35 %)	32 (64.00 %)
≥40 g	3 (18.75 %)	4 (23.53 %)	0	7 (14.00 %)

Table 56. Flesh characters of the traditional mango varieties/ accessions collected from southern Kerala

Acc. No.	Pulp Weight(g)	Pulp %	Flesh content	Texture	Adherence of skin to pulp	Flesh colour
Pickling type						
1	112.50	61.64	1.61	Firm	Present	Orange
2	20.90	46.44	0.87	Juicy	Absent	Yellow
3	74.11	70.58	2.06	Firm	Absent	Yellow
4	149.00	67.73	2.10	Firm	Present	Yellow
5	111.02	58.43	1.40	Juicy	Absent	Orange
6	134.11	61.66	1.60	Juicy	Present	Yellow
7	43.00	50.59	1.02	Juicy	Present	Yellow
8	90.00	58.06	1.38	Firm	Absent	Yellow
9	82.00	54.38	1.05	Soft	Present	Orange
10	14.75	33.71	0.51	Juicy	Absent	Yellow
11	105.75	61.3	1.60	Soft	Present	Yellow
12	160.00	61.54	1.60	Firm	Present	Orange
13	52.70	62.00	1.63	Juicy	Absent	Yellow
14	32.00	49.23	0.97	Firm	Present	Yellow
15	55.00	44.00	0.79	Soft	Present	Yellow
16	162.67	73.38	2.76	Soft	Present	Orange
Average	87.47	57.17	1.43			
SE	12.19	2.59	0.14			
Table type						
17	676.10	81.87	4.51	Firm	Present	Orange
18	352.95	78.26	3.60	Firm	Present	Orange
19	282.50	76.98	3.34	Firm	Present	Deep orange
20	156.00	69.96	2.33	Soft	Absent	Orange
21	191.00	70.74	2.42	Firm	Present	Orange
22	139.50	64.88	1.85	Firm	Present	Deep orange
23	119.00	61.34	1.59	Soft	Absent	Yellow
24	247.00	77.92	3.53	Soft	Present	Orange
25	191.00	79.58	3.90	Soft	Present	Orange
26	65.00	56.03	1.27	Soft	Present	Deep orange
27	337.00	79.29	3.83	Firm	Present	Yellow
28	77.50	59.62	1.48	Soft	Present	Deep orange
29	72.67	66.26	1.96	Juicy	Absent	Orange
30	390.00	80.41	4.11	Firm	Present	Deep orange
31	261.33	76.34	3.23	Soft	Present	Orange
32	150.83	74.30	2.87	Soft	Absent	Yellow
33	217.00	75.87	3.14	Firm	Absent	Deep orange
Average	230.96	2.88	2.88			
SE	36.68	0.24	1.00			

Continued...

Table 56. Continued

Acc. No.	Pulp weight(g)	Pulp percentage	Flesh content	Texture	Adherence of skin to pulp	Flesh colour
	Dual type					
34	155.00	75.61	2.82	Firm	Present	Deep orange
35	166.00	66.14	1.95	Firm	Present	Deep orange
36	151.80	67.53	2.08	Soft	Absent	Yellow
37	189.00	75.60	3.10	Firm	Present	Deep orange
38	147.50	68.60	2.19	Soft	Present	Orange
39	159.00	70.67	2.40	Firm	Present	Deep orange
40	99.00	70.21	2.41	Firm	Present	Yellow
41	178.00	72.65	2.66	Firm	Present	Yellow
42	65.00	51.59	1.07	Soft	Present	Deep orange
43	111.50	70.57	2.40	Firm	Present	Deep orange
44	96.25	64.17	1.79	Soft	Present	Orange
45	80.00	68.09	2.13	Firm	Present	Orange
46	52.67	49.84	0.99	Juicy	Absent	Deep orange
47	97.00	61.78	1.62	Soft	Present	Orange
48	30.75	41.00	0.69	Firm	Present	Orange
49	97.00	66.90	2.02	Soft	Present	Orange
50	306.00	80.53	4.14	Firm	Absent	Deep orange
Average	128.32	65.97	2.145			
SE	15.75	2.45	0.20			
Overall average	150.15	65.32	2.17			
SE	16.30	1.59	0.14			

Table 57. Pulp weight of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
≤ 35 g	3 (18.75%)	0	1 (5.88%)	4 (8.00 %)
35-265 g	13 (81.25 %)	12 (70.59 %)	15 (88.24 %)	40 (80.00 %)
≥265g	0	5 (29.41 %)	1 (5.88%)	6 (12.00 %)

No. 10) to 81.87 (Acc. No. 17). The average pulp content was 65.32 per cent. The highest pulp per cent was recorded in Acc. No. 17, followed by accessions 50 (80.53%) and 30 (80.41%) (Fig. 9 to 11).

2. Flesh texture

Twenty four varieties had firm flesh. Thirteen varieties each possessed soft and juicy textured flesh (Table 58).

3. Adherence of skin to pulp (absent / present)

Adherence of skin to pulp was present in 36 varieties, whereas, it was absent in 14 varieties (Table 59).

4. Fibre in pulp

Fibre content was less (≤0.6%) in 14 varieties, while it was medium (0.6 to 0.9%) in 21 and high (≥ 0.9%) in 15 varieties (Table 60).

5. Flesh content

Flesh content (ratio of pulp weight to skin + stone weight) varied from 0.51 to 4.51(Table 61).

6. Flesh colour

Flesh colour of ripe fruits ranged from yellow to deep orange. Among the pickling types, 68.75 per cent had yellow flesh. The highest per cent (47.06% each) of table and dual types possessed orange and deep orange flesh, respectively (Table 62 and Plate 10).

4.3.3.1.7 Stone characters

Stone characters were studied and tabulated (Table 63).

1. Length

Stone length varied from 3.1 cm to 13.75 cm. Stone length was the highest in Acc. 17 and the lowest in Accessions 10 and 48 (Table 64).

Table 58. Flesh texture of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Firm	6 (37.50%)	8 (47.06 %)	10 (58.82 %)	24 (48.00 %)
Soft	6 (37.50 %)	1 (5.88%)	6 (35.29 %)	13 (26.00 %)
Juicy	4 (25.00%)	8 (47.06 %)	1 (5.88%)	13 (26.00 %)

Table 59. Adherence of skin to pulp of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Present	10 (62.5 %)	12 (70.59 %)	14 (82.35 %)	36 (72.00 %)
Absent	6 (37.50 %)	5 (29.41 %)	3 (17.65 %)	14 (28.00 %)

Table 60. Fibre content of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Less (≤0.6%)	3 (18.75 %)	8 (47.06%)	3 (17.65 %)	14 (20.00 %)
Medium (0.6-0.9%)	5 (31.25 %)	6 (35.29 %)	10 (58.82 %)	21 (42.00 %)
High (≥0.9%)	8 (50.00 %)	3 (17.65 %)	4 (23.53 %)	15 (30.00 %)

Table 61. Flesh content of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Low (<2)	13 (18.75 %)	5 (29.41 %)	6 (35.29 %)	24 (48.00 %)
Medium (2-3)	3 (18.75%)	3 (17.65%)	9 (52.94 %)	15 (30.00 %)
High (>3)	0	9 (52.94 %)	2 (11.76%)	11 (22.00 %)

Table 62. Flesh colour of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Yellow	11 (68.75 %)	3 (17.65%)	3 (17.65%)	17 (34.00 %)
Orange	5 (31.25 %)	8 (47.01 %)	6 (35.29)	19 (38.00 %)
Deep Orange	0	6 (35.29 %)	8 (47.01 %)	14 (28.00 %)

Table 63. Stone characters of the traditional mango varieties/ accessions collected from southern Kerala

Acc. No.	Stone Length (cm)	Stone breadth (cm)	Stone Weight (g)	Stone %	Fibre length (cm)	Veins	Pattern of venation
Pickling types							
1	6.90	5.20	25.00	13.70	2.70	E	Parallel & forked
2	3.80	3.60	12.50	27.78	6.00	D	Parallel
3	7.40	3.60	20.00	19.05	1.10	E	Parallel
4	7.60	7.20	38.00	17.27	1.10	D	Parallel
5	7.80	4.20	47.50	25.00	3.50	E	Parallel
6	6.30	4.20	38.40	17.66	9.00	L	Parallel & forked
7	6.90	4.50	17.00	20.00	3.00	E	Forked
8	7.40	4.00	30.00	19.35	1.50	E	Parallel & forked
9	7.50	4.50	43.00	26.88	3.50	E	Parallel
10	3.10	2.80	12.50	28.57	1.50	D	Parallel
11	5.50	4.80	40.00	23.19	7.00	D	Parallel
12	7.80	6.20	60.00	23.08	5.00	L	Parallel
13	7.35	2.95	21.30	25.06	5.20	D	Parallel
14	5.20	2.50	23.00	35.38	0.75	D	Parallel
15	7.10	5.50	40.00	32.00	5.00	D	Forked
16	6.50	3.60	35.00	15.79	6.30	E	Parallel
Average	6.51	4.33	31.45		3.88		
SE	0.35	0.31	3.37		0.61		
Table types							
17	13.75	6.05	77.90	9.43	1.50	E	Parallel
18	9.40	5.80	49.75	11.03	2.30	E	Parallel
19	12.50	3.60	35.50	9.67	1.20	D	Forked
20	9.90	4.00	32.00	14.35	3.30	L	Parallel
21	8.50	4.90	49.00	18.15	3.50	E	Parallel
22	7.70	4.80	40.00	18.60	3.50	E	Parallel
23	4.70	3.80	37.00	19.07	2.30	E	Parallel
24	6.90	3.90	40.00	12.62	4.00	E	Parallel
25	5.00	4.80	24.00	10.00	4.20	E	Forked
26	6.90	3.80	36.00	31.03	1.80	L	Forked
27	8.40	4.80	50.00	11.76	4.50	E	Parallel
28	7.40	3.90	31.00	23.85	6.00	L	Parallel
29	6.00	3.35	17.00	15.50	3.60	D	Parallel & forked
30	7.30	4.20	51.00	10.52	4.60	E	Parallel
31	10.80	4.30	44.00	12.85	2.00	L	Parallel
32	8.30	2.90	25.00	12.32	1.10	D	Parallel
33	7.90	4.10	37.00	12.94	0.60	E	Parallel
Average	8.31	4.29	39.77		2.94		
SE	0.58	0.20	3.50		0.36		

Continued...

Table 63. Continued..

Acc. No.	Stone length (cm)	Stone breadth (cm)	Stone weight (g)	Stone %	Fibre length (cm)	Vein	Pattern of venation
Dual types							
34	7.90	4.60	25.00	12.20	3.50	E	Parallel
35	8.30	4.10	46.00	18.33	4.50	E	Parallel
36	7.40	5.50	35.00	15.57	5.00	E	Parallel & forked
37	6.70	4.50	35.00	14.00	2.70	E	Parallel & forked
38	6.20	3.20	37.50	17.44	3.20	E	Parallel & forked
39	7.20	4.20	37.00	16.44	7.00	E	Parallel
40	6.10	4.00	21.00	14.89	3.40	L	Forked
41	7.10	4.50	31.00	12.65	3.50	E	Forked
42	6.90	4.00	38.00	30.16	4.00	D	Parallel
43	6.10	4.40	21.50	13.61	1.00	D	Parallel
44	4.90	4.10	32.50	21.67	1.00	D	Parallel
45	3.20	3.90	23.50	20.00	0.50	D	Parallel
46	6.35	3.50	29.00	27.44	5.50	D	Parallel
47	7.20	4.50	40.00	25.48	4.30	D	Parallel
48	3.10	2.90	26.25	35.00	1.50	L	Forked
49	7.00	5.00	20.00	13.79	2.40	E	Parallel
50	8.45	4.05	42.00	11.05	2.00	L	Parallel & forked
Average	6.48	4.17	31.78		3.24		
SE	0.37	0.15	1.93		0.42		
Overall average	7.11	4.27	34.39		3.34		
SE	0.28	0.13	1.76		0.27		

D – Depressed; E – Elevated; L – Level with the surface

Table 64. Stone length of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
≤5.0 cm	2 (12.5%)	2 (11.76%)	3 (17.65 %)	7 (14.00 %)
5- 9.0	14 (87.50 %)	10 (58.82 %)	14 (82.35 %)	38 (76.00 %)
≥9.0	0	5 (29.41 %)	0	5 (10.00 %)

Fig. 9 Physical composition of fruits of pickling type of mango varieties

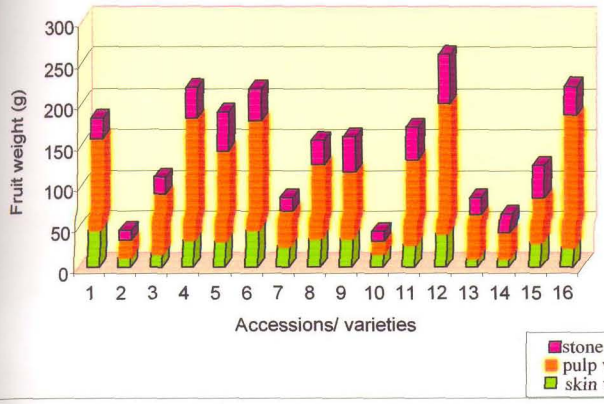


Fig.10 Physical composition of fruits of table type mango varieties

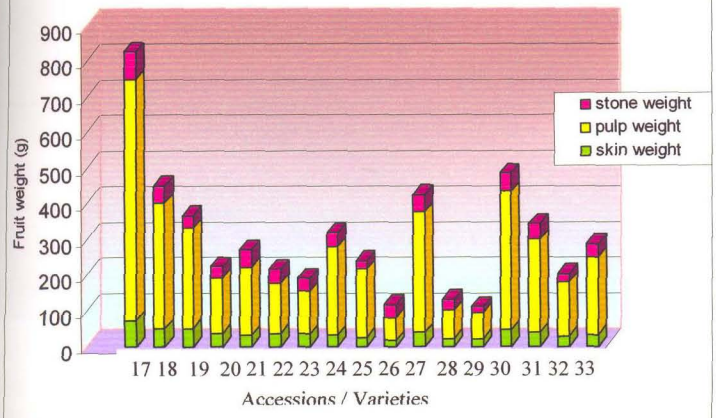
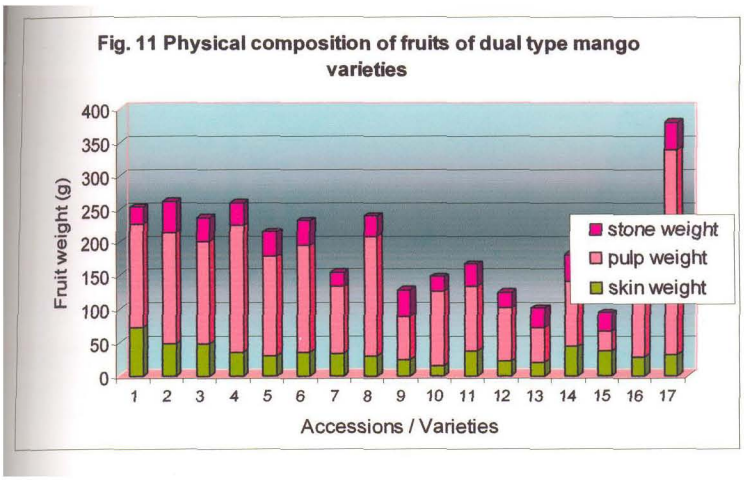


Fig. 11 Physical composition of fruits of dual type mango varieties



Thali manga

Kotookonam Varikka

Karimbu manga

Champa Varikka

Neenda Karpooram

Vellari Type I

Plate 10 Pulp colour types of mango varieties

2. Breadth

Stone breadth was the highest in Acc.4 (7.2 cm) followed by Acc.12 (6.2 cm). Acc. 14 possessed the lowest stone breadth (2.5 cm) (Table 65).

3. Weight

Stone weight ranged from 12.5g to 77.9 g. The lowest weight was recorded in accessions 2 and 10 and the highest in Acc. 17 (Table 66). Stone percentage ranged from 9.43 (in Acc. No 17) to 35.38 (in Acc. No.14) (Fig. 9 to 11).

4. Veins

The stones were washed well using water and the veins observed. In 25 varieties, it was elevated and in 16 varieties it was depressed (Plate 11). The veins were level with the surface in nine varieties (Table 67).

5. Pattern of venation

The pattern of venation was parallel in 34 and forked in eight varieties. Both parallel and forked patterns were observed in eight varieties (Table 68).

6. Length of fibres

The stones were washed well with water and the length of fibre attached to the stone was measured. Fibre length was the lowest in Acc. 45 (0.5 cm) and the highest in Acc. 6 (9.0 cm) (Table 69).

4.3.3.2 Maturity period

The fruits were reported to mature three to four months after flowering. Hence, these were classified as early maturing. Early flowering varieties matured in February. The varieties which were intermediate in flowering produced mature fruits in March- May. These were classified as intermediate maturing. Maturity period was also reported to be highly dependant on the weather conditions.

Table 65. Stone breadth of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
≤3.4cm	3 (18.75 %)	2 (11.76%)	2 (11.76%)	7 (14.00 %)
3.4-5.2 cm	9 (56.25 %)	13 (82.35 %)	14 (82.35 %)	36 (72.00 %)
≥5.2	4 (25.00 %)	2 (11.76%)	1 (5.88%)	7 (14.00 %)

Table 66. Stone weight of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
≤22 g	5 (31.25 %)	1 (5.88%)	3 (17.65 %)	9 (18.00 %)
22- 47 g	9 (56.25 %)	11 (64.71 %)	14 (82.35 %)	34 (68.00 %)
≥47 g	2 (12.5%)	5 (29.41 %)	0	7 (14.00 %)

Table 67. Classification of the traditional mango varieties / accessions collected from southern Kerala based on veins

Class	Pickling	Table	Dual	Total
Level with surface	2 (12.5%)	4 (23.53 %)	3 (17.65 %)	9 (18.00 %)
Depressed	7 (43.75 %)	3 (17.65 %)	6 (35.29 %)	16 (32.00 %)
Elevated	7 (43.75 %)	10 (58.82 %)	8 (47.06 %)	25 (50.00 %)

Table 68. Pattern of venation of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Forked	2 (12.5%)	3 (17.65 %)	3 (17.65 %)	8 (16.00 %)
Parallel	11 (68.75 %)	13 (76.47 %)	10 (58.82 %)	34 (68.00 %)
Parallel and forked	3 (18.75 %)	1 (5.88%)	4 (23.53 %)	8 (16.00 %)

Table 69. Stone fibre length of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
≤ 1.4cm	3 (18.75 %)	3 (17.65 %)	3 (17.65 %)	9 (18.00 %)
1.4-5.3cm	9 (56.25 %)	13 (76.47 %)	12 (70.59 %)	34 (68.00 %)
≥ 5.3cm	4 (25.00 %)	1 (5.88%)	2 (11.76%)	7 (14.00 %)

Elevated

Depressed

Level with the surface

Plate 11 Stone vein types of mango varieties

4.3.3.3 Yield

The yield per tree per year was recorded as reported by the farmers during survey. The highest yield was reported in Acc. 2 and 15 (5000 fruits each) followed by Acc. 47 (4000). The yield was lowest for Acc. 49 (200) (Tables 70 and 71).

4.3.3.4 Number of fruits per bunch

Number of fruits in a bunch varied from one (Acc. No. 17 and 27) to 40 in Acc. No. 15 (Plate 12).

4.3.3.5 Shelf life of fruits

Storage life was highest for Acc.10 (14 days).The accessions 2, 7 and 13 could not be stored for more than a day since it was difficult to attain edible ripening stage. The average storage life was 4.92 days (Table 70 and 72).

4.4 QUALITY CHARACTERS

Quality analysis of ripe fruits, were conducted and results tabulated (Table 73).

4.4.1 Acidity

Percentage of acidity as per cent anhydrous citric acid ranged from 0.12 per cent in Acc. 18 to 4.03 per cent in Acc. No. 16 (Fig. 12). Of the pickling type mango varieties, 62.5 per cent had high acidity (>0.6%) while 25 and 12.5 per cent had medium (0.3 to 0.6 %) and low (<0.3%) acidity. Among the table types, 58.82 percent had low acidity, while 29.41 per cent had medium acidity. Among the dual purpose varieties, 52.94 per cent had medium acidity (Table 74).

4.4.2 Ascorbic acid content

Ascorbic acid content ranged from 3.08 to 119.05mg/ 100g (Fig. 13 to 15). Acc. 7 showed the highest value for ascorbic acid content and Acc. 31, the lowest. Among the pickling types, 68.75 per cent had medium ascorbic acid content

Table 70. Yield and storage life of the traditional mango varieties/ accessions collected from southern Kerala based on survey

Acc. No.	No. of fruits per bunch	Yield (Approximate no. of fruits/tree/year)	Storage life (days)
1	<5	300	3
2	10 -20	5000	3
3	5- 10	1000	1
4	5- 10	750	2
5	10 - 20	800	4
6	<5	500	3
7	5 -10	2000	6
8	5- 10	2000	1
9	5 -10	500	4
10	5 -15	2000	14
11	5 -10	1500	4
12	5 - 10	1000	3
13	5 - 10	1500	7
14	10 - 20	2000	1
15	30 -40	5000	4
16	<5	2000	6
17	1	350	7
18	<5	500	6
19	<5	500	7
20	<5	1000	6
21	5 - 10	300	4
22	3 to 5	1000	4
23	< 5	300	10
24	<5	1000	3
25	5 - 10	1000	3
26	5 - 10	750	4
27	1	300	5
28	5 - 10	800	5
29	<5	3000	5
30	<5	500	4
31	<5	500	4
32	5 - 10	2500	5
33	<5	1000	8
34	<5	1000	5
35	<5	500	7
36	5-10	1500	8
37	<5	1000	7
38	<5	1500	5
39	<5	400	3
40	5 - 10	500	5

Continued..

Table 70. Continued.

Acc. No.	No. of fruits per bunch	Yield (Approximate no. of fruits/tree/year)	Storage life (days)
41	<5	400	5
42	<5	500	7
43	<5	750	4
44	<5	800	2
45	<5	600	5
46	<5	2500	3
47	5 - 10	4000	7
48	<5	2500	6
49	<5	200	4
50	5 - 10	1200	7
Average		1260	4.92
SE		157.65	0.70

Table 71. Yield of the traditional mango varieties / accessions collected from southern Kerala

	Pickling	Table	Dual	Total
Low (≤500)	3 (18.75 %)	8 (47.06 %)	6 (35.29 %)	17 (34.00 %)
Medium (500-2000)	6 (37.50 %)	7 (41.18 %)	8 (47.06 %)	21 (42.00 %)
High (≥2000)	7 (43.75 %)	2 (11.76%)	3 (17.65 %)	12 (24.00 %)

Table 72. Storage life of the traditional mango varieties / accessions collected from southern Kerala

Storage life (days)	Pickling	Table	Dual	Total
Short <2.5	4 (25.00 %)	0	1 (5.88%)	5 (10.00 %)
Intermediate 2.5-7	10 (62.50 %)	13 (76.47 %)	10 (58.82 %)	33 (66.00 %)
Long ≥7	2 (12.5%)	4 (23.53%)	6 (35.29 %)	12 (24.00 %)

Table 73.a Fruit quality characters of the traditional mango varieties/ accessions collected from southern Kerala

Acc. No.	TSS (^{0}Brix)	Carotenoids (mg/100g)	Vitamine C (mg/100g)	Titrable acidity (%)	Crude fibre (%)
	Pickling type				
1	12.71	1.66	18.75	1.08	0.89
2	13.77	0.55	68.75	1.66	1.14
3	11.69	0.32	45.00	0.32	0.65
4	10.69	0.36	42.00	1.20	0.82
5	9.69	1.46	9.52	0.32	0.75
6	15.00	0.69	46.88	1.15	2.80
7	8.77	0.5	119.05	1.40	1.40
8	11.69	0.34	90.72	0.18	0.92
9	13.78	0.87	36.92	1.28	0.67
10	10.69	0.58	23.81	0.83	1.20
11	11.69	0.56	12.31	0.13	2.92
12	12.77	1.38	37.50	0.42	1.20
13	11.77	0.59	66.67	2.80	0.90
14	12.77	0.21	47.62	0.57	0.82
15	9.69	0.28	46.20	2.20	1.50
16	14.73	0.68	24.62	4.03	0.58
Average	11.99	0.69	46.02	1.22	1.188
SE	0.45	0.11	7.25	0.26	0.18
	Table type				
17	14.61	0.98	9.23	0.30	0.61
18	19.00	1.10	12.50	0.12	0.40
19	16.61	1.88	24.62	0.26	0.47
20	17.78	2.69	25.00	0.96	0.63
21	25.71	3.84	33.33	0.19	0.52
22	12.18	1.29	12.50	0.40	0.90
23	18.66	0.88	31.25	0.26	0.60
24	19.79	1.58	9.52	0.38	0.76
25	13.78	1.12	28.57	1.00	1.61
26	14.77	1.50	62.50	0.26	0.45
27	15.69	1.36	24.62	0.23	0.50
28	15.78	1.69	23.80	0.13	2.40
29	15.67	0.62	33.33	0.52	1.30
30	15.78	1.38	9.52	0.13	0.88
31	15.78	0.98	3.08	0.25	0.64
32	18.66	1.11	12.31	0.20	0.60
33	19.71	1.25	31.20	0.41	0.46
Average	17.06	1.49	22.76	0.35	0.81
SE	0.75	0.19	3.45	0.06	0.13

Continued...

Table 73.a Continued.

Acc. No.	TSS (^{0}Brix)	Carotenoids (mg/100g)	Vitamine C (mg/100g)	Titrable acidity (%)	Crude fibre (%)
Dual type					
34	17.78	1.83	18.75	0.19	0.71
35	15.70	1.45	12.50	0.72	0.80
36	19.71	2.65	31.20	0.31	0.75
37	17.68	0.69	37.10	0.32	0.97
38	14.67	1.88	12.31	0.35	0.59
39	13.67	1.12	12.50	0.68	1.00
40	12.77	1.36	37.50	0.25	0.76
41	13.77	0.67	61.90	0.62	0.80
42	12.71	0.93	57.14	0.50	0.47
43	20.66	7.97	24.62	1.20	0.84
44	14.78	0.73	23.50	0.40	0.75
45	12.18	0.80	46.88	0.45	0.67
46	15.78	0.96	71.43	0.70	1.30
47	13.77	1.10	57.14	0.66	0.79
48	13.77	1.20	12.40	0.58	0.70
49	14.73	2.00	12.31	0.50	0.97
50	17.78	0.96	27.69	0.35	0.54
Average	15.41	1.66	32.76	0.52	0.79
SE	0.61	0.42	4.78	0.06	0.05
Overall Average	14.88	1.29	33.60	0.69	0.92
SE	0.46	0.17	3.29	0.10	0.08

Table 73. b. Fruit quality characters of the traditional mango varieties / accessions collected from southern Kerala

Acc. No.	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)
	Pickling types		
1	6.06	1.54	4.52
2	6.90	2.27	4.63
3	5.06	3.33	1.73
4	4.90	1.60	3.30
5	5.33	2.94	2.39
6	10.81	5.00	5.81
7	2.90	1.36	1.54
8	3.36	2.11	1.25
9	5.55	1.58	3.97
10	3.90	1.50	2.40
11	7.27	1.98	5.29
12	5.97	2.08	3.89
13	2.31	0.90	1.41
14	2.01	1.20	0.81
15	3.50	1.70	3.70
16	5.33	1.63	3.70
Average	5.07	2.05	3.15
SE	0.55	0.25	0.39
	Table types		
17	9.11	3.45	5.66
18	13.90	4.10	9.80
19	14.29	2.50	11.79
20	12.69	5.71	6.98
21	18.40	6.10	12.30
22	10.26	3.64	6.62
23	15.10	3.08	12.02
24	6.45	3.45	3.00
25	6.56	1.69	4.87
26	6.15	3.85	2.30
27	11.11	4.17	6.94
28	9.10	5.41	3.69
29	8.70	2.60	6.10
30	8.82	3.17	5.65
31	8.88	4.17	4.71
32	22.20	5.40	16.80
33	13.70	4.33	9.37
Average	11.50	3.93	7.56
SE	1.06	0.29	0.95

Continued..

Table 73. b. Continued..

Acc. No.	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)
Dual types			
34	10.26	3.20	7.06
35	9.09	2.82	6.27
36	13.92	3.70	10.22
37	10.88	3.77	7.11
38	11.11	3.03	8.08
39	7.41	3.64	3.77
40	5.63	3.33	2.30
41	7.20	2.00	5.20
42	8.08	2.33	5.75
43	13.79	2.67	11.12
44	7.90	3.10	4.80
45	6.25	2.30	3.95
46	6.67	2.78	3.89
47	6.67	1.87	4.80
48	7.17	3.17	4.00
49	7.89	3.90	3.99
50	13.40	5.33	8.07
Average	9.02	3.11	5.90
SE	0.38	0.20	0.59
Overall average	8.60	3.05	5.59
SE	0.59	0.18	0.47

Fig. 12 Variability in titrable acidity among the traditional mango varieties collected from southern Kerala

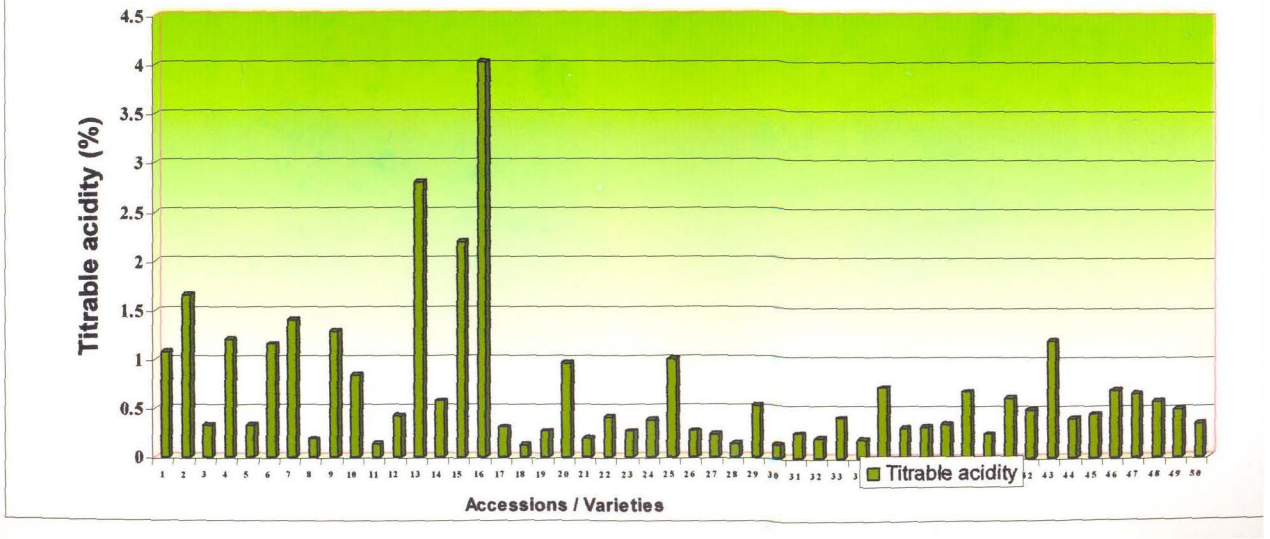


Fig. 13 Variability in ascorbic acid content of the pickling type traditional mango varieties of southern Kerala

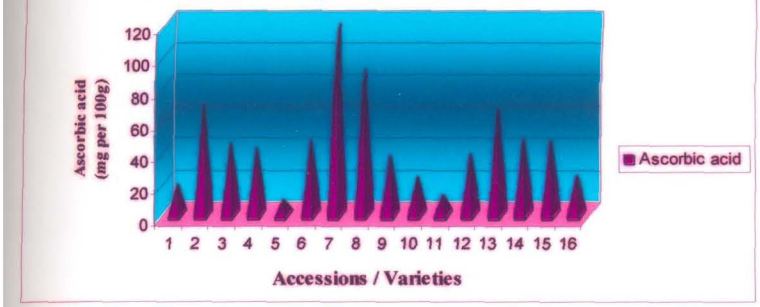
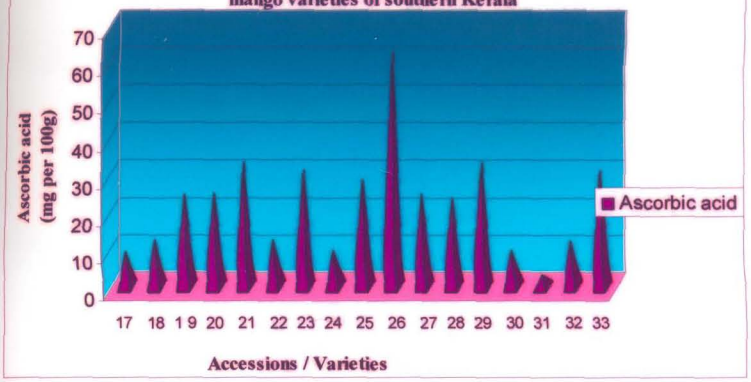


Fig. 14 Variability in ascorbic acid content of table type traditional mango varieties of southern Kerala



1. Muthalamookan

2. Vellari Type-1

3. Natumavu Type-5

4. Vazhapazhithi

Plate 12 Variability in fruit number per bunch of mango varieties

(10 to 57 mg/ 100g), while, 25 per cent had high acidity (>57 mg/ 100g). Among the table types, 70.59 per cent had medium ascorbic acid content (10 to 57 mg/ 100g) while in 23.53 per cent, it was low. In dual types, the percentage of mango varieties having high and medium contents, were, respectively 23.53 and 82.35 (Table 75).

4.4.3 Total carotenoids

The total carotenoid content ranged from 0.21 (in Acc. 14) to 7.97 mg/ 100g (in Acc. 43) (Table 76). Of the pickling types, 75 percentage had low (<0.7 mg/100g) carotenoid content. Among the table and dual types, 47.06 and 41.18 per cent, respectively had a high carotenoid content (>1.3 mg/100g).

4.4.4 Total soluble solids (TSS)

The TSS of ripe fruits ranged from 8.77 to 25.71 ^{0}B (Fig. 16 to 18). The highest per cent (56.25%) of pickling type varieties had low T.S.S ($\leq 12^{0}$B) while it was medium for table (64.71%) and dual (88.24%) types (Table 77).

4.4.5 Total sugars and reducing sugars

Total sugar content was the highest in Acc. No. 32 (22.2%). The lowest value was recorded in Acc. No. 14 (2.01%). The reducing sugar content ranged from 0.9 per cent in Acc. No. 13 to 6.1 per cent in Acc. No. 21 (Fig. 19). The highest non educing sugar content was recorded in Acc. No. 32 (16.8%) and the lowest in Acc. No. 14 (0.81 %). Seventy per cent of the mango varieties had total sugar content between 4.5 and 13 per cent. Nine varieties had high total sugar content ($\geq$ 13%) of which, six were table varieties (Table 78 to 80).

4.4.6 Crude fibre content

The crude fibre content in fruit pulp ranged from 0.4 per cent in Acc. No. 18 to 2.92 per cent in Acc. No. 11 (Fig. 20).

4.4.7 Organoleptic qualities

The sensory analysis was done using a four point score (Appendix I). The major quality attributes included in the score were appearance (fruit shape, skin

Table 74. Titrable acidity of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
<0.3 %	2 (12.5%)	10 (58.82 %)	2 (11.76%)	14 (28.00 %)
0.3-0.6%	4 (25.00 %)	5 (29.41 %)	9 (52.94 %)	18 (36.00 %)
>0.6%	10 (62.50 %)	2 (11.76%)	6 (35.29 %)	18 (36.00 %)

Table 75. Ascorbic acid content of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
≤ 10 mg/ 100g	1 (6.25%)	4 (23.53 %)	0	5 (10.00%)
10-57 mg/ 100g	11 (68.75 %)	12 (70.59 %)	13 (82.35%)	36 (72.00%)
≥ 57 mg/ 100g	4 (25.00 %)	1 (5.88%)	4 (23.53%)	9 (18.00%)

Table 76. Carotenoid content of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
<0.7 mg/ 100g	12 (75.00%)	1 (5.88%)	2 (11.76%)	15 (30.00%)
0.7-1.3 mg/ 100g	2 (12.5%)	8 (47.06%)	8 (47.06 %)	18 (36.00%)
>1.3 mg/ 100g	2 (12.5%)	8 (47.06%)	7 (41.18 %)	17 (34.00%)

Table 77. T.S.S content of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
Low (≤12)	9 (56.25 %)	0	0	9 (18.00 %)
Medium (12-18)	7 (43.75 %)	11 (64.71 %)	15 (88.24 %)	33 (66.00 %)
High (≥18)	0	6 (35.29 %)	2 (11.76%)	8 (16.00 %)

Table 78. Total sugar content of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
≤ 4.5%	6 (37.50 %)	0	0	6 (12.00 %)
4.5- 13%	10 (62.50 %)	11 (64.71 %)	14 (82.35 %)	35 (70.00 %)
≥ 13%	0	6 (35.29 %)	3 (17.65 %)	9 (18.00 %)

Table 79. Reducing sugar content of the traditional mango varieties/ accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
≤ 1.78%	9 (56.25%)	1 (5.88%)	0	10 (20.00 %)
1.78 – 4.3%	6 (37.50%)	11 (64.71%)	16 (94.12 %)	33 (66.00 %)
≥4.3 %	1 (6.25%)	5 (29.41%)	1 (5.88%)	7 (14.00 %)

Table 80. Non reducing sugar content of the traditional mango varieties / accessions collected from southern Kerala

Class	Pickling	Table	Dual	Total
≤ 2.2 %	2 (12.5%)	3 (17.65 %)	1	6 (12.00 %)
2.2- 8.9%	12 (75.00 %)	12 (70.59 %)	12 (70.59 %)	36 (72.00 %)
≥ 8.9 %	2 (12.5%)	2 (12.5%)	4 (23.53 %)	8 (16.00 %)

Fig. 15 Variability in ascorbic acid content of dual type traditional mango varieties of southern Kerala

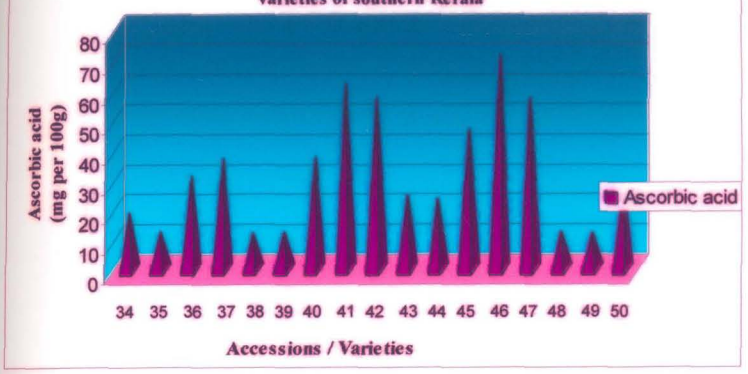


Fig. 16 Variability in TSS among the pickling type traditional mango varieties of southern Kerala

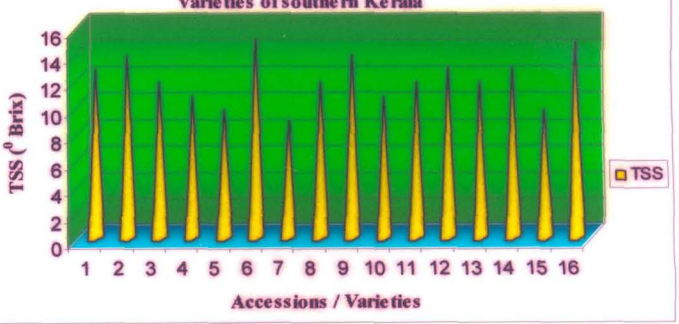


Fig. 17 Variability in TSS among the table type traditional mango varieties of southern Kerala

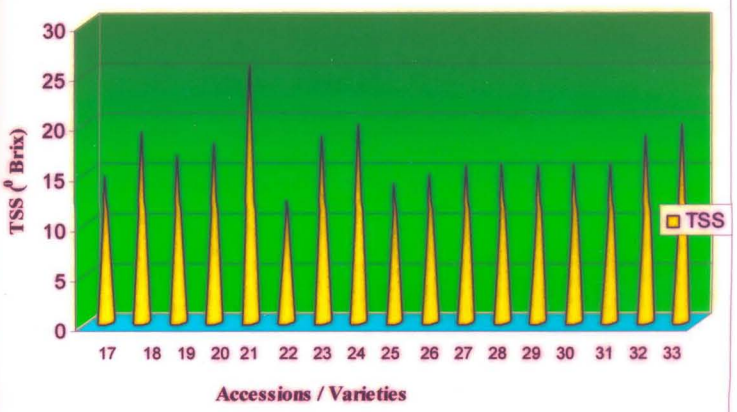


Fig. 18 Variability in TSS among the dual type traditional mango varieties of southern Kerala

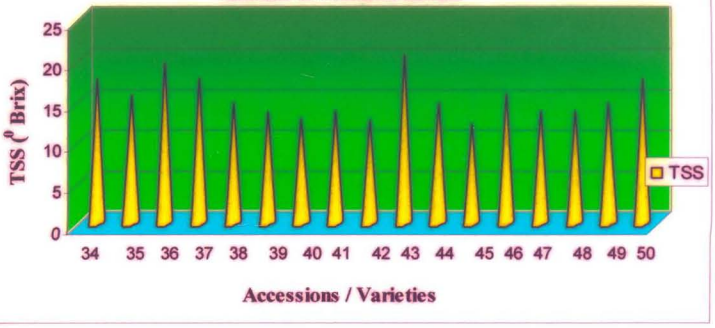


Fig. 19 Variability in reducing and non reducing sugar contents among the traditional mango varieties collected from southern Kerala

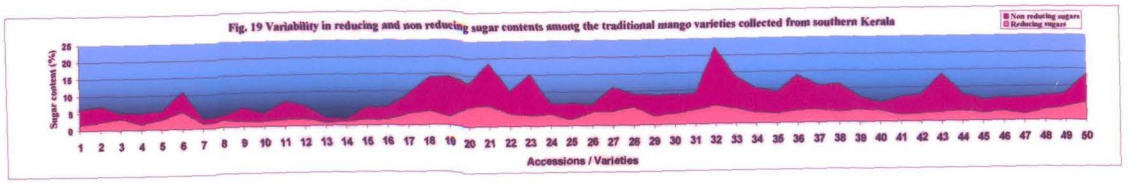
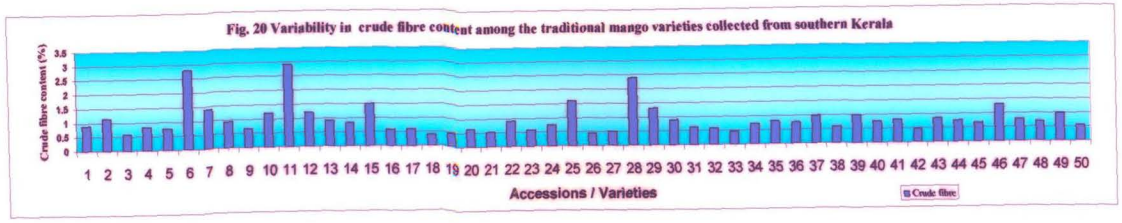


Fig. 20 Variability in crude fibre content among the traditional mango varieties collected from southern Kerala



colour), flesh colour, flavour, taste and texture. Scores for overall acceptability was obtained by determining the average mean scores for each character. The data on organoleptic qualities were recorded (Table 81, Fig. 21).

The highest score for fruit shape was obtained for Acc. No. 34. Acc. No. 26 recorded the highest score for fruit skin colour followed by 34 and 37. The highly performed variety with respect to flesh colour was Acc. No. 43 followed by 19. The highest score for flavour was observed in Acc. No. 33, followed by, accessions 18 and 32. Acc. No. 32 recorded the highest score for taste, followed by 23 and 21. The least score for taste was obtained for Acc. No. 15. For texture, the highest score was obtained for Acc. No. 21. In overall acceptability, Acc. No. 21 was rated the best followed by Acc. No. 33. Acc. No. 14 was the least preferred one.

4.5 STATISTICAL ANALYSIS

4.5.1 Correlation studies

Correlation among the various characters, were studied and the coefficients were tabulated (Table 82). Significant positive correlation was observed for fruit weight with pulp weight (0.9954), stone weight (0.7813), skin weight (0.8321), fruit length (0.8981), organoleptic quality (0.4862) and fruit volume (0.9963). Significant negative correlation was observed for fruit weight with ascorbic acid content (-0.4622), specific gravity (-0.4394) and yield. There was high positive correlation between yield per tree and number of fruits per bunch (0.6598). Titrable acidity and fruit weight were negatively correlated. Fruit volume and TSS content were positively correlated. TSS was positively correlated with organoleptic quality and negatively correlated with titrable acidity (-0.2807). The crude fibre content and organoleptic quality were negatively correlated (-0.321).

4.5.2 Dependence among various qualitative characters

Dependence among various qualitative or between qualitative and quantitative characters was studied by preparing two way tables corresponding to

Table 81. Organoleptic evaluation of ripe fruits of the traditional mango varieties / accessions collected from southern Kerala

Acc. No	Fruit shape	Skin colour	Flesh colour	Flavour	Taste	Texture	Overall acceptability	Rank
1	2.3	1.8	3.3	2.5	2.0	1.7	2.27	38
2	1.4	2.0	2.0	3.1	1.2	1.7	1.90	46
3	2.4	1.6	1.9	1.7	1.4	1.6	1.77	47
4	2.4	2.9	2.7	1.9	2.0	2.1	2.33	36
5	2.2	1.6	2.2	2.3	1.7	1.6	1.93	44
6	2.9	1.7	2.7	2.6	1.5	1.3	2.12	40
7	2.5	2.5	2.2	2.5	1.6	1.4	2.12	39
8	2.3	1.5	1.9	1.6	1.4	1.2	1.65	49
9	2.8	1.4	2.0	1.9	1.5	1.9	1.92	45
10	2.2	1.7	2.5	2.8	1.6	1.4	2.03	41
11	2.6	2.9	3.0	2.5	2.4	2.4	2.63	23
12	2.6	2.9	2.3	1.3	1.4	1.5	2.00	42
13	2.3	2.0	2.0	2.6	1.7	1.3	1.98	43
14	2.1	1.9	1.5	1.2	1.2	1.7	1.60	50
15	2.3	2.0	1.8	1.4	1.1	1.6	1.70	48
16	3.2	3.6	2.5	1.8	1.5	2.4	2.50	32
17	2.6	2.3	3.5	3.3	3.4	3.6	3.12	8
18	2.7	2.7	3.4	3.6	3.6	3.6	3.27	4
19	3.3	2.7	3.9	2.6	3.6	3.7	3.30	3
20	3.3	2.2	3.4	2.7	3.2	3.1	2.98	13
21	3.6	3.6	3.7	3.5	3.8	3.9	3.68	1
22	3.1	1.7	3.2	3.4	2.7	2.0	2.68	21
23	3.0	1.7	2.8	3.5	3.8	3.5	3.05	10
24	3.2	2.8	3.0	2.6	2.4	2.8	2.80	17
25	2.7	2.5	2.6	2.7	2.5	2.1	2.52	30
26	3.3	3.8	3.4	2.5	3.0	2.8	3.13	8
27	2.6	1.6	3.1	2.9	2.9	2.7	2.63	24
28	2.4	1.8	3.4	2.4	3.0	2.3	2.55	27
29	2.9	2.7	2.9	3.3	2.9	2.4	2.85	16
30	3.2	2.2	3.0	2.3	2.8	2.5	2.67	19
31	2.8	2.1	3.0	2.6	2.8	3.0	2.72	18
32	3.4	2.6	2.5	3.6	3.9	2.9	3.15	7
33	3.1	2.6	3.8	3.7	3.4	3.3	3.32	2
34	3.7	3.7	3.6	2.4	2.4	2.3	3.02	12
35	3.2	2.8	3.2	2.2	2.3	2.2	2.65	22
36	3.6	3.1	3.2	2.8	3.3	2.7	3.12	9
37	3.3	3.7	3.6	2.7	2.9	2.8	3.17	6
38	3.0	1.7	3.2	2.6	2.9	2.0	2.57	26
39	2.6	2.0	3.2	2.0	2.4	1.5	2.28	37
40	3.2	2.6	3.3	3.2	2.4	2.5	2.87	15

Table 81. Continued..

Acc. No	Fruit shape	Skin colour	Flesh colour	Flavour	Taste	Texture	Overall acceptability	Rank
41	3.0	2.0	2.6	2.7	2.3	1.9	2.42	34
42	3.1	1.8	2.9	3.4	2.7	2.0	2.65	20
43	2.8	2.6	4.0	3.0	2.5	2.8	2.95	14
44	3.1	2.7	2.6	2.3	2.2	2.2	2.52	31
45	2.6	2.7	2.6	2.1	2.3	2.8	2.52	28
46	2.0	1.4	2.9	3.5	2.7	1.9	2.40	35
47	2.9	2.5	3.0	2.6	2.0	2.1	2.52	29
48	2.6	2.3	2.7	2.6	2.4	2.3	2.48	33
49	2.3	2.4	3.2	2.8	2.6	2.2	2.58	25
50	3.5	2.9	3.5	3.2	3.1	3.3	3.25	5

Table 82. Correlation between selected characters of the traditional mango varieties/ accessions collected from southern Kerala

Characters	X1	X2	X3	X5	X6	X7	X8	X10	X11	X12	X13
X1	1										
X2	0.660 **	1									
X3	0.092	0.191	1								
X4	0.069	-0.070									
X5	-0.415**	-0.367*	0.041	1							
X6	-0.401**	-0.296*	0.084	0.898**							
X7	-0.408**	-0.396**	0.021	0.995**	0.884**	1					
X8	-0.424**	-0.387**	0.009	0.996**	0.897**	0.991**	1				
X9	0.495**	---	---	-0.439**	-0.494**	-0.410**	-0.491**				
X10	-0.254	-0.440**	-0.253	0.325*	0.884**	0.361*	0.325*	1			
X11	0.371*	---	0.371**	-0.263	-0.242	-0.262	-0.261	-0.281*	1		
X12	0.361*	---	0.361*	-0.462**	-0.281*	-0.443**	-0.438**	-0.349*	0.271	1	
X13	0.190	---	0.190	-0.216	-0.235	-0.261	-0.234	-0.281*	0.085	0.117	1
X14	-0.360*	-0.526**	---	0.486**	0.314**	0.499**	0.466**	0.785**	-0.388**	-0.397**	-0.321*

Characters

X1	Yield	X6	Fruit length	X11	Acidity
X2	Average number of fruits per bunch	X7	Pulp weight	X12	Vit C
X3	Tree height	X8	Fruit volume	X13	Fibre content
X4	% of hermaphrodite flowers	X9	Specific gravity	X14	Organoleptic quality
X5	Fruit weight	X10	TSS		

* significant at 5 per cent level; ** significant at 1 per cent level

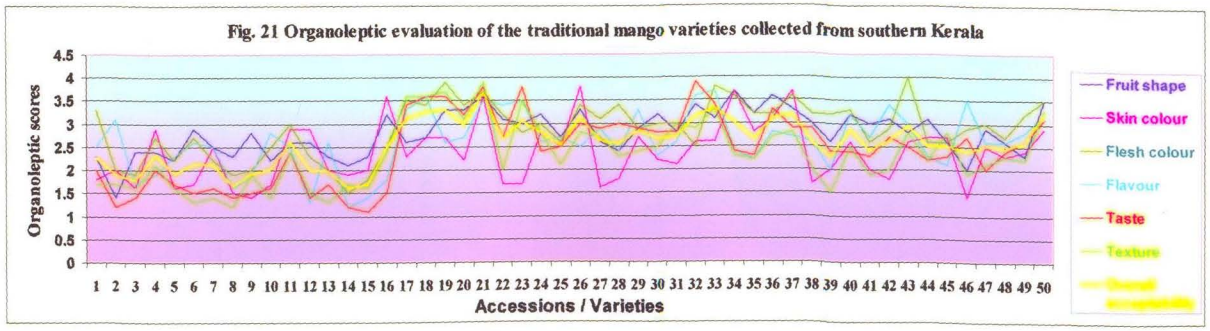


Fig. 21 Organoleptic evaluation of the traditional mango varieties collected from southern Kerala
Organoleptic scores
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
Accessions / Varieties
Fruit shape
Skin colour
Flesh colour
Flavour
Taste
Texture

scores of different qualitative characters. The dependence was tested by using the Chi square test. Relationships were observed among the following traits:

1. Plant height and plant habit

No dependence was observed between these two characters.

2. Leaf shape and leaf margin

No dependence was observed between the traits, leaf shape and leaf margin

3. Leaf shape and leaf tip

The character leaf shape was independent of the character, leaf tip.

4. Inflorescence length and inflorescence shape

Majority of the varieties possessed medium to high inflorescence length. Dependence was observed between medium length of inflorescence (58.97% were pyramidal) and pyramidal shape.

5. Inflorescence shape and leaf shape

Both these characters were independent of each other.

6. Fruit shape and beak type

There was dependence between fruit shape and beak type. Absence of beak was observed in 66.00 per cent of the accessions. Out of this, 57.58 per cent had round shaped fruits.

7. Beak type and sinus type

Beak type and sinus type were dependent on each other. Beak was absent in fruits of 66 per cent varieties. Out of this, absence of sinus was observed in 90.9 per cent.

8. Shoulder type and slope of shoulder

Dependence was observed between these two characters. Sixty two per cent varieties had ventral shoulders higher than dorsal. Out of this, 80.65 per cent had rising and then rounded slope.

9. Slope of shoulders and fruit shape

Slope of shoulders and fruit shape showed dependence between them. Sixty percent of the varieties possessed rising and rounded. Majority of these varieties (63.33%) produced round shaped fruits.

10. Young leaf colour and fruit colour

Fruit colour was dependent on young leaf colour. Ninety two per cent fruits had green colour when raw. Varieties with green fruit colour had green and its shades as young leaf colour. Varieties with red fruits or green with red blushed fruits produced purple or reddish brown young leaves.

11. Flower colour and fruit colour

Dependence was evident between the two characters. Varieties with red coloured fruits or green fruits with red blush produced deep crimson or red flowers. Green fruited varieties were predominantly cream, yellow or green flowered.

12. Flower colour and young leaf colour

Flower colour and young leaf colour showed dependence with each other. Varieties, which produced light green or yellowish green coloured young leaves tended to produce predominantly cream green or yellow flowers.

13. Utility and texture of fruits

No dependence could be observed between the two characters.

14. Flesh colour and carotenoid colour

Majority of the varieties with orange and deep orange coloured flesh had high carotenoid contents compared to yellow fleshed ones.

4.5.3 Assessment of similarity between the accessions

Similarity was worked out for all the fifty accessions by making use of 24 characters (twenty morphological and four quality characters). The similarity

values for all the pairs were counted and similarity index was worked out and a similarity matrix was constructed (Table 83). The similarity values ranged from 0.042 to 0.708.

The lowest value of similarity index was between accessions 4 and 26 and that of accession 2 with 28 and 34. The highest value for similarity index was obtained for accessions 32 and 33. In the dendrogram (Fig. 22), along the point corresponding to a similarity coefficient of 0.54, all the accessions got grouped into twenty two clusters. Cluster I contained eleven accessions (Accessions 42, 37, 39, 41, 44, 38, 48, 14, 1, 11 and 43). Cluster II contained six accessions (Accessions 23, 36, 47, 24, 31 and 49). Cluster III contained four accessions (Accessions 20. 29, 32 and 33). Clusters IV to VI contained three accessions each and clusters VII to X, two each. Clusters XI to XXII contained only one each.

4.6 MOLECULAR CHARACTERISATION

4.6.1 Extraction of DNA

DNA was extracted from young leaves using hexadecyl trimethyl ammonium bromide (CTAB) method (Dellaporta *et al.*, 1983) with slight modification (Anuj *et al.*, 2004).

4.6.2 Quantification of DNA

DNA quantification was carried out with the help of UV- Vis spectrophotometer. Yield of DNA ranged from 90.00 to2640µg per ml. The purity ratio of the different samples ranged from 1.45 to 2.00 (Table 84).

4.6.3 RAPD Analysis

Twenty primers (Operon Inc., CA, USA) each from OP-A and OP-B series and two primers from OPS series (OPS-11 and OPS-12) were screened for amplification with the DNA of Velutha Muvandan variety as

Table 83. Similarity matrix of fifty traditional mango varieties/ accessions collected from southern Kerala based on Jaccard's similarity index using morphological and quality characters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	1.000	0.375	0.292	0.542	0.542	0.542	0.250	0.417	0.333	0.417	0.667	0.458	0.208	0.333	0.292	0.417	0.292	0.292	0.292	0.292	0.333	0.583	0.458	0.375	0.458
2		1.000	0.167	0.375	0.333	0.333	0.500	0.333	0.333	0.542	0.375	0.208	0.458	0.500	0.292	0.250	0.125	0.208	0.125	0.208	0.083	0.292	0.333	0.208	0.292
3			1.000	0.250	0.333	0.375	0.250	0.625	0.333	0.292	0.417	0.417	0.333	0.375	0.458	0.208	0.292	0.208	0.250	0.250	0.292	0.250	0.292	0.208	0.208
4				1.000	0.375	0.542	0.417	0.417	0.375	0.583	0.542	0.417	0.250	0.333	0.458	0.333	0.375	0.208	0.250	0.375	0.333	0.500	0.458	0.208	0.500
5					1.000	0.542	0.375	0.458	0.250	0.375	0.500	0.417	0.250	0.250	0.292	0.333	0.333	0.167	0.250	0.333	0.417	0.375	0.417	0.500	0.375
6						1.000	0.417	0.417	0.500	0.417	0.500	0.417	0.250	0.292	0.333	0.333	0.333	0.125	0.208	0.417	0.375	0.417	0.542	0.208	0.417
7							1.000	0.375	0.375	0.500	0.333	0.208	0.458	0.333	0.500	0.208	0.125	0.208	0.333	0.500	0.208	0.292	0.458	0.167	0.375
8								1.000	0.250	0.417	0.542	0.250	0.333	0.417	0.375	0.333	0.250	0.250	0.208	0.250	0.292	0.375	0.375	0.292	0.375
9									1.000	0.167	0.292	0.375	0.167	0.208	0.458	0.292	0.333	0.208	0.208	0.375	0.250	0.333	0.375	0.208	0.542
10										1.000	0.375	0.167	0.333	0.375	0.333	0.250	0.208	0.208	0.250	0.333	0.125	0.375	0.375	0.083	0.458
11											1.000	0.417	0.417	0.375	0.458	0.458	0.250	0.333	0.333	0.333	0.375	0.500	0.500	0.333	0.375
12												1.000	0.292	0.292	0.167	0.208	0.208	0.417	0.250	0.375	0.458	0.417	0.125	0.417	0.292
13													1.000	0.417	0.292	0.292	0.167	0.208	0.208	0.333	0.333	0.333	0.292	0.250	0.167
14														1.000	0.375	0.292	0.250	0.292	0.292	0.125	0.125	0.292	0.333	0.167	0.208
15															1.000	0.375	0.333	0.125	0.208	0.250	0.125	0.292	0.500	0.167	0.333
16																1.000	0.292	0.333	0.250	0.292	0.333	0.417	0.458	0.375	0.542
17																	1.000	0.417	0.250	0.250	0.333	0.333	0.375	0.250	0.292
18																		1.000	0.500	0.292	0.375	0.292	0.292	0.458	0.375
19																			1.000	0.333	0.375	0.333	0.333	0.333	0.375
20																				1.000	0.458	0.375	0.500	0.250	0.500
21																					1.000	0.375	0.417	0.500	0.292
22																						1.000	0.417	0.292	0.500
23																							1.000	0.333	0.458
24																								1.000	0.292
25																									1.000

Table 83. continued

	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1	0.208	0.417	0.167	0.208	0.208	0.333	0.292	0.375	0.333	0.333	0.500	0.542	0.625	0.500	0.542	0.583	0.375	0.542	0.542	0.583	0.375	0.333	0.458	0.500	0.208
2	0.125	0.333	0.042	0.292	0.083	0.208	0.250	0.208	0.042	0.125	0.292	0.375	0.333	0.417	0.292	0.500	0.417	0.292	0.417	0.292	0.375	0.417	0.458	0.292	0.208
3	0.458	0.333	0.500	0.375	0.292	0.333	0.333	0.333	0.500	0.333	0.167	0.250	0.333	0.125	0.417	0.250	0.250	0.292	0.208	0.083	0.292	0.417	0.375	0.375	0.250
4	0.042	0.542	0.125	0.125	0.250	0.208	0.417	0.333	0.167	0.333	0.542	0.375	0.375	0.542	0.458	0.625	0.333	0.417	0.375	0.375	0.375	0.333	0.292	0.333	0.292
5	0.333	0.333	0.167	0.292	0.292	0.500	.375	0.458	0.417	0.375	0.458	0.375	0.583	0.458	0.375	0.542	0.208	0.292	0.375	0.292	0.375	0.417	0.292	0.458	0.250
6	0.292	0.375	0.250	0.333	0.250	0.417	0.500	0.417	0.292	0.292	0.583	0.375	0.458	0.375	0.375	0.625	0.250	0.375	0.375	0.458	0.458	0.458	0.208	0.458	0.208
7	0.250	0.292	0.250	0.375	0.083	0.292	0.542	0.417	0.083	0.167	0.375	0.250	0.167	0.333	0.250	0.458	0.375	0.208	0.333	0.250	0.417	0.333	0.208	0.333	0.250
8	0.292	0.375	0.333	0.167	0.375	0.250	0.500	0.542	0.417	0.375	0.292	0.333	0.333	0.417	0.375	0.500	0.250	0.292	0.250	0.500	0.375	0.500	0.417	0.458	0.208
9	0.250	0.250	0.417	0.375	0.167	0.375	0.375	0.333	0.125	0.250	0.333	0.250	0.292	0.333	0.292	0.458	0.333	0.208	0.417	0.417	0.292	0.333	0.333	0.417	0.208
10	0.083	0.500	0.250	0.167	0.208	0.167	0.417	0.333	0.250	0.250	0.375	0.250	0.375	0.500	0.250	0.417	0.375	0.375	0.333	0.292	0.417	0.375	0.500	0.333	0.208
11	0.250	0.333	0.250	0.250	0.167	0.333	0.500	0.375	0.333	0.250	0.542	0.375	0.583	0.417	0.500	0.542	0.375	0.375	0.500	0.500	0.375	0.458	0.333	0.458	0.208
12	0.375	0.333	0.333	0.458	0.250	0.375	0.292	0.375	0.458	0.375	0.375	0.292	0.292	0.292	0.333	0.417	0.333	0.417	0.333	0.500	0.125	0.125	0.250	0.208	0.292
13	0.417	0.208	0.250	0.500	0.125	0.250	0.333	0.250	0.208	0.167	0.292	0.250	0.167	0.250	0.417	0.250	0.333	0.333	0.292	0.292	0.417	0.250	0.208	0.167	0.292
14	0.250	0.208	0.083	0.250	0.292	0.167	0.375	0.375	0.125	0.250	0.250	0.375	0.292	0.292	0.500	0.417	0.417	0.333	0.417	0.500	0.250	0.333	0.583	0.292	0.167
15	0.292	0.208	0.250	0.292	0.208	0.167	.458	0.292	0.125	0.250	0.292	0.250	0.375	0.208	0.458	0.292	0.292	0.125	0.292	0.375	0.375	0.458	0.333	0.500	0.083
16	0.417	0.417	0.333	0.375	0.417	0.375	0.375	0.333	0.208	0.333	0.458	0.583	0.583	0.500	0.500	0.333	0.500	0.417	0.542	0.542	0.542	0.542	0.375	0.417	0.292
17	0.250	0.333	0.125	0.208	0.583	0.458	0.167	0.167	0.208	0.500	0.208	0.208	0.375	0.208	0.292	0.375	0.167	0.208	0.333	0.292	0.250	0.292	0.333	0.375	0.375
18	0.333	0.250	0.292	0.417	0.375	0.417	0.458	0.375	0.333	0.292	0.250	0.458	0.250	0.333	0.208	0.292	0.375	0.333	0.458	0.417	0.208	0.250	0.417	0.167	0.542
19	0.250	0.417	0.250	0.250	0.250	0.292	0.500	0.542	0.375	0.208	0.500	0.375	0.292	0.292	0.292	0.333	0.292	0.375	0.333	0.250	0.167	0.167	0.250	0.125	0.583
20	0.333	0.250	0.375	0.542	0.167	0.500	0.542	0.458	0.208	0.208	0.375	0.208	0.292	0.292	0.125	0.333	0.292	0.417	0.333	0.167	0.292	0.292	0.208	0.417	0.375
21	0.292	0.333	0.333	0.375	0.333	0.542	0.250	0.333	0.542	0.375	0.500	0.333	0.333	0.292	0.333	0.333	0.167	0.375	0.292	0.250	0.292	0.250	0.083	0.375	0.500
22	0.333	0.500	0.292	0.292	0.417	0.333	0.333	0.458	0.250	0.375	0.458	0.542	0.500	0.625	0.583	0.500	0.417	0.500	0.500	0.417	0.417	0.292	0.292	0.292	0.458
23	0.375	0.375	0.250	0.375	0.167	0.542	0.542	0.458	0.167	0.250	0.625	0.583	0.458	0.375	0.458	0.542	0.500	0.375	0.500	0.375	0.500	0.625	0.292	0.583	0.375
24	0.417	0.250	0.333	0.333	0.292	0.583	0.292	0.292	0.375	0.333	0.333	0.458	0.458	0.333	0.333	0.292	0.292	0.333	0.500	0.333	0.250	0.250	0.167	0.375	0.542
25	0.208	0.458	0.292	0.375	0.250	0.333	0.542	0.458	0.208	0.292	0.500	0.417	0.500	0.583	0.292	0.542	0.417	0.417	0.542	0.417	0.417	0.458	0.542	0.333	0.375

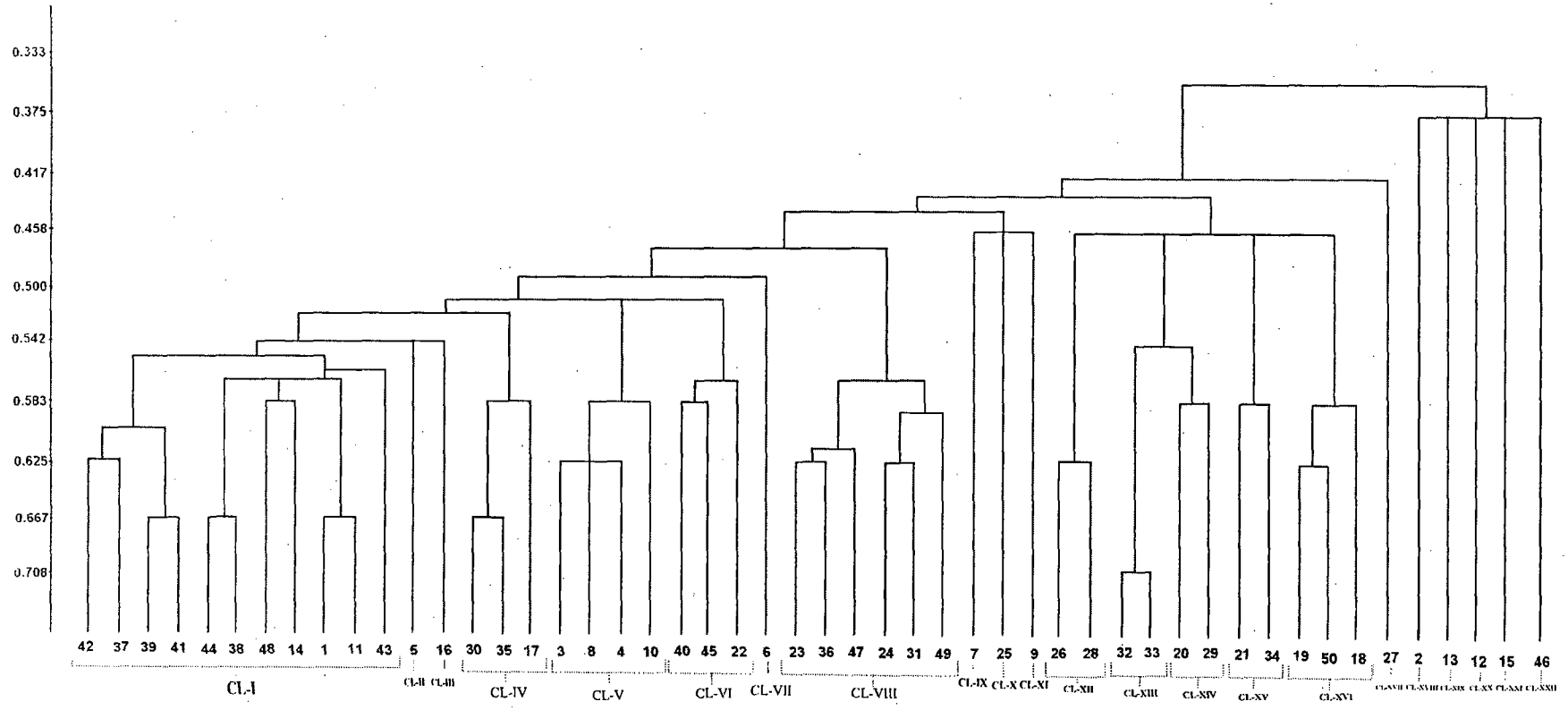
Table 83. continued

	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
26	1.000	0.208	0.625	0..500	0.375	0.500	0.333	0.333	0.458	0.417	0.292	0.458	0.375	0.208	0.458	0.208	0.417	0.292	0.375	0.333	0.458	0.375	0.125	0.375	0.292
27		1.000	0.292	0.250	0.292	0.208	0.250	0.333	0.208	0.292	0.542	0.333	0.458	0.458	0.417	0.417	0.333	0.292	0.375	0.417	0.458	0.333	0.333	0.250	0.458
28			1.000	0.417	0.375	0.375	0.333	0.417	0.458	0.417	0.167	0.250	0.250	0.292	0.208	0.125	0.417	0.292	0.292	0.250	0.375	0.292	0.167	0.417	0.292
29				1.000	0.167	0.500	0.375	0.375	0.208	0.167	0.208	0.333	0.292	0.292	0.250	0.250	0.458	0.333	0.458	0.375	0.417	0.333	0.333	0.333	0.500
30					1.000	0.375	0.208	0.292	0.417	0.250	0.125	0.333	0.250	0.292	0.375	0.292	0.250	0.417	0.250	0.250	0.208	0.250	0.250	0.250	0.375
31						1.000	0.333	0.250	0.333	0.458	0.333	0.458	0.417	0.292	0.292	0.417	0.417	0.292	0.500	0.208	0.292	0.417	0.167	0.458	0.542
32							1.000	0.708	0.292	0.167	0.500	0.417	0.250	0.458	0.292	0.458	0.333	0.333	0.333	0.375	0.375	0.458	0.375	0.250	0.333
33								1.000	0.375	0.292	0.458	0.417	0.208	0.542	0.292	0.417	0.292	0.417	0.208	0.375	0.375	0.375	0.375	0.333	0.333
34									1.000	0.542	0.292	0.333	0.375	0.292	0.250	0.292	0.208	0.458	0.167	0.250	0.167	0.208	0.250	0.333	0.250
35										1.000	0.208	0.375	0.333	0.417	0.333	0.458	0.333	0.375	0.333	0.292	0.292	0.375	0.292	0.375	0.292
36											1.000	0.500	0.542	0.417	0.500	0.500	0.375	0.417	0.458	0.375	0.375	0.417	0.167	0.375	0.250
37												1.000	0.500	0..583	0.625	0.458	0.625	0.542	0.583	0.542	0.500	0.500	0.333	0.375	0.458
38													1.000	0.458	0.500	0.458	0.417	0.375	0.667	0.458	0.458	0.500	0.417	0.625	0.250
39														1.000	0.375	0.667	0.458	0.500	0.500	0.375	0.583	0.500	0.458	0.333	0.458
40															1.000	0.375	0.458	0.375	0.542	0.583	0.500	0.375	0.292	0.417	0.208
41																1.000	0.417	0.458	0.542	0.417	0.375	0.542	0.375	0.375	0.375
42																	1.000	0.417	0.625	0.542	0.458	0.542	0.375	0.458	0.333
43																		1.000	0.458	0.458	0.333	0.208	0.375	0.250	0.458
44																			1.000	0.583	0.458	0.417	0.458	0.542	0.417
45																				1.000	0.542	0.417	0.583	0.458	0.208
46																					1.000	0.500	0.417	0.500	0.292
47																						1.000	0.375	0.542	0.250
48																							1.000	0.417	0.208
49																								1.000	0.125
50																									1.000

Table 84. Quantity and quality of DNA isolated from the different traditional mango varieties collected from southern Kerala using modified CTAB method

Sl.No.	Name of variety	A260	A280	A260/A280	Quantity of DNA (µg/ml)
1	Thamboru	0.020	0.012	1.67	600.00
2	Velutha Muvandan	0.018	0.012	1.50	540.00
3	Karutha Muvandan	0.003	0.002	1.50	90.00
4	Muthalamookan	0.010	0.006	1.67	300.00
5	Nedungolan	0.056	0.029	1.93	1680.00
6	Vellari Type -2	0.007	0.004	1.75	210.00
7	Vellari Type- 1	0.023	0.014	1.64	690.00
8	Kotookonam Varikka	0.014	0.008	1.75	420.00
9	Champa Varikka	0.008	0.004	2.00	240.00
10	Kallu Varikka	0.004	0.002	2.00	120.00
11	Kolambi	0.077	0.050	1.54	2310.00
12	Perakka manga	0.013	0.008	1.63	390.00
13	Vazhapazhithi	0.006	0.003	2.00	180.00
14	Thali	0.069	0.040	1.73	2070.00
15	Natumav Type-2	0.028	0.015	1.87	840.00
16	Karpoora Varikka	0.005	0.003	1.67	150.00
17	Kappa manga	0.015	0.010	1.50	450.00
18	Komanga	0.041	0.028	1.46	1230.00
19	Puliyan	0.010	0.005	2.00	300.00
20	Karimbu manga	0.034	0.020	1.70	1020.00
21	Mavelikkara Local	0.055	0.033	1.67	1650.00
22	Thenga manga	0.040	0.022	1.82	1200.00
23	Mylapore	0.008	0.005	1.60	240.00
24	Koli manga	0.088	0.049	1.80	2640.00
25	Kalluketty	0.013	0.007	1.86	390.00
26	Manacaud Local -2	0.016	0.011	1.45	480.00
27	Natumavu Type-4	0.019	0.013	1.46	390.00
28	Neenda Karpooram	0.010	0.006	1.67	300.00
29	Karpooram manga	0.015	0.008	1.88	450.00
30	Kandiyoor Local	0.013	0.007	1.86	390.00

Fig. 22 Dendrogram based on morphological and quality characters of fifty traditional mango varieties of southern Kerala



representative sample at random. Out of the 42 primers used, all the primers except OPA-16, OPB-07, OPB-08, OPB-09, OPB-10 and OPB-12 yielded amplification products with the DNA from Velutha Muvandan. The total number of bands, number of faint bands and the number of intense bands produced by the primers were recorded (Table 85).

A total of 157 RAPDs (average of 3.74 bands per primer) were generated, of which 96.18 per cent (151 bands) were polymorphic. This accounts to an average of 3.6 bands per primer. Monomorphic bands were produced by the primers OPA-05, OPA-06, OPB-13, OPB-15, OPB-16 and OPB-20.

The highest number of RAPDs, (seven each) was produced by the primers OPA-01, OPA-02, OPA-13, OPA-14, OPB-03, OPB-6, OPS-11 and OPS-12. Of these primers, the highest number of intense bands (six bands) was produced by OPA-01 followed by OPA- 02, OPA- 13 and OPS-11 (five bands each). A total of six bands each were produced by the primers, OPA-03, OPA-04, OPA-10, OPA-12, OPA-15, OPB- 01, OPB-04 and OPB-05. Of these, all the six bands amplified by OPB-04 were intense. Five intense bands each were produced by OPA-10 and OPA-15.

The ten primers which produced the highest number of bands as well as the highest number of intense bands were selected for amplifying DNA from thirty mango accessions. The PCR reaction was repeated at least twice in order to check the reproducibility. Data from the ten primers that gave reproducible product formation on at least two runs alone were included in statistical analysis.

The ten primers used in this analysis (OPA-01, OPA- 02, OPA-03, OPA-10, OPA-13, OPA-15, OPB-03, OPB-04, OPB-06 and OPS-11) yielded 92 scorable bands with an average of 9.2 bands per primer. The number of bands resolved per amplification was primer dependent and varied from a minimum of six to a maximum of 14 (Table 86). The highest number of scorable bands (14 bands) was given by the primer OPA-01.

Table 85. Primer associated banding patterns with the DNA of Velutha Muvandan using 42 primers supplied by the Operon Inc., CA, USA

Sl. No.	Primers	No. of faint bands	No. of Intense bands	Total no. of bands
1.	OPA-01	1	6	7
2.	OPA-02	3	5	7
3.	OPA-03	3	3	6
4	OPA-04	2	4	6
5.	OPA-05	0	1	1
6.	OPA-06	1	0	1
7.	OPA-07	2	3	5
8.	OPA-08	2	2	4
9.	OPA-09	1	2	2
10.	OPA-10	1	5	6
11.	OPA-11	1	3	4
12.	OPA-12	5	1	6
13.	OPA-13	2	5	7
14.	OPA-14	4	3	7
15.	OPA-15	1	5	6
16.	OPA-16	0	0	0
17.	OPA-17	0	3	3
18.	OPA-18	0	2	2
19.	OPA-19	1	1	2
20.	OPA-20	3	1	4
21.	OPB-01	5	1	6

Table 85. Continued

Sl. No	Primers	No. of faint bands	No. of Intense bands	Total no. of bands
22.	OPB-02	1	1	2
23.	OPB-03	3	4	7
24.	OPB-04	0	6	6
25.	OPB-05	4	2	6
26.	OPB-06	3	4	7
27.	OPB-07	0	0	0
28.	OPB-08	0	0	0
29.	OPB-09	0	0	0
30.	OPB-10	0	0	0
31.	OPB-11	0	5	5
32.	OPB-12	0	0	0
33.	OPB-13	0	1	1
34.	OPB-14	2	1	3
35.	OPB-15	1	0	1
36.	OPB-16	0	1	1
37.	OPB-17	3	2	5
38.	OPB-18	1	2	3
39.	OPB-19	1	2	3
40.	OPB-20	0	1	1
41	OPS-11	2	5	7
42	OPS-12	5	2	7

Table 86. Nucleotide sequences of primers and total number of informative RAPD markers amplified with them in thirty traditional mango varieties/ accessions collected from southern Kerala

Primer	Sequence	Number of informative RAPD markers
OPA - 01	CAGGCCC TTC	14
OPA- 02	TGCCGAGCTG	11
OPA - 03	AGTCAGCCAC	8
OPA- 10	GTGATCGCAG	8
OPA - 13	CAGCACCCAC	11
OPA- 15	TTCCGAACCC	6
OPB - 03	CATCCCCCTG	10
OPB- 04	GGACTGGAGT	7
OPB - 06	TGCTCTGCCC	8
OPS- 11	AGTCGGGTGG	9

The primers, OPA-02 and OPA-13 gave eleven bands each. The nucleotide sequence of these ten primers and number of informative RAPD markers given by each primer were recorded (Table 86).

The primer OPA-02 produced eleven scorable bands. One band was monomorphic in all the varieties. Two more bands were monomorphic, except for two varieties and three varieties, respectively (Plate 13).

The primer OPA-03 produced amplification in all the varieties except Acc. No. 38. Seven scorable bands were produced by OPA-03. In Acc. No. 10, only one band was amplified (Plate 14).

When OPA-10 was used for amplification, eight scorable bands were produced in total. One band was monomorphic in all except Acc. No. 38. Another band was monomorphic for all except Acc. No. 43.

Two bands were monomorphic when OPA-13 was used to amplify the thirty accessions of mango (Plate 15).

When OPA-15 was used for amplification, two bands were monomorphic for all except two varieties (Acc. No.s 17 and 21 in one and Acc. No.s 3 and 32 in the other). Two varieties were present only in two varieties, Acc. No.s 17 and 18.

The primer OPB-03 could not produce amplification in three accessions (Acc. No.s 13, 26 and 38) (Plate 16).

Two bands were monomorphic for all the varieties except in Acc. No. 38 on amplification with OPB-04. No bands were produced by this variety (Plate 17).

Amplification was produced in all the accessions except Acc. No. 38 with OPB-06. Two bands were monomorphic in all the other varieties except two.

One band was monomorphic in all the varieties except Acc. No. 38 with the primer OPS-11. Nine scorable bands were produced by this primer.

FIGURE LEGEND

Lane	Variety
M	100 bp DNA ladder
1	Thamboru
2	Velutha Muvandan
3	Karutha Muvandan
4	Muthalamookan
5	Nedungolan
6	Vellari Type -2
7	Vellari Type- 1
8	Kotookonam Varikka
9	Champa Varikka
10	Kallu Varikka
11	Kolambi
12	Perakka manga
13	Vazhapazhithi
14	Thali
15	Natumav Type-2
16	Karpoora Varikka
17	Kappa manga
18	Komanga
19	Puliyan
20	Karimbu manga
21	Mavelikkara Local
22	Thenga manga
23	Mylapore
24	Koli manga
25	Kalluketty
26	Manacaud Local -2
27	Natumav Type-4
28	Neenda Karpooram
29	Karpooram manga
30	Kandiyoor Local

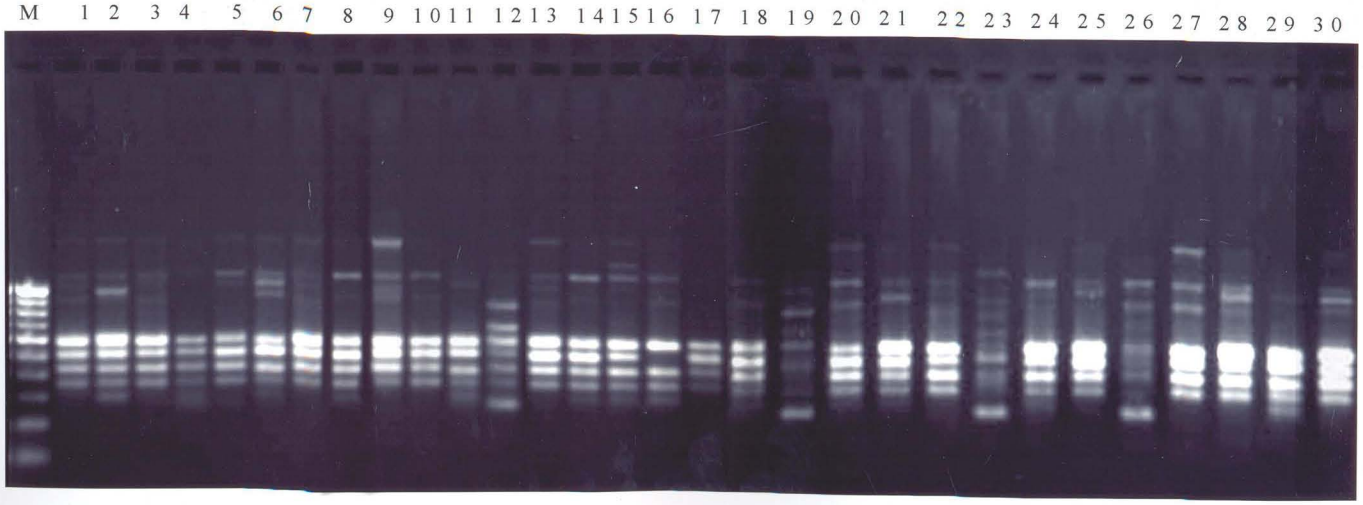


Plate 13 Amplification profiles of the DNA of 30 traditional mango varieties using the primer OPA-02

FIGURE LEGEND

Lane	Variety
M	100 bp DNA ladder
1	Thamboru
2	Velutha Muvandan
3	Karutha Muvandan
4	Muthalamookan
5	Nedungolan
6	Vellari Type -2
7	Vellari Type- 1
8	Kotookonam Varikka
9	Champa Varikka
10	Kallu Varikka
11	Kolambi
12	Perakka manga
13	Vazhapazhithi
14	Thali
15	Natumav Type-2
16	Karpoora Varikka
17	Kappa manga
18	Komanga
19	Puliyan
20	Karimbu manga
21	Mavelikkara Local
22	Thenga manga
23	Mylapore
24	Koli manga
25	Kalluketty
26	Manacaud Local -2
27	Natumav Type-4
28	Neenda Karpooram
29	Karpooram manga
30	Kandiyoor Local

Plate 14 Amplification profiles of the DNA of 30 traditional mango varieties using the primer OPA-03

FIGURE LEGEND

Lane	Variety
M	100 bp DNA ladder
1	Thamboru
2	Velutha Muvandan
3	Karutha Muvandan
4	Muthalamookan
5	Nedungolan
6	Vellari Type -2
7	Vellari Type- 1
8	Kotookonam Varikka
9	Champa Varikka
10	Kallu Varikka
11	Kolambi
12	Perakka manga
13	Vazhapazhithi
14	Thali
15	Natumav Type-2
16	Karpoora Varikka
17	Kappa manga
18	Komanga
19	Puliyan
20	Karimbu manga
21	Mavelikkara Local
22	Thenga manga
23	Mylapore
24	Koli manga
25	Kalluketty
26	Manacaud Local -2
27	Natumav Type-4
28	Neenda Karpooram
29	Karpooram manga
30	Kandiyoor Local

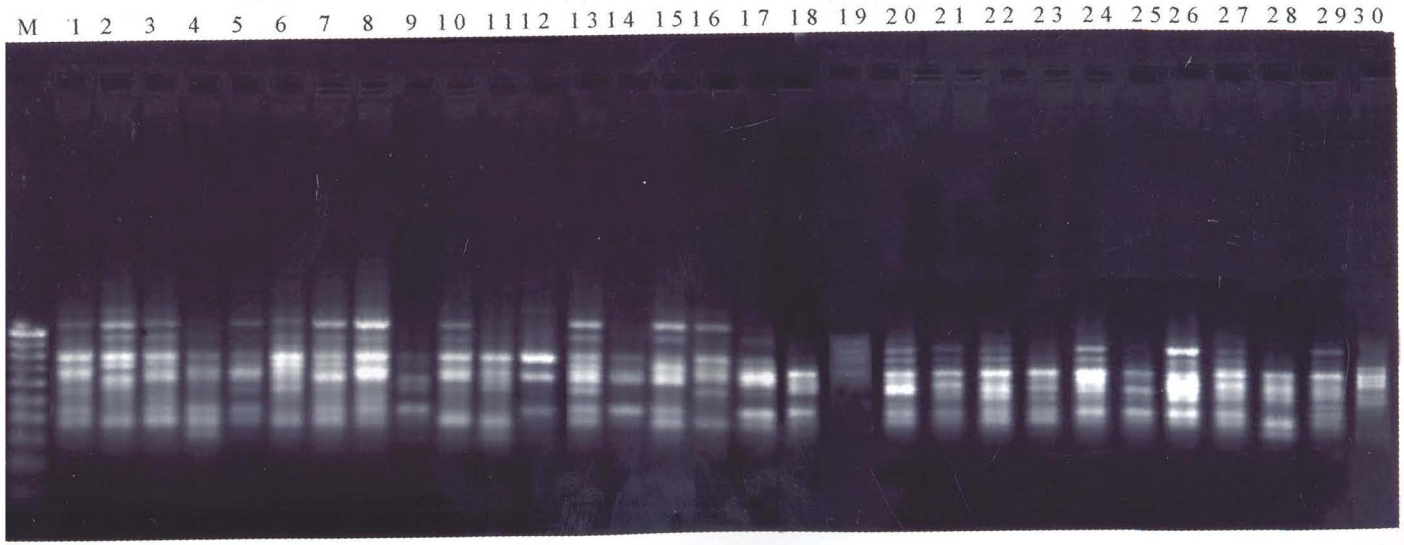


Plate 15 Amplification profiles of the DNA of 30 traditional mango varieties using the primer OPA-13

FIGURE LEGEND

Lane	Variety
M	100 bp DNA ladder
1	Thamboru
2	Velutha Muvandan
3	Karutha Muvandan
4	Muthalamookan
5	Nedungolan
6	Vellari Type -2
7	Vellari Type- 1
8	Kotookonam Varikka
9	Champa Varikka
10	Kallu Varikka
11	Kolambi
12	Perakka manga
13	Vazhapazhithi
14	Thali
15	Natumav Type-2
16	Karpoora Varikka
17	Kappa manga
18	Komanga
19	Puliyan
20	Karimbu manga
21	Mavelikkara Local
22	Thenga manga
23	Mylapore
24	Koli manga
25	Kalluketty
26	Manacaud Local -2
27	Natumav Type-4
28	Neenda Karpooram
29	Karpooram manga
30	Kandiyoor Local

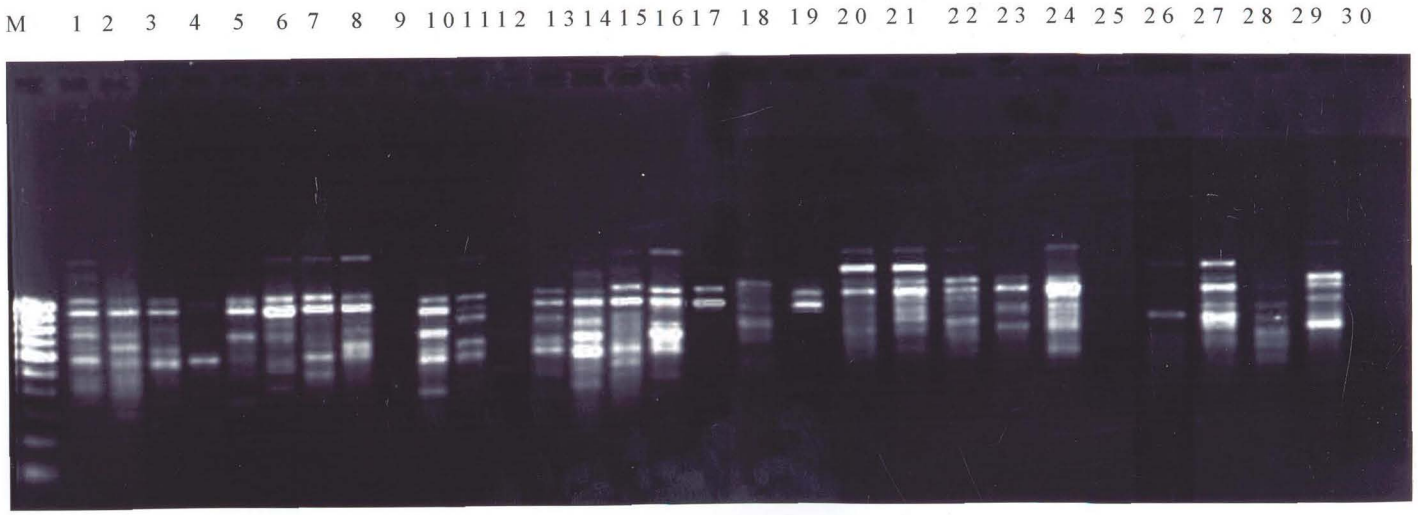


Plate 16 Amplification profiles of the DNA of 30 traditional mango varieties using the primer OPB- 03

FIGURE LEGEND

Lane	Variety
M	100 bp DNA ladder
1	Thamboru
2	Velutha Muvandan
3	Karutha Muvandan
4	Muthalamookan
5	Nedungolan
6	Vellari Type -2
7	Vellari Type- 1
8	Kotookonam Varikka
9	Champa Varikka
10	Kallu Varikka
11	Kolambi
12	Perakka manga
13	Vazhapazhithi
14	Thali
15	Natumav Type-2
16	Karpoora Varikka
17	Kappa manga
18	Komanga
19	Puliyan
20	Karimbu manga
21	Mavelikkara Local
22	Thenga manga
23	Mylapore
24	Koli manga
25	Kalluketty
26	Manacaud Local -2
27	Natumav Type-4
28	Neenda Karpooram
29	Karpooram manga
30	Kandiyoor Local

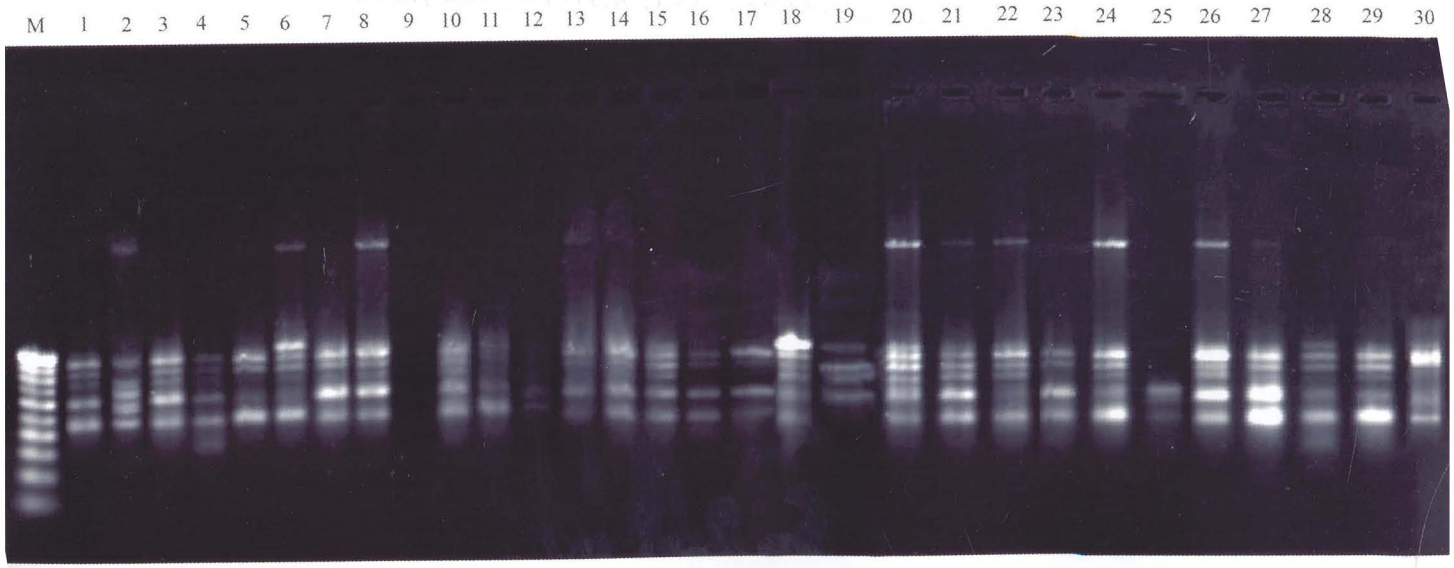


Plate 17 Amplification profiles of the DNA of 30 traditional mango varieties using the primer OPB- 04

4.6.4 Data analysis

Reproducible bands were scored for their presence (1) or absence (0) for all the thirty traditional mango varieties studied. A genetic similarity matrix was constructed using the Jaccard's coefficient method (Table 87). The pair wise similarity coefficient values varied between 0.2174 and 0.8333. The least similarity coefficient value was that of Acc. No. 26 with Acc. No. 38. The next higher value was that between Acc. No. 3 and 37 (0.220)

The highest value for similarity index was obtained for Acc. No. 27-Acc. No. 29 pair (0.8333) followed by Acc. No. 27-Acc. No. 46 pair (0.811).

Based on the similarity coefficient, a dendrogram was constructed with the help of software package 'NTSYS' (Version 2.02). In the dendrogram (Fig. 23), along the point corresponding to a similarity coefficient of 0.540, all the thirty accessions got grouped into seven clusters. The largest cluster Cluster I contained 20 accessions. Four table varieties, Kappa manga, Mylapore manga, Neenda Karpooram and Kandiyoor Local formed the second largest cluster. All these were soft fleshed. Muthalamookan and Kolambi manga formed cluster III. Puliyan, Perakka manga, Kalluketty and Champa varikka formed four separate clusters (clusters IV to VII). All the pickling types except Puliyan and Kalluketty were grouped together. The table varieties, Thenga manga and Koli manga were observed to group together. Neenda Karpooram (Pathanamthitta) was different from Karpooram manga (Alappuzha), Nedungolan (Karpooram) of Kollam and Karpoora Varikka of Thiruvananthapuram district, which were observed to group together. The variety with the smallest fruit (Puliyan) formed a separate cluster.

Table 87 Similarity matrix of thirty traditional mango varieties/ accessions collected from southern Kerala based on Jaccard's similarity index

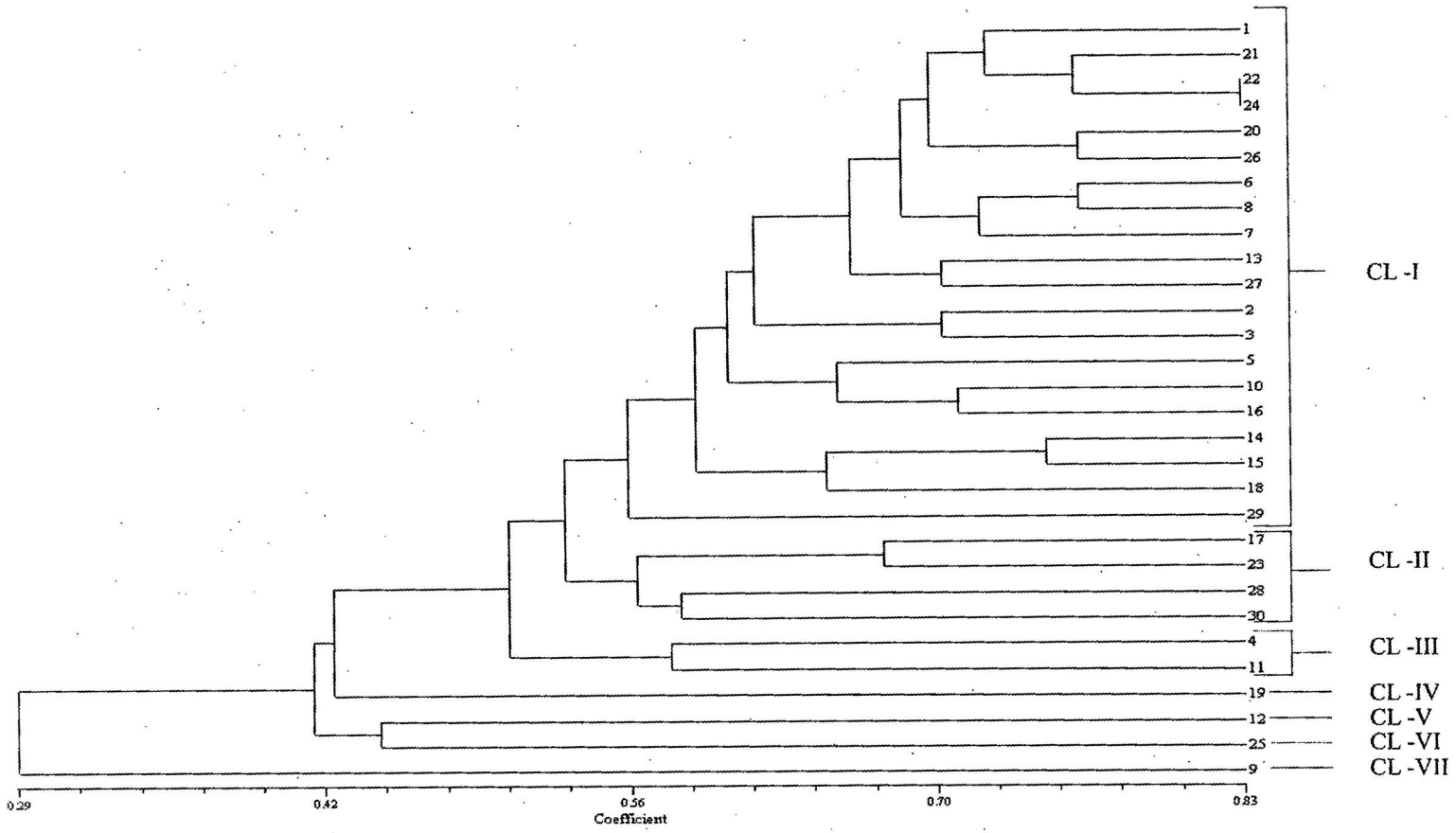
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.000														
2	0.543	1.000													
3	0.703	0.700	1.000												
4	0.431	0.493	0.465	1.000											
5	0.617	0.551	0.612	0.460	1.000										
6	0.723	0.649	0.708	0.427	0.609	1.000									
7	0.678	0.557	0.642	0.403	0.581	0.712	1.000								
8	0.705	0.629	0.691	0.435	0.609	0.761	0.721	1.000							
9	0.291	0.286	0.302	0.300	0.346	0.308	0.220	0.242	1.000						
10	0.678	0.557	0.692	0.469	0.690	0.638	0.695	0.721	0.263	1.000					
11	0.508	0.500	0.493	0.579	0.516	0.557	0.524	0.578	0.308	0.600	1.000				
12	0.452	0.493	0.423	0.466	0.348	0.465	0.379	0.477	0.313	0.444	0.500	1.000			
13	0.689	0.592	0.652	0.485	0.672	0.696	0.625	0.730	0.333	0.677	0.639	0.484	1.000		
14	0.641	0.597	0.657	0.587	0.552	0.653	0.606	0.708	0.279	0.683	0.619	0.540	0.667	1.000	
15	0.609	0.638	0.629	0.508	0.545	0.603	0.552	0.677	0.246	0.625	0.563	0.557	0.714	0.746	1.000
16	0.531	0.523	0.627	0.453	0.617	0.623	0.547	0.677	0.268	0.707	0.638	0.406	0.661	0.591	0.609
17	0.492	0.485	0.500	0.509	0.500	0.544	0.586	0.540	0.255	0.533	0.600	0.482	0.600	0.607	0.574
18	0.515	0.551	0.479	0.508	0.500	0.586	0.463	0.585	0.273	0.463	0.567	0.435	0.594	0.651	0.645
19	0.403	0.576	0.438	0.413	0.409	0.479	0.397	0.471	0.264	0.397	0.379	0.433	0.414	0.464	0.500
20	0.652	0.587	0.667	0.425	0.612	0.732	0.667	0.667	0.242	0.594	0.493	0.403	0.676	0.611	0.606
21	0.702	0.551	0.612	0.460	0.600	0.657	0.581	0.661	0.321	0.581	0.516	0.413	0.672	0.600	0.569
22	0.764	0.574	0.688	0.460	0.627	0.708	0.661	0.746	0.296	0.661	0.541	0.413	0.729	0.625	0.594
23	0.618	0.456	0.515	0.474	0.571	0.609	0.607	0.610	0.265	0.579	0.536	0.421	0.567	0.600	0.492
24	0.695	0.572	0.657	0.484	0.597	0.727	0.603	0.710	0.259	0.629	0.540	0.438	0.694	0.646	0.641
25	0.362	0.413	0.343	0.396	0.393	0.409	0.333	0.417	0.405	0.379	0.434	0.449	0.377	0.410	0.377
26	0.646	0.539	0.662	0.417	0.559	0.729	0.636	0.687	0.356	0.588	0.529	0.456	0.697	0.583	0.534
27	0.672	0.486	0.612	0.484	0.500	0.632	0.580	0.609	0.321	0.556	0.593	0.435	0.700	0.576	0.619
28	0.517	0.507	0.569	0.483	0.500	0.522	0.559	0.565	0.280	0.5333	0.571	0.431	0.574	0.581	0.548
29	0.556	0.479	0.557	0.431	0.492	0.577	0.523	0.552	0.291	0.547	0.557	0.364	0.585	0.479	0.515
30	0.456	0.409	0.469	0.368	0.414	0.426	0.474	0.435	0.217	0.448	0.404	0.316	0.491	0.429	0.443

Table 87. (Continued)

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
16	1.000														
17	0.468	1.000													
18	0.492	0.607	1.000												
19	0.362	0.475	0.525	1.000											
20	0.535	0.545	0.565	0.438	1.000										
21	0.516	0.552	0.548	0.431	0.714	1.000									
22	0.590	0.552	0.574	0.388	0.714	0.811	1.000								
23	0.534	0.673	0.600	0.441	0.538	0.600	0.692	1.000							
24	0.587	0.603	0.623	0.412	0.734	0.707	0.833	0.717	1.000						
25	0.436	0.440	0.444	0.415	0.343	0.418	0.393	0.458	0.373	1.000					
26	0.551	0.493	0.514	0.431	0.761	0.656	0.710	0.556	0.730	0.397	1.000				
27	0.590	0.607	0.581	0.368	0.612	0.627	0.627	0.544	0.650	0.418	0.656	1.000			
28	0.517	0.585	0.525	0.403	0.545	0.525	0.607	0.577	0.576	0.412	0.563	0.636	1.000		
29	0.531	0.542	0.516	0.343	0.557	0.565	0.672	0.561	0.667	0.386	0.597	0.672	0.569	1.000	
30	0.383	0.583	0.414	0.386	0.446	0.464	0.491	0.510	0.440	0.391	0.438	0.547	0.583	0.482	1.000

1	Thamboru
2	Velutha Muvandan
3	Karutha Muvandan
4	Muthalamookan
5	Nedungolan
6	Vellari Type -2
7	Vellari Type- 1
8	Kotookonam Varikka
9	Champa Varikka
10	Kallu Varikka
11	Kolambi
12	Perakka manga
13	Vazhapazhithi
14	Thali
15	Natumav Type-2
16	Karpoora Varikka
17	Kappa manga
18	Komanga
19	Puliyan
20	Karimbu manga
21	Mavelikkara Local
22	Thenga manga
23	Mylapore
24	Koli manga
25	Kalluketty
26	Manacaud Local -2
27	Natumav Type-4
28	Neenda Karpooram
29	Karpooram manga
30	Kandiyoor Local

Fig. 23 Dendrogram obtained from RAPD analysis of 3 traditional mango varieties/accessions collected from southern Kerala using the software Kerala using the software package 'NTSYS' (Version 2.02



4.7 TRADITIONAL KNOWLEDGE

The traditional knowledge associated with the varieties was recorded. Name of the variety Kilichundan refers to the shape of beak of mango fruit which resembles the beak of birds. Ripe fruits of Thamboru were reported to have laxative property and increased the production of blood. It was comparatively resistant to fruit flies. Skin colour of raw fruits of Velutha Muvandan have lighter shade of green (almost white) ('velutha' in Malayalam means white) and those of Karutha Muvandan have dark green ('karutha' means black) even after ripening. In order to improve skin colour, fruits are covered using leaves of pala (*Alstonia* sp.), cashew flushes or straw. Karutha Muvandan was reported to be susceptible to pests. Name of the variety Muthalamookan might have originated from the shape of the prominent fruit beak resembling the nose of 'muthala' which means crocodile. Fruits of Karpooram manga have the flavour of camphor ('Karpooram'). Its leaves, when crushed, have smell of camphor. Nedungolan seeds showed difficulty in germination. Slices made from lateral sides are sweeter than that of dorsal and ventral sides. Use of sugar as manure resulted in production of sweeter fruits in Vellari Type 2. Also application of river sand to soil helped to reduce pre-bearing period. Gravelly soil was reported to be suited for Kotookonam Varikka. Red colour of skin and flesh earned the name 'Chenka Varikka'. Ash like white coating over the skin of Champa Varikka' gave it the name ('champal' meaning ash). Kallu Varikka is a comparatively hardy plant. It was resistant to most pests and diseases. Kolambi fruit is believed to have been brought from Colombo (SriLanka). Fruits and leaves of Perakka had the flavour of guava ('perakka') fruits. Fruits of Kalkanda Vellari have exceptionally firm flesh which remained crisp even after long periods of brining and pickling. If ripened after harvesting at correct maturity, it was very sweet (like 'kalkandam'). Ripening behaviour of Vazhapazhithi fruit bunch resembled that of banana bunch. At first, a single fruit turned yellow, which indicated harvest maturity. Consequently, all the other

fruits ripened. The fruits were reported to be useful for treating ulcer. Pulichi fruits were sour even when ripe. Leaves when crushed had the smell of tamarind. Panchasara Varikka derived its name from the fact that they are very sweet like 'panchasara' or sugar. Bark of Kappa manga possessed medicinal properties. When ripe, Karimbu manga was sweet like 'karimb' or sugarcane and its flesh is firm. Fruits of Nattumavu are widely used as substitutes for B complex vitamins by patients. Fruit juice was used for making mango flakes and 'mampazha pulissery', a traditional culinary preparation of Kerala. Ripe fruits of Mylapore were reported to be useful as laxative for babies. It is less susceptible to fruit fly and stem weevil. Koli manga fruits are slender like a 'kol' or stick hence the name.

Discussion

5. DISCUSSION

India is the centre of origin of mango (*Mangifera indica* L.). There are at least 1000 named cultivars in India (Kumar *et al.*, 2001). However, substantial reduction in the mango germplasm occurred during recent times, resulting in genetic erosion. This is a serious concern. Altered land use pattern and socio-economic scenario has led to the erosion of mango germplasm in Kerala also. The present study was undertaken in this context with the objective of characterizing the traditional mango varieties of southern Kerala (Thiruvananthapuram, Kollam, Pathanamthitta and Alappuzha districts) based on vegetative, floral and fruit characters and RAPD profiles and to document the traditional knowledge associated with the varieties. The results obtained are discussed in this chapter.

A sample survey was conducted and seventeen varieties / accessions from Thrivandrum, ten from Kollam, seventeen from Alappuzha and six from Pathanamthitta districts were randomly selected for conducting the study.

5.1 MORPHOLOGICAL CHARACTERS

The standard descriptor prescribed by IBPGR (1989) was used as the guideline to describe the vegetative, floral and fruit characters.

5.1.1 Vegetative characters

The age of the trees varied from ten to seventy five years. Based on the habit, the fifty accessions / varieties were grouped into three *viz.* erect, intermediate and spreading. Nineteen varieties (38%) were erect, 15 (30%) were intermediate and 16 (32%) spreading. Tree height varied from 4.5 m to 30.0 m. Kalkanda Vellari was the tallest and Panchasara Varikka and Kandiyoor local were the shortest. Radha and Manjula (2000) reported that in a study conducted in the central part of Kerala, in Thrissur and Palakkad districts, the

age of the trees ranged from 10 to 80 years and the approximate height of the trees from 10 to 35 m.

Leaf characters described include leaf shape, leaf tip, leaf margin, leaf length, leaf width, petiole length and young leaf colour. Significant variation was observed in leaf length, leaf width and petiole length. Wide variation was observed in other leaf characters also. Wide variation in leaf characters was also observed by Samanta *et al.* (1990) and Radha and Manjula (2000). Since leaf characters are used as the key factors in classification, this also has considerable importance. Significant positive correlation was observed between leaf length (0.575) and leaf breadth (0.456), with petiole length. However, dependence could not be observed among the various qualitative leaf characters studied. Among the three utility groups, table types had higher leaf length, leaf width and petiole length.

5.1.2 Floral characters

Forty per cent of the varieties had light green young leaves with brown tinch. Light green and reddish brown leaves were produced by 30 and 14 per cent of the accessions, respectively. Two accessions produced purple and six produced yellowish green leaves. Colour of new flushes was observed by Davenport and Nunez-Elizea (1977). According to them, the elongating vegetative structures were usually green, but sometimes bronze red or shades of red, which varied depending on cultivars. They were considered mature when they turned dark green, which occurred after two or three months.

Variation in flowering season was observed among the accessions. Twenty one varieties were early flowering (Nov-Dec) and twenty eight were mid season (Jan-Feb). None of the accessions studied were late. Early flowering provides the farmers with the option of marketing them to other parts of the country where the mango season starts only in June-July months. Flowering behaviour varied with local conditions. In North India, generally, the flowering

is one month late, compared to south India (Kulkarni and Rameshwar, 1981). Flowering season of fourteen clones of cashew grown in Bapatla conditions was between December and March (Dorajeerao *et al.*, 2002).

Varietal influence in secondary (off-season) flowering is obvious. In the present study, frequent secondary flowering was reported in Vellari type-1, Thali, Kizhakkan Thali and Ambalathara local. Of these varieties, Vellari Type-1 has importance in pickling. Ambalathara Local has good organoleptic qualities also. Hence both are economically very important. Secondary flowering helps to get fruits during off- season. According to Naik (1963) the ability to produce more than one crop of flowers and fruits in a year is a unique feature of South India, favoured by the entire absence of frost, hail storms and severe winter conditions, as well as due to the long growing seasons in its vast plains. Kannan (1973) also reported varietal influence in off-season flowering. The varieties which flower throughout the year are referred to as 'Baramasis'. These do not require long term storage of nutrients in their shoots and flowering is seen even in two months old shoots.

Inflorescence characters studied included position of the inflorescence, shape, length and colour of inflorescence, presence of leafy bracts, hairiness of the inflorescence, density of flowers and percentage of hermaphrodite flowers in the inflorescence. Inflorescence length varied from 12.0 cm (Vellari Type 1) to 41.0 cm (Neenda Karpooram). Majority (62.5, 82.35 and 58.82 per cent) of the pickling, table and dual types produced medium sized inflorescences. Wide variability in inflorescence length was observed by Chandra *et al.* (2002) also. The length was the highest in Mallika. Timmappaiah and Suman (1987) and Anila (2002) also made more or less similar observations. According to Timmappaiah and Suman (1987), panicle size in mango varied from 11.25 to 42.20 cm. It ranged from 15 to 30 cm in the selected varieties and hybrids investigated by Anila (2002).

The percentage of hermaphrodite flowers varied widely among accessions. It ranged from 8.4 per cent (Velutha Muvandan) to 96.0 per cent in Eara Local. Variation in percentage of bisexual flowers according to variety and climatic condition has already been reported by different authors (Singh, 1954; Naik and Rao, 1943; Radha and Manjula, 2000). Dependence was observed between inflorescence length and shape. Majority of the varieties possessed medium to high length of inflorescence, of which 58.97 per cent were pyramidal.

Correlation could not be obtained between yield and percentage of bisexual flowers. According to Majumdar and Mukherjee (1961), the percentage of bisexual flowers and bearing capacity are positively correlated. According to Chadha (1963) though better sex ratio may result in better initial fruit set, the final yield in mango need not always be proportionate. This might be due to the subsequent fruit fall occurring due to various climatic and other factors. A similar observation was made by Anila (2002). Among the selected varieties and hybrids of mango, the yield per tree was the lowest in Alphonso with maximum percentage of bisexual flowers.

Flower characters studied included flower type and diameter, nature of disc and number of stamens. Inflorescence colour and young leaf colour showed dependence with each other. Varieties which produced light green or yellowish green young leaves, tended to produce predominantly cream, green or yellow inflorescences. Dependence was also observed between inflorescence colour and fruit colour. Accessions with red or green with red blushed fruits produced predominantly red or crimson coloured inflorescences.

Pollen characters studied included size and fertility percentage. Pollen size did not show much variability. It varied from 19.18 (Kasthuri) to 34.18 micron (Cheriya Kilichundan). Pollen fertility per cent varied from 47.92 (Vellari

Type-1 to 100 (Chadayamangalam Local, Velutha Muvandan, Kotookonam Varikka and Ponnadan manga). Correlation between pollen fertility and yield was positive but not significant (0.193). Lack of correlation between pollen viability and fruit set on three cultivars, *viz.*, Nam Dok Mai, Kheiw Sawoey and Choke Anan was reported by Jutamanee *et al.* (2000).

5.1.3 Fruit characters

Based on the utility of fruits, the accessions were classified as table (17), pickling (16) and dual purpose (17) types.

Fully ripened fruits were observed for recording the morphological characters as per the IPGRI descriptor. The varieties exhibited wide variation in the morphological characters. According to Manay and Shadksharaswamy (1995), the mango fruit is a large drupe in varied shape, size, colour and flavour. They also reported that the shapes were normally round, oval or oblong and the size ranged from plum sized to giants (more than 22 cm long).

Wide variability was observed in fruit length, breadth and width among the varieties. Fruit length ranged from 4.4 to 18.1 cm (Plate 9). Puliyan was the smallest and Muthalamookkan, the longest. Eight varieties produced fruits with more than 12 cm length, of which six were table types. Varieties with long fruits were Muthalamookkan, Nedungolan, Vellari Type-2, Panchasara Varikka, Neendakara manga and Ambalathara Local. The fruit length, breadth and thickness were the highest for table types, compared to the other two groups. Fruit breadth varied from 3.9 cm (Puliyan) to 12.0 cm (Muthalamookkan). Sixty eight per cent of the varieties had medium fruit breadth. Seven varieties (Muthalamookkan, KalkandaVellari, Manacaud Local-1, Nedungolan, Thenga manga, Velutha Muvandan and Champa Varikka) had high fruit breadth (≥8.5 cm). Fruit thickness varied from 3.6 cm (Puliyan) to 9.6 cm (Muthalamookkan). Percentage of varieties with high fruit thickness (> 7.0

cm) was the highest in table types, while those having medium thick and thin fruits were in dual and pickling types, respectively. Fruit thickness was high in Muthalamookkan, Nedungolan, Kappa manga, Thenga manga, Kundara manga, Neendakara manga, Thamboru and Ambalathara Local.

Forty four per cent of the varieties produced round fruits. Oblong and ellipsoid fruits were produced by 36 and 16 per cent varieties, respectively. Vellari Type-1 and Panchasara Varikka were oblong ellipsoid. Fruits were observed for the presence or absence of basal cavity. It was present in 14 varieties and absent in the rest. Beak type was prominent in Kolambi and point in 16 varieties. Absence of beak was observed in 33 varieties. The shape of the fruit including the presence / absence of beak is considered as the most important character of mango fruits (Gangolly and Ranjit, 1957).

Wide variation in fruit weight could be observed among the accessions. Fruit weight ranged from 37.5 g to 826.0 g. Muthalamookan recorded the highest value, followed by Kundara manga (485). Puliyan recorded the least weight. The average fruit weight of the superior variety Alphonso under Kerala conditions has been reported as 230 g (Radha *et al.*, 1996). Out of the fifty accessions, twenty five had fruit weight of 200g and above, which is comparable to that of the best commercial variety.

Pulp per cent exhibited high variability among the varieties. Percentage of pulp in fruit ranged from 33.71 (Puliyan) to 81.87 (Muthalamookan). The average pulp content was 65.32 per cent. The highest pulp per cent was recorded in Muthalamookan, followed by Ambalathara Local (80.53%) and Kundara manga (80.41%). Twelve varieties including Muthalamookan, Ambalathara Local, Kundara manga, Kappa manga, Thenga manga, Nedungolan and Panchasara Varikka recorded pulp content of more than 75 per cent.

Percentage contribution of stone and peel to fruit weight, have been worked out. The average peel and stone percentages were 15.97 and 18.86, respectively. Percentage contribution of skin weight to the fruit weight varied from 8.42 (Ambalathara Local) to 37.71(Puliyan). Thirteen varieties including Muthalamookan, Nedungolan, Vellari Type-2, Perakka manga, Panchasara Varikka, Thenga manga, Kundara manga, Neendakara manga and Ambalathara Local had skin weight less than 12 per cent. Stone percentage ranged from 9.43 (Muthalamookan) to 35.38 (Natumav Type 4). Stone percentage was less than 15 in 19 varieties including Muthalamookan, Nedungolan, Vellari Type-2, Panchasara Varikka, Kundara manga and Ambalathara Local.

The highest pulp content of 676 g (81.87 per cent) was recorded in Muthalamookan, followed by 390g in Kundara manga (80.41%) both of which had bigger fruit size. Muthalamookan had proportionally light skin and ideal small stone. The higher pulp content of this variety would make it suitable for processing. Desai and Dhandar (2000) studied the physico-chemical and morphogenetic characters of some mango varieties of Goa. The highest pulp content of 351.25 g was recorded in RC- MS-1 (83.21%), followed by Salcette Mussarat (311.33g = 74.24%) both of which had bigger fruits.

Pulp weight was significantly and positively correlated with fruit weight. However, this was contradictory to the observations made by Desai and Dhandar (2000) where the trend of pulp contents was not similar to that of fruit weight but varied with stone weight and peel contents of each variety.

The nature of veins on the stone was considered as a varietal character. They are usually parallel or forked and may either be slightly raised or slightly depressed and are rarely either grooved or prominently ridged (Gangolly and Ranjith, 1957). In the present study, in 25 varieties, it was elevated and in 16 varieties it was depressed. The veins were level with the surface in nine varieties. Sixty eight per cent of the varieties had parallel venation and 16 per

cent had forked. Both parallel and forked patterns were observed in 16 per cent of the varieties. The pattern of venation was parallel in 83.33 per cent of the polyembryonic mango varieties studied by Radha and Manjula (2000). It was depressed in Gomanga and Vatta manga.

Less variation was observed in the specific gravity of fruits of different varieties. Syamal and Misra (1987) also observed less variation in specific gravity among the fruits of different varieties studied.

Yield of mango varies greatly, depending on the variety and agroclimatic conditions prevailing in a region. Based on the survey, high variability could be observed in yield among the traditional mango varieties. The yield ranged from 300 (Karutha Muvandan, Perakka manga, Inamanga and Thenga manga) to 5000 (Natumavu Type-1 and Natumavu Type-5) fruits per tree per year. Twelve varieties produced more than 2000 fruits. Twenty one varieties produced 500 to 2000 fruits. Singh (1990) reported that in the age group 20-40 years, a mango tree produced 1000 to 3000 fruits in an 'on year'. Varieties having high yield included Natumavu Type-1, Natumavu Type-5, Kizhakkan Thali, Koli manga, Mavelikkara Local and Neenda Karpooram. These can be recommended as high yielding varieties.

The ripe fruit skin colour varied from green to reddish orange. Ten varieties were orange and red, 16 were yellow and the rest green. These could be the sources of fruit colour genes for using in breeding programmes, as the external appearance could get special advantage in fresh fruit market, especially in export market.

Storage life of fruits varied widely among the varieties. It was less than seven days in 76 per cent of the varieties. Puliyan was reported to have the longest storage life of fourteen days. It was difficult to attain edible ripeness in varieties like various types of Natumavu, Vellari Type-1 and Chadayamangalam Local. They could not be stored for more than a day after

fully ripe. According to Kalra and Tandon (1983), since matured mango fruits are climacteric and highly perishable in nature, it is difficult to store them for more than a week at ambient conditions after harvest.

5.2 QUALITY CHARACTERS

The composition of mango fruit in general differed with the cultivar and stage of maturity (Majumdar and Sharma, 1990). There was remarkable variability in acidity among the varieties (Fig. 12). Nedungolan was the variety with the least (0.12%) acidity and Eara Local had the highest (4.03%) acidity. Among the pickling varieties, 62.5 per cent had high acidity (>0.6%) and 25 per cent had medium acidity. In table types, 58.82 per cent had low acidity (<0.3%) and 29.41 per cent had medium acidity. Only 11.76 per cent of the table varieties had high acidity. In dual types majority (52.94%) of the varieties had medium acidity. Acidity was negatively correlated with fruit weight. Acidity of the fruit gives a blend whereas sweetness is the taste of sugar or molasses, which are only sweet with no flavour (Manay and Shadaksharaswamy, 1995). The fruits have a rich luscious aromatic flavour and a delicious taste in which sweetness and acidity are delicately blended and so this makes the mango fruit one of the most highly prized dessert fruits of the tropics. According to Mitra and Mitra (2001), the variety with least titrable acidity (0.1%) was Mohan Bhog. The varieties, Nedungolan, Perakka manga, Chadayamangalam Local, Natumav Type-3, Mylapore manga, Kundara manga, and Cheriya Kilichundan which had <0.20 per cent acidity can be designated as varieties with less acidity.

Mango fruit is an important source of vitamin C (Manay and Shadaksharaswamy, 1995). Ascorbic acid content varied drastically from 3.08 (Neendakara manga) to 119.05mg / 100g (Natumavu Type-2). The highest percentage (72) of varieties possessed ascorbic acid content of 10 to 57 mg /

100 g and 18 per cent had high ascorbic acid content (>57 mg /100 g). Varieties containing high ascorbic acid content were Natumav Type-1, Natumav Type-2, Chadayamangalam Local, Kalluketty, Kandiyoor Local, Vellayani Local, Thali manga, Mavelikkara Local and Kizhakkan Thali. The pickling and dual types had four varieties each with high ascorbic acid content. But, among the table types, only Kandiyoor Local had high (62.5 mg /100g) content. Smaller fruits were observed to possess higher content of ascorbic acid. The ascorbic acid content of local varieties of Kerala, as reported by Satyavati (1972), ranged from 19.84 to 54.72 mg per 100 g of fruit. Ascorbic acid content of varieties and hybrids grown under Kerala conditions, investigated by Anila (2002) ranged from 1.50 to 53.00 mg per 100 g. The highest value of ascorbic acid obtained in the present study was much higher than the other two reports from Kerala. Also, nine varieties having ascorbic acid content higher than the highest value in these earlier reports could be identified.

Indian cultivars were reported by Singh (1968) to contain 13.20 to 80.30 mg of vitamin C per 100 g of fruit pulp, whereas, some west Indian cultivars contained 93.00 to 130.80 mg per 100 g of fruit pulp. Mitra *et al.* (2001) reported that Langra fruits recorded ascorbic acid content of 125.4 mg / 100g. Natumavu Type-2 was comparable to Langra in ascorbic acid content. Among the utility groups, the average ascorbic acid was the highest in pickling types (46.02mg per 100g) followed by the dual types (32.76 mg per 100g). Among the pickling types, it ranged from 9.52 (Vazhapazhithi) to 119.05 mg per 100g (Natumav Type 2) (Fig. 13). Among the table types, it ranged from 3.08 (Neendakara manga) to 62.5 mg per 100g (Kandiyoor Local) (Fig. 14). It ranged from 12.31 to 71.43 mg per 100g in the dual types (Fig. 15).

Mango is the richest source of carotenoids among the fruits. Carotenoid contents of mango varieties have not been thoroughly analysed. In the present study the carotenoid contents of fifty traditional mango varieties of southern

Kerala have been analysed. It varied from 0.21 (Natumav Type-4) to 7.97 mg/ 100g (Karpoora Varikka). Perakka manga (3.84), Kolambi (2.69), Velutha Muvandan (2.65) and Manacaud Local-2 (2.00) are some of the varieties rich in carotenoid content. Hoda *et al.* (2003a) evaluated twenty mango cultivars for fruit quality. Mallika recorded the highest total carotenoid (4.95 mg per 100g) contents. In the present study, we could identify Karpoora Varikka as the variety having carotenoid content higher than the leading superior variety cultivated in North India. Hence, Karpoora Varikka can be recommended as a mango variety having high carotenoid content.

. TSS gives a rough idea of sweetness in the fruits. The varieties varied greatly in TSS content (Fig.16). TSS ranged from 8.77 (Natumav Type-2) to 25.71 ^{0}B (Perakka manga). Karpooram Varikka had a TSS content of 20.66^0 Brix. Oommen (1997) reported that the highest TSS was observed in Panchasara Varikka (19.65 ^{0}B) and the lowest in Prior (13.75 ^{0}B). The highest TSS content reported by Syamal and Misra (1987) in West Bengal was in variety Langra (21.8 %) and by Mitra *et al.* (2001) was in Prabha Shankar (20.66 ^{0}B). Hence, Perakka manga and Karpooram Varikka can be recommended as varieties having high TSS.

The TSS was more in varieties having big sized fruits. This was contradictory to the observations made by Syamal and Misra (1989). According to them, the varieties having big sized fruits like Vanraj, Malgoa, Fajri, Baneshan and Bangalora showed lower values of TSS. The highest per cent (56.25%) of varieties of the pickling group had low T.S.S ($\leq 12^0$ B) while it was medium for table (64.71%) and dual (88.24%) group. The varieties, Nedungolan, Inamanga, Panchasara Varikka, Neenda Karpooram, Karpooram manga and Velutha Muvandan also had TSS more than 18.0 ^{0}B. TSS was less than 12 only in nine varieties. TSS of fruits is a genetic character, which might be affected by the date of harvesting (Kumar, 1998). During ripening, the conversion of starch, acids and other

insoluble substances into soluble form takes place resulting in the sweetness of the fruits. Sugar content is the most important quality criterion. The total sugar content of ripe fruits (Fig.19) ranged from 2.01 (Natumav Type-4) to 22.20 per cent (Neenda Karpooram). The average total sugar content was the highest (11.5%) in table varieties followed by dual (9.02%) and pickling types (5.07%). Nine varieties had total sugar content ≥13 per cent. Of these, six were table and three were dual. Majority of the varieties of each utility groups had medium total sugar content (4.5- 13%). Varieties with high total sugars were Nedungolan, Vellari Type-2, Perakka manga, Inamanga, Neenda Karpooram, Velutha Muvandan, Karpoora Varikka and Ambalathara Local. The highest value of total sugar content was recorded in Lata Bombai (16.23 %) by Mitra and Mitra (2001) and in Ratna (20.66%) by Anila (2002). In the present study the variety Neenda Karpooram was identified as the variety with total sugar content more than that of Ratna. Neenda Karpooram can be recommended as the variety having high total sugar content.

Among the pickling types, TSS ranged from 8.77 ^{0}B (Natumav Type-2) to 15 ^{0}B (Pulichi) (Fig. 16). Among the table types, it varied from 12.18 ^{0}B to 25.71 (Fig. 17). In dual purpose varieties, TSS ranged from 12.18 to 20.66 (Fig. 18). Of the three utility groups, average TSS was the lowest for pickling type (11.99 ^{0}B) followed by dual type (15.41 ^{0}B). The average TSS was the highest for table type (17.06).

The reducing sugars ranged from 0.9 (Kalluketty) to 6.1 per cent (Perakka manga). The majority of the varieties of pickling, table and dual types had medium reducing sugar contents. Seven varieties had high (>4.3%) reducing sugars. They are Pulichi, Kolambi, Perakka manga, Mylapore manga, Neenda Karpooram, Karpooram manga and Ambalathara Local. Mitra *et al.* (2001) reported that fruits of Neelum had the highest reducing sugar content of 8.23 per cent. Mitra and Mitra (2001) reported 6.2 per cent in Mohan Bhog.

This was comparable to the reducing sugar content of Perakka manga in the present study.

The reducing as well as total sugars in Muvandan were 3.2 and 10.26 per cent, respectively. In another work conducted in southern Kerala, (Oommen, 1997), the corresponding values were 3.37 and 13.59, respectively, which was comparable to that of the present study. The corresponding values were less (1.94 and 4.85 %) in Muvandan grown in central Kerala, as reported by Anila (2002). This might be due to the difference in the agroclimatic conditions in these two regions.

The non-reducing sugar content ranged from from 0.81 (Natumav Type-4) to 16.8 (Neenda Karpooram) per cent. It was medium in 36 per cent of the varieties. Eight varieties had high (>8.9 %) non- reducing sugar content. The highest percentage of varieties in each utility group had medium content of non- reducing sugars. The highest value for non- reducing sugars was reported (Syamal and Misra, 1987) as 11.5 per cent in Langra. Radha *et al.* (1996) reported that the non- reducing sugar content of Alphonso was 14.2 per cent. In the present study, Neenda Karpooram was observed to have a higher content of non- reducing sugar than Alphonso, the leading commercial variety of south India.

The morphological appearance of fruits is an important trait from the marketing point of view, while flesh or pulp colour is also equally important for both table and processing purposes. The pulp colour of varieties ranged from yellow to deep orange. Dependence between flesh colour and carotenoid content was observed. Majority of the orange to deep orange fleshed varieties, had medium to high carotenoid content, while, yellow fleshed varieties were mostly low in carotenoid content. Degree of intensity of pulp colour could be an indicator for higher content of carotenoids (Desai and Dhandar, 2000). Kalra *et al.* (1994) suggested that total carotenoids could improve the natural

appearance of fruit products, particularly in the international market where the addition of synthetic colour would be discouraged. This is specially important in view of the fact that 97.70 per cent of the processed fruit export from India is contributed by mango (Shikhamany and Murti, 2005).

Variability in fibre content could be observed between varieties (Fig. 20). It ranged from 0.4 per cent (Nedungolan) to 2.92 (Natumavu Type-3). Of the pickling types, 50 per cent had high fibre content (≥0.9%). Among the table and dual types, high fibre content was in 17.65 and 23.53 per cent, respectively. The highest percentage (47.06) of varieties with lower fibre content was observed in table types. Fibre content was less (≤0.6%) in 14 varieties, while it was medium (0.6 to 0.9%) in 21 and high (≥ 0.9%) in 15 varieties. Varieties with less fibre content included Nedungolan, Vellari Type-2, Perakka manga, Inamanga, Neenda Karpooram, Kandiyoor Local, Karpooram manga and Ambalathara Local. Of the three utility groups, the average crude fibre content was the highest for pickling followed by the table types.

Pulp texture also showed considerable variation between varieties. Twenty four varieties had firm flesh. Thirteen varieties each possessed soft and juicy textured flesh. Among the fibrous types, Kolimanga and Mavelikkara Local were more juicy and sweet. Mavelikkara Local possessed an attractive smell. The fibre content was less in those varieties with high organoleptic acceptance. Consumer preference is for succulence and low fibre. Juicy and fibrous varieties are not suitable for canning (Lal *et al.*, 1960). They are useful for making juice, squash, nectar, chutney and pickles. Fibrous nature of pulp is a wild character. Wild mangoes have fruits which are unacceptably fibrous (Singh, 1976).

The overall fruit quality depends on nutritional and other hidden attributes and sensory quality as assessed by means of human sensory organs

(Manay and Shadaksharaswamy, 1995). Organoleptic evaluation of the ripe fruits was done based on a four point score.

The major part of our willingness to accept a food depends on its appearance. The mean score values for fruit shape ranged from 1.4 (Natumavu Type-1) to 3.7 (CheriyaKilichundan) The highest mean score for fruit shape was recorded in Cheriya Kilichundan, followed by Perakka manga and Velutha Muvandan. Nine varieties had mean scores more than 3.3. Seventy two per cent of the varieties had mean scores between 2.2 and 3.3. The average mean score for fruit shape was 2.8.

Colour of foods contributes to increase in one's appreciation. When organoleptic evaluation was done, the highest mean score for skin colour was recorded in Kandiyoor Local (3.8) and the lowest in Komanga and Mavelikkara Local (1.4). Five varieties, Eara Local, Perakka manga, Kandiyoor Local, Cheriya Kilichundan and Kotookonam Varikka had mean scores more than 3.28. The highest mean score for flesh colour was recorded in Karpoora Varikka (4.0) and the lowest in Natumavu Type-4 (1.5). The average mean score was 2.9. Eight varieties had mean score for flesh colour more than 3.5. They include Muthalamookan, Vellari Type-2, Perakka manga, Karpooram manga, Cheriya Kilichundan, Kotookonam Varikka and Ambalathara Local.

Flavour determines the quality and acceptability of food. Sensory evaluation of flavour is based on the sensation of taste and smell. The highest score for the quality attribute, flavour was obtained for Karpooram manga (3.7).The mean scores for flavour ranged from 1.2 (Natumavu Type-4) to 3.7. The average mean score for flavour was 2.6. The mean score between 2 and 3.2 was observed in thirty varieties. Twelve varieties had mean scores more than 3.2. These include Muthalamookan, Nedungolan, Perakka manga, Kasthuri, Inamanga, Karpooram manga, Neenda Karpooram, Mavelikkara Local, Vellamkolli and Thali. Oommen (1997) reported that the highest score (4.0) for

flavour was obtained for the varieties, Suvarnarekha, Baneshan, Kalapady and Neelum and the least in Panchasara Varikka (1.6).

The sense of taste refers to the ability of sense organs to perceive and recognize the four basic tastes *viz.* sweet, sour, salty and bitter. Neenda Karpooram recorded the highest mean score (3.9) for taste followed by Inamanga and Perakka manga. The least score for taste was recorded in Natumavu Type-5 (1.1). The average mean score for taste was 2.5. Mean score more than 3.2 was reported in nine varieties. These include Muthalamookan, Nedungolan, Vellari Type-2, Perakka manga, Inamanga, Neenda Karpooram, Karpooram manga and Velutha Muvandan.

Texture is the property of food which is associated with the sense of feel or touch experienced by the finger or mouth (Ranganna, 1986). The highest score for texture (3.9) was obtained in Perakka manga and the least in Chadayamangalam Local. The mean score value for texture was 2.3. Eight varieties had mean scores more than 3.0. These include Muthalamookan, Nedungolan, Vellari Type-2, Kolambi manga, Perakka manga, Inamanga, Karpooram manga and Ambalathara Local.

The overall acceptability depends on the concentration of particular components, nutritional and other hidden attributes of food and its palatability or sensory quality. The variety scored as the best in overall acceptability was Perakka manga, followed by Karpooram manga. The scores of overall acceptability ranged from 1.60 (Natumavu Type-4) to 3.68 (Perakka manga) (Fig. 21). Perakka manga, Karpooram manga, Vellari Type-2, Nedungolan, Ambalathara Local, Kotookonam Varikka, Neenda Karpooram, Kandiyoor Local, Muthalamookan, Velutha Muvandan and Inamanga ranked the top positions in overall acceptability. These can be recommended as excellent edible varieties. The average mean score for overall acceptability was 2.58. Ten varieties had scores above 3.0. Eleven varieties alone were scored below 2.0.

The changes in organoleptic qualities can be attributed to the alteration in chemical composition among the different varieties (Nanjundaswamy, 1976).

The accessions, Pulichi, Natumav Type- 2, Natumav Type-5, Kalluketty, Vellari Type-1and Kalkanda Vellari can be recommended as outstanding in pickling qualities. Of these, Kalkanda Vellari and Vellari Type-1are superior with respect to the firmness of flesh. The rest of the varieties are superior in terms of high acidity and fibre content. Of the table types, Nedungolan, Perakka manga, Muthalamookkan, Vellari Type-2, Karpooram manga and Neenda Karpooram can be recommended as superior with respect to important economic characters like fruit weight, pulp content and eating quality. Among the dual types, Kotookonam Varikka, Velutha Muvandan, Karpoora Varikka, Ambalathara Local and Kizhakkan Thali can be recommended as excellent in overall acceptability.

Similarity assessment based on morphological and quality characters suggested that there was very high diversity among the traditional mango varieties. The pair wise similarity coefficient values varied between 0.042 and 0.708.

5.3 MOLECULAR CHARACTERISATION

Out of the 42 primers used, only 36 primers amplified mango DNA. A total of 157 RAPDs were generated, of which 96.18 per cent were polymorphic. Only data generated from ten primers which gave the highest number of bands were included in the statistical analysis. The ten primers used in this analysis (OPA-01, OPA- 02, OPA-03, OPA-10, OPA-13, OPA-15, OPB-03, OPB-04, OPB-06 and OPS-11) yielded 92 scorable bands. However, none of the primers used in this study produced unique band patterns that could differentiate all the accessions. Similar observation was made by Ravishankar *et al.*(2000) when eighteen mango cultivars were subjected to the study. Twenty seven out of 30 primers amplified the mango genomic DNA. None of the primers produced

unique band pattern for each cultivar. Parentage analysis of mango hybrids was done by Anuj *et al.* (2004). One RAPD primer revealed Neelum – specific bands present in all the three hybrids (Ratna, Amrapali and Mallika) and Neelum exclusively.

The RAPD analysis of thirty mango varieties suggested that diversity was moderate to high. The pair wise similarity coefficient values varied between 0.217 and 0.833.

Corresponding to a similarity coefficient of 0.540, all the thirty accessions were observed to group into seven clusters. The largest cluster contained 20 accessions. Four table varieties, Kappa manga, Mylapore manga, Neenda Karpooram and Kandiyoor Local were grouped together. All these were soft fleshed. Except Kandiyoor Local, all the others in the cluster were of medium plant height. Pulp content and fruit length were medium for all the four varieties. The skin adhered to the pulp in all these varieties, except in Neenda Karpooram. The four varieties had fruits with level shoulders, more or less equal fruit skin thickness and medium skin weight. In total sugar content, all the four varieties were medium, except Neenda Karpooram in which it was high. Muthalamookan and Kolambi manga, which were also table types, clustered together. Both these varieties were of equal height and produced inflorescence with equal percentage of hermaphrodite flowers. Their fruits had comparable fibre content, medium TSS and total sugar contents. Puliyan, Perakka manga, Kalluketty and Champa varikka formed four separate clusters. All the eight pickling types, subjected to RAPD analysis, except Puliyan and Kalluketty were grouped together. Except Kalluketty and Vazhapazhithi, all the pickling type varieties were medium statured. Puliyan differed from the other pickling types. It had the smallest fruit. The inflorescence of Puliyan was conical and glabrous. The table varieties, Thenga manga and Koli manga were the closest. Both these varieties were of medium height, erect in habit, with

same inflorescence length (17.0 cm), with medium per cent of hermaphrodite flowers and high per cent of fertile pollen, intermediate in flowering season, regular without secondary flowering. Neenda Karpooram (Pathanamthitta district) was different from Karpooram manga of Eara (Alappuzha district) Nedungolan (Karpooram) of Kollam and Karpoora Varikka of Thiruvananthapuram districts, which were grouped together.

The clustering pattern based on RAPD analysis was not strictly in accordance with that based on morphological and quality characters. In the dendrogram based on morphological and quality characters, three pairs, Neenda Karpooram - Karpooram manga, Muthalamookkan - Valiya Kilichundan and Vellari Type-1 - Puliyan were clustered together. But, in the dendrogram based on RAPD markers, these were grouped in different clusters. However, some similarities could be observed between the two dendrograms (Fig. 22 and 23). Kotookonam Varikka, Natumav Type-4, Karutha Muvandan, Kallu Varikka, Karpoora Varikka, Thali and Natumavu Type - 4 were observed to cluster together in both the dendrograms. Similarly Mylapore manga and Kandiyoor Local formed a single cluster. Vellary Type II and Nedungolan also were observed to group together in both the dendrograms. Kalluketty was different from the rest of the accessions in both the dendrograms. Phylogenetic relationships among nine *Mangifera* species based on RAPD markers were studied by Schnell *et al.* (1993). They reported that RAPD - generated cluster did not always agree with the taxonomic classification based on phenotypic traits. DNA fingerprinting of Indian cashew varieties using RAPD and ISSR techniques was done by Archak *et al.* (2003). There was no correlation between the relationships based on molecular data and the pedigree of the varieties.

No influence of geographical location could be observed on the grouping of accessions based on RAPD markers. The varieties collected from the four districts of southern Kerala were distributed in the clusters without any regular

pattern. In a similar work conducted by Ravishankar *et al.* (2000), cluster analysis based on RAPD data showed two groups- the first consisting of mango cultivars from western, northern and eastern parts of India and the second group consisting of cultivars from southern parts. Karihaloo *et al.* (2003) reported that 94.7 per cent of genetic diversity in mango existed within the regions. However, differences among regions were significant; northern and eastern regions formed one zone and western and southern regions formed another zone of mango diversity in India.

5.4 TRADITIONAL KNOWLEDGE

Traditional knowledge and its validation through scientific tools is important. Attempts were made to document the traditional knowledge associated with the varieties. Some varieties like Kallu Varikka and Mylapore manga were reported to be hardy and relatively less susceptible to pests. Tough skinned varieties like Inamanga and Vellari Type -2 were also reported to be less attacked by fruit flies and weevils. Some varieties like Vazhapazhithi, Natumavu and Thamboru are reported to possess medicinal value. Medicinal properties of mango have already been reported. Ash of burnt leaves are used as household remedy for burns and scalds, fumes from burning leaves for relief from hiccups and affections of throat. (Majumder and Sharma, 1990). Leaves are masticated to tone up the gums. Dried flowers have curative properties for treating diarrhoea and chronic dysentery. There is a general belief that addition of sugar to soil increased sweetness of fruits. Gravelly soils were reported to be suitable for Kotookonam. Some farmers were of the opinion that application of river sand reduced pre- bearing period. Natumanga types were reported to be useful for making mampazhapulisseri, a traditional culinary preparation of Kerala and mango flakes and Karpooram manga, for juice preparation.

The local names of accessions indicate the specific characters of the accessions. Muvandan means yielding in three years. Puliyan refers to the

sourness of the fruit. Kilichundan and Muthalamookan point out the beaked shape of the fruit. Kalkanda vellari, Karimb manga and Panchasara varikka indicates the sweetness of the fruit. Karpooram manga and Perakka manga are having the flavour of camphor and guava fruit, respectively. Kotookonam varikka, Kolambi manga, Neendakara manga and Kundara manga refer probably to the place of introduction. This system of naming mango accessions is interesting and helpful to understand their specific characters.

Most of the pickling varieties had characters such as pest and disease resistance, higher acid content, more fibrous pulp, thicker skin. They also had high adaptability to the agroclimatic situations of southern Kerala. Certain dual types like Kallu Varikka, Kotookonam Varikka and Karpoora Varikka were also comparatively less susceptible to pests and diseases. Table varieties like Muthalamookan were susceptible to pests and diseases. In fruit size and quality parameters, the table varieties were superior.

Of the two types of Muvandan, Karutha Muvandan had wild characters like thick and dark skin and resistance to pests and diseases. It had more fibre content. Velutha Muvandan is sweeter, had better external appearance (light green skin when raw and yellow when ripe), more susceptibility to pests and diseases and less fibre content.

5.5 GENERAL OBSERVATIONS

Difference in the geographical distribution could be observed among the varieties. Kotookonam Varikka, Kallu Varikka, Champa Varikka, Kasthuri and Vellari Type-1 were more prevalent in Thiruvananthapuram district. Muvandan was distributed mainly in Alappuzha district. Natumanga types were more in Pathanamthitta district. Nedungolan (Karpooram) was distributed from Nilamel, Kilimanoor and nearby regions (Trivandrum district) upto Chadayamangalam. Mylapore manga is mostly located in southern parts of Trivandrum district.

Vellari Type-2 is found more in Varkala, Parippally and Chadayamangalam regions. Kolambi manga is located mostly Kollam district (Chadayamangalam and near by places). Muthala mookan was mostly located in Chettikulangara, Karunagapalli (Kollam district) and Cherthala (Alappuzha). Mavelikkara and Cherthala of Alappuzha district can be considered as hot spot areas for traditional mangoes in south Kerala, as many of the varieties are concentrated in the area.

5.6 CONCLUSIONS

In the present study, fifty traditional mango varieties of southern Kerala were characterized based on vegetative, floral and fruit characters. On detailed analysis, varieties having high carotenoids, ascorbic acid, TSS, total and reducing sugars could be identified. Also, varieties having pest resistance and high yield could be identified based on the survey. They could be used for breeding works. Concerted efforts have to be taken to prevent genetic erosion of rare and valuable varieties with characters like pest resistance. Karutha Muvandan, Mavelikkara Local, Vellari Type-2, Nedungolan, Karpoora Varikka, Kasthuri, Kalkanda Vellari, Thenga manga, Neenda Karpooram and Karimbu manga are facing the threat of extinction. Characterization of the traditional mango varieties of central and Northern Kerala is also needed.

Summary

6. SUMMARY

Attempts were made at the Department of Pomology and Floriculture and the Department of Plant Biotechnology, College of Agriculture, Vellayani during June 2003 to December 2005 for characterising the traditional mango (Mangifera indica L.) varieties of southern Kerala. The salient features of the studies are summarized below.

Fifty varieties were located in the four districts of southern Kerala, Trivandrum (17), Kollam (10), Pathanamthitta (6) and Alappuzha (17). They were grouped into three as pickling (32 %), table (34%) and dual (34%) types based on the utility of the fruits. The different utility groups differed from each other in most of the important characters.

Wide variability could be observed in the vegetative characters. Tree height varied from 4.5 to 30.0 m. Average leaf length ranged from 13.65 cm (Thamboru) to 31.08 cm (Kalluketty). Leaf length, leaf width and petiole length varied significantly between the varieties. There was wide variation in leaf shape, leaf tip, leaf margin and young leaf colour.

The varieties/ accessions varied widely with respect to the floral characters like position of inflorescence, shape, length, colour and density of flowers. Inflorescence length varied from 12.0 cm (Vellari Type 1) to 41.0 cm (Neenda Karpooram). The inflorescence colour ranged from light green to crimson The percentage of hermaphrodite flowers ranged from 8.4 (Velutha Muvandan) to 96.0 (Eara Local). The average percentage of hermaphrodite flowers of all the accessions was 42.2. The flower diameter varied from 3.5 mm in Komanga to 7.50 mm in Valiya Kilichundan.

Forty two varieties were regular bearing, seven were intermediate and one was irregular. Variation in flowering season was observed between the accessions. Twenty two accessions were early and 28 were intermediate with respect to the season of flowering. None of the

accessions were late. Vellari Type-1, Thali manga, Kizhakkan Thali and Ambalathara Local showed off- season flowering frequently.

Pollen fertility percentage varied from 47.92 to 100. The lowest value was recorded in Vellari Type 1 and the highest in Chadayamangalam Local, Velutha Muvandan, Kotookonam Varikka and Ponnadan manga.

The fruit characters like shape, presence of basal cavity, beak type, sinus type, presence of groove, type and slope of shoulders and apex exhibited by the varieties/ accessions showed great variation. Beak type was prominent in Kolambi manga and point in 16 varieties. Absence of beak was observed in 33 varieties. Sinus was present in 18 varieties. It was deep in five and shallow in 13 varieties. Twenty one varieties had ventral shoulder higher than dorsal one while, 15 had level type. The dorsal shoulder was higher than ventral in 14 varieties. Presence of groove was observed only in Muthalamookan, Thenga manga and Ambalathara Local. Apex of the fruit was acute in 26 and round in 24 varieties High variability in fruit length, breadth, thickness, weight, volume and specific gravity could also be observed among the fifty varieties / accessions. Muthalamookan recorded the highest length, breadth, thickness, weight and volume of fruits and Puliyan manga recorded the lowest values. Fruit weight ranged from 37.5 g to 826.0 g. Among the three utility groups, the highest per cent of fruits weighing more than 348 g was for table type.

Fruit length ranged from 4.4 to 18.1 cm. Fruit thickness varied from 3.55 to 9.6 cm. Percentage of fruits having thickness more than 7.00 cm was the highest in table type. The average fruit breadths of the pickling, table and dual varieties were 6.58, 7.74 and 7.19 cm respectively. The range of fruit volume was from 30 ml to 676.1 ml. Pickling type varieties possessed the highest per cent (25%) of fruits with less than 70 ml volume, while, the table types had the highest per cent(29.41%) of fruits with more than 350 ml volume.

Skin characters like colour, thickness, texture and weight also showed high variability among the varieties/accessions studied. Ripe fruit skin colour varied from green to red. Eara Local, Kandiyoor Local, Cheriya Kilichundan, Kotookonam Varikka, Thali and Panchasara Varikka are superior in terms of skin colour. Skin thickness was lowest in Kolambi and highest in Kundara manga. Percentage contribution of skin weight to the fruit weight varied from 8.42 (Ambalathara Local) to 37.71 (Puliyan).

The different varieties / accessions varied considerably in the various flesh characters like weight, texture, adherence of skin to pulp, fibre content and colour. Pulp weight ranged from 14.75g to 676.0g. The highest pulp per cent was recorded in Muthalamookan (81.87 %), followed by Ambalathara Local (80.53%) and Kundara manga (80.41%). Twenty four varieties had firm flesh. Thirteen varieties each possessed soft flesh and juicy textured flesh. Fibre content was less in 14 varieties. Flesh content (ratio of pulp weight to skin + stone weight) varied from 0.51 to 4.51. Flesh colour of ripe fruits ranged from yellow to deep orange. Among the pickling types, 68.75 per cent had yellow flesh. The highest per cent (47.06% each) of table and dual types possessed orange and deep orange flesh, respectively

Stone characters like length, breadth, weight, veins, pattern of venation and fibre length varied among the accessions. Stone length varied from 3.1 cm to 13.75 cm. Fibre length was the shortest in Karimbu manga (0.5 cm) and the longest in Pulichi (9.0 cm). Stone percentage ranged from 9.43 (Muthalamookan) to 35.38 (Natumav Type-4). In 25 varieties, veins were elevated and in 16 varieties it was depressed. The veins were level with the surface in nine varieties. The pattern of venation was parallel in 34 and forked in eight varieties. Both parallel and forked patterns were observed in eight varieties

The mode of attachment of the stalk to the fruit was vertical in 29 and oblique in 21varieties.

The highest yield was reported in Natumav Type-1 and Natumav Type-5 (5000 fruits each) followed by Kizhakkan thali (4000). Koli manga, Mavelikkara Local and Neenda Karpooram are the other varieties which are outstanding with regard to fruit yield. Storage life was highest for Puliyan (14 days). Kalluketty, Muthalamookkan, Vellari Type-2, Inamanga, Kotookonam Varikka and Champa Varikka are some of the accessions with higher storage life.

Quality characters of fruits varied widely among the accessions. Percentage of acidity as per cent anhydrous citric acid ranged from 0.12 per cent in Nedungolan to 4.03 per cent in Eara Local. Ascorbic acid content ranged from 3.08 to 119.05 mg/ 100g. Natumav Type-2 showed the highest value for ascorbic acid content and Neendakara manga, the lowest. The total carotenoid content varied from 0.21 (Natumav Type-4) to 7.97 mg/ 100g (Karpoora Varikka). The TSS of ripe fruits ranged from 8.77 (Natumav Type-2) to 25.71 ^{0} Brix (Perakka manga). The highest per cent (56.25%) of pickling type varieties had low T.S.S ($\leq 12^{0}$ B) while it was medium for table (64.71%) and dual (88.24%) types Total sugar content was the highest in Neenda Karpooram (22.2%). The lowest value was recorded in Natumav Type-4 (2.01%). The reducing and non-reducing sugar content ranged from 0.9 (Kalluketty) to 6.1 per cent (Perakka manga) and from 0.81 (Natumav Type-4)to 16.8 (Neenda Karpooram) per cent, respectively. The crude fibre content in fruit pulp ranged from 0.4 per cent in Nedungolan to 2.92 per cent in Natumav Type-3.

The varieties, Nedungolan, Perakka manga, Chadayamangalam Local, Natumav Type-3, Mylapore manga, Kundara manga, and Cheriya Kilichundan which had <0.20 per cent acidity can be designated as varieties with less acidity.

Perakka manga, Karpooram Varikka, Nedungolan, Inamanga, Panchasara Varikka, Neenda Karpooram, Karpooram manga and Velutha Muvandan are outstanding with regard to TSS.

Perakka manga was rated the best followed by Karpooram manga on organoleptic evaluation.

The accessions, Pulichi, Natumav Type- 2, Natumav Type-5, Kalluketty, Vellari Type-1and Kalkanda Vellari can be recommended as outstanding in pickling qualities. Of the table types, Nedungolan, Perakka manga, Muthalamookkan, Vellari Type-2, Karpooram manga and Neenda Karpooram can be recommended as superior with respect to important economic characters like fruit weight, pulp content and eating quality. Among the dual types, Kotookonam Varikka, Velutha Muvandan, Karpoora Varikka, Ambalathara Local and Kizhakkan Thali can be recommended as excellent in overall acceptability.

Significant negative correlation was observed for fruit weight with ascorbic acid content (-0.462). Significant positive correlation was observed for fruit weight with pulp weight (0.995), stone weight (0.7813), skin weight (0.832), fruit length (0.898), organoleptic quality (0.486) and fruit volume (0.996). High negative correlation was observed for fruit weight with specific gravity (-0.439) and yield. Titrable acidity and fruit weight were negatively correlated.

Varieties which produced red coloured fruits or green fruits with red blush produced deep crimson or red flowers. Green fruited varieties were predominantly cream, yellow or green flowered.

Fruit colour was dependent on young leaf colour. Ninety two per cent fruits had green colour when raw. Varieties with green fruit colour had green and its shades as young leaf colour. Varieties with red fruits or green with red blushed fruits produced purple or reddish brown young leaves. Dependence was observed between the type and slope of

shoulders. Sixty two per cent varieties had ventral shoulders higher than dorsal. Out of this, 80.65 per cent had rising and then rounded slope.

A total of 157 RAPDs (average of 3.74 bands per primer) were generated when PCR amplification was carried out using 42 decamer primers, of which 96.18 per cent (151 bands) were polymorphic. This accounts to an average of 3.6 bands per primer. Of these, ten primers (OPA-01, OPA- 02, OPA-03, OPA-10, OPA-13, OPA-15, OPB-03, OPB-04, OPB-06 and OPS-11) yielded 92 scorable bands with an average of 9.2 bands per primer. The number of bands resolved per amplification was primer dependent and varied from six to fourteen.

The pair wise similarity coefficient values ranged from 0.217 to 0.833. The highest value for similarity index was obtained for Thenga manga - Koli manga pair, followed by Thenga manga - Mavelikkara Local pair (0.811) and the least value was for Kandiyoor Local- Champa Varikka pair.

In the dendrogram, the thirty accessions subjected to RAPD analysis, were observed to group into seven clusters. The largest cluster contained 20 accessions. Four table varieties, Kappa manga, Mylapore manga, Neenda Karpooram and Kandiyoor Local were observed to group together. All these were soft fleshed. Muthalamookkan and Kolambi formed a single cluster. Puliyan (the variety with the smallest fruit), Perakka manga, Kalluketty and Champa Varikka formed four separate clusters. All the pickling varieties subjected to RAPD analysis except Puliyan and Kalluketty were observed to group together. Similarity assessment based on morphological and quality characters suggested that there was very high diversity among the traditional mango varieties. The pair wise similarity coefficient values varied between 0.042 and 0.708. The clustering pattern based on RAPD analysis was not strictly in accordance with that based on morphological and quality characters.

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* Originals not seen

Appendices

APPENDIX –I

Score card for organoleptic qualities of mango

	Criteria	Accessions / Varieties																								
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1	Appearance																										
a.	Fruit shape																										
	Very good-4																										
	Good-3																										
	Fair-2																										
	Poor-1																										
b.	Skin colour																										
	Most acceptable-4																										
	Acceptable-3																										
	Fairly acceptable-2																										
	Not acceptable-1																										
c.	Flesh colour																										
	Most acceptable-4																										
	Acceptable-3																										
	Fairly acceptable-2																										
	Not acceptable-1																										
2.	Flavour																										
	Most acceptable-4																										
	Acceptable-3																										
	Fairly acceptable-2																										
	Not acceptable-1																										
3.	Taste																										
	Very good-4																										
	Good-3																										
	Fair-2																										
	Poor-1																										
4.	Texture																										
	Most acceptable-4																										
	Acceptable-3																										
	Fairly acceptable-2																										
	Not acceptable-1																										
	Overall acceptability																										
5.	Overall acceptability																										

APPENDIX –I Continued

	Criteria	Accessions / Varieties																							
		27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1	Appearance																								
a.	Fruit shape																								
	Very good-4																								
	Good-3																								
	Fair-2																								
	Poor-1																								
b.	Skin colour																								
	Most acceptable-4																								
	Acceptable-3																								
	Fairly acceptable-2																								
	Not acceptable-1																								
c.	Flesh colour																								
	Most acceptable-4																								
	Acceptable-3																								
	Fairly acceptable-2																								
	Not acceptable-1																								
2.	Flavour																								
	Most acceptable-4																								
	Acceptable-3																								
	Fairly acceptable-2																								
	Not acceptable-1																								
3.	Taste																								
	Very good-4																								
	Good-3																								
	Fair-2																								
	Poor-1																								
4.	Texture																								
	Most acceptable-4																								
	Acceptable-3																								
	Fairly acceptable-2																								
	Not acceptable-1																								
	Overall acceptability																								
5.	Overall acceptability																								

CHARACTERIZATION OF TRADITIONAL MANGO (*Mangifera indica* L.) VARIETIES OF SOUTHERN KERALA

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Abstract of the
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ABSTRACT

Attempts were made at the Department of Pomology and Floriculture and the Department of Plant Biotechnology, College of Agriculture, Vellayani during June 2003 to December 2005 for characterizing the traditional mango (*Mangifera indica* L.) varieties of southern Kerala. Field visits were made in order to locate the varieties, to conduct survey and to collect the research materials. Fifty varieties were located in the four districts of southern Kerala, Trivandrum (17), Kollam (10), Pathanamthitta (6) and Alappuzha (17). Wide variability could be observed in the vegetative characters. The varieties / accessions varied remarkably in the vegetative characters like tree height, tree habit, leaf shape, leaf margin and leaf tip. Leaf length, leaf width and petiole length varied significantly between the varieties. The varieties / accessions varied widely with respect to the floral characters like position of inflorescence, shape, length, colour and density of flowers and season and regularity of flowering. The percentage of hermaphrodite flowers ranged from 8.4 (Velutha Muvandan) to 96.0 (Eara Local). The fruit characters like shape, presence of basal cavity, beak type, sinus type, presence of groove, type and slope of shoulders and apex exhibited by the varieties / accessions showed remarkable variation. High variability in fruit length, breadth, thickness, weight and volume could also be observed among the varieties / accessions. Muthalamookan recorded the highest length, breadth, thickness, weight and volume of fruits and Puliyan manga recorded the lowest values. Fruit weight ranged from 37.5 g to 826.0 g. Skin characters like colour, thickness, texture and weight also showed high variability. Percentage contribution of skin weight to the fruit weight varied from 8.4 (Ambalathara Local) to 37.7 (Puliyan). The different varieties varied considerably in the various flesh characters like weight, texture,

adherence of skin to pulp, fibre content and colour. Pulp weight ranged from 14.8 g to 676.0g. Stone characters showed wide variation among the accessions. Quality characters of fruits varied widely among the accessions. Titrable acidity ranged from 0.12 per cent (Nedungolan) to 4.03 per cent (Eara Local). Ascorbic acid content ranged from 3.08 (Neendakara manga) to 119.05 (Natumav Type-2) mg / 100g. The total carotenoid content varied from 0.21 (Natumav Type-4) to 7.97 mg / 100g (Karpoora Varikka). The TSS of ripe fruits ranged from 8.77 to 25.71 ^{0} Brix. Total sugar content ranged from 2.0 (Natumav Type-4) to 22.2 per cent (Neenda Karpooram). The reducing sugar content ranged from 0.9 per cent (Kalluketty) to 6.1 per cent (Perakka manga). Non-reducing sugar content varied from 0.81 per cent (Natumav Type-4)to 16.8 (Neenda Karpooram). The crude fibre content in fruit pulp ranged from 0.4 per cent (Nedungolan) to 2.92 per cent (Natumav Type-3). Perakka manga was rated as the best in organoleptic evaluation. The accessions, Pulichi, Natumav Type- 2, Natumav Type-5, Kalluketty, Vellari Type-1and Kalkanda Vellari can be recommended as outstanding in pickling qualities. Of the table types, Nedungolan, Perakka manga, Muthalamookkan, Vellari Type-2, Karpooram manga and Neenda Karpooram can be recommended as superior with respect to important economic characters like fruit weight, pulp content and eating quality. Among the dual types, Kotookonam Varikka, Velutha Muvandan, Karpoora Varikka, Ambalathara Local and Kizhakkan Thali can be recommended as excellent in overall acceptability. DNA was extracted from young leaves using CTAB method (Dellaporta *et al.*, 1983) with slight modification (Anuj *et al.*, 2004). A total of 157 RAPDs (average of 3.74 bands per primer) were generated on PCR amplification using 42 decamer primers, of which 96.18 per cent (151 bands) were polymorphic. This accounts to an average of 3.6 bands per primer. Of these, ten primers yielded 92 scorable bands with an average of 9.2 bands per primer. The number of bands resolved per amplification

varied from six to fourteen. A genetic similarity matrix was constructed using the Jaccard's coefficient method. The pair wise similarity coefficient values ranged from 0.217 to 0.833. In the dendrogram, the thirty accessions subjected to RAPD analysis, were observed to group into seven clusters. The largest cluster contained 20 accessions. Four table varieties, Kappa manga, Mylapore manga, Neenda Karpooram and Kandiyoor Local were grouped together. All these were soft fleshed. Muthalamookan and Kolambi manga clustered together. Puliyan, Perakka manga, Kalluketty and Champa Varikka formed four separate clusters. Similarity assessment based on morphological and quality characters suggested that there was very high diversity among the traditional mango varieties. The pair wise similarity coefficient values varied between 0.042 and 0.708. The clustering pattern based on RAPD analysis was not strictly in accordance with that based on morphological and quality characters.