

EVALUATION OF PINK PULPED NAVALUR GUAVA SELECTIONS

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CONTENTS

Sl. No.	Chapter Particulars
	CERTIFICATE
	ACKNOWLEDGEMENT
	LIST OF TABLES
	LIST OF FIGURES
	LIST OF PLATES
	LIST OF APPENDIX
1.	INTRODUCTION
2.	REVIEW OF LITERATURE
	2.1 Growth parameters
	2.2 Yield parameters
	2.3 Quality parameters of fruits
3.	MATERIAL AND METHODS
	3.1 Experimental site
	3.2 Climate
	3.3 Experimental details
	3.4 Observations recorded
	3.5 Statistical analysis
4.	RESULTS
	4.1 Growth parameters
	4.2 Yield parameters
	4.3 Quality parameters of the fruits
5.	DISCUSSION
	5.1 Growth parameters
	5.2 Yield parameters
	5.3 Quality parameters of the fruits
	5.4 Future line of work
6.	SUMMARY
	REFERENCES

LIST OF TABLES

Table No.	Title
1.	Growth parameters of pink pulped Navalur guava selections
2.	Yield parameters of pink pulped Navalur guava selections
3.	Physical quality parameters of pink pulped Navalur guava selections
a.	Fruit length, fruit diameter and fruit volume
b.	Fruit weight, pulp weight, fruit shape at stalk end and pulp colour
c.	Number of seeds/fruit, weight of 100 seeds and seed hardness
4.	Chemical quality parameters of pink pulped Navalur guava selections
a.	Total soluble solids, titrable acidity and ascorbic acid
b.	Reducing sugars, non-reducing sugars, total sugars and Sugar/Acid ratio
c.	Lycopene content

LIST OF FIGURES

Figure No.	Title
1.	Layout map
2.	Yield parameters of pink pulped Navalur guava selections
3.	Number of seeds per fruit and weight of 100 seeds in pink pulped Navalur guava selections
4.	Total soluble solids, titrable acidity and ascorbic acid in fruits of pink pulped Navalur guava selections
5.	Sugar content of pink pulped Navalur guava selections
6.	Lycopene content of pink pulped Navalur guava selections

LIST OF PLATES

Plate No.	Title
1.	General view of tree of Selection-3
2.	General view of tree of Selection-5
3.	View (whole, L. S., C. S.) of fruits of Selection-1 and Selection-3
4.	View (whole, L. S., C. S.) of fruits of Selection-5 and Selection-6
5.	View (whole, L. S., C. S.) of fruits of Selection-7 and Selection-9
6.	View (whole, L. S., C. S.) of fruits in Selection-11
7.	Photograph showing comparative pink colour of fruit pulp in guava selections

LIST OF APPENDIX

Appendix No.	Title
I.	Monthly meteorological data during crop growth period (2009-10) and the average of 58 years (1950-2008) at Main Agricultural Research Station, UAS, Dharwad

1. INTRODUCTION

Guava (*Psidium guajava* L.) is the most important and commercially cultivated fruit crop belonging to the family *Myrtaceae*. It is originated in tropical America, stretching from Mexico to Peru, and gradually became a crop of commercial significance in several countries like Brazil, Mexico, China, Malaysia, the Hawaiian Islands, Cuba and India. It was introduced to India during 17th century by Portuguese (Menzel and Paxton, 1985).

The fruit occupies an important place in the horticultural wealth of our nation and ranks fourth with respect to area and production (NHB, 2009). It is commercially cultivated in different states, viz. Uttar Pradesh, Bihar, Punjab, Andhra Pradesh, Karnataka, Gujarat, Maharashtra, West Bengal, Madhya Pradesh and Tamil Nadu. The total guava production in our country is 22.70 lakh MT from an area of 204 thousand hectares, whereas in Karnataka it is grown in an area of 7000 ha with an annual production of 137.5 thousand tonnes during the year, 2008 (NHB, 2009). The crop has gained considerable prominence in our country in general and the state of Karnataka in particular on account of its high nutritive value, pleasant aroma, good flavour and availability at moderate price. Besides, it is one of the hardiest among the fruits in productivity, adaptability with nutritional quality and hence aptly known as 'Poor man's apple' and 'Apple of tropics'.

The fruit has 165 mg of vitamin C, as against a mere 69 mg in orange. It is also an excellent source of beta carotene, lycopene, potassium and soluble fiber. Guavas are very rich in antioxidants which can act against the free radicals that damage cells and cause cancer, diabetes and coronary diseases. Guava possesses antiseptic, astringent and antihelminthic properties, useful to cure many diseases and ailments. It was used in ancient Chinese medicine to treat diabetes for a very long time. Recent studies have now proven that it lowers blood sugar. It may be a natural way to help in preventing diabetes. It is also rich in Vitamin A and B and thus very useful in the preparation of products for anti-aging skin care. The extract of the guava leaf is used in many skin whitening products. Drinking a glass of guava juice can meet the daily requirement of Vitamin C. It can also save the money often spent on less nutritious soft drinks.

Pink pulped guava varieties supply a carotenoid called as Lycopene. It has been considered a potential agent for prevention of some types of cancers, particularly prostate cancer. Lycopene is a key intermediate in the biosynthesis of many important carotenoids, such as beta-carotene and xanthophylls. Thus, nutritionally it is a fruit of good choice.

Provision of quality food to the growing population is the need of the day. Besides meeting the daily requirements in terms of quantity, the food should be able to source all the nutritional requirements of the people across the various income groups. Unless this is achieved, scientific and administrative efforts directed towards nurturing the people will not become comprehensive. Deficiency of vitamin A is found to be one of the most serious nutritional problems faced by human beings especially children from the poor nations. The harmful effects of the vitamin A deficiency (VAD) are manifested in the form of disorders, viz. night blindness and vision problems. Approximately 2.5 to 5 lakh children go blind each year and half of them die within a year due to VAD (Anon., 2010a). At the beginning of the 21st century, 124 million people, in 118 countries in Africa and South East Asia, were estimated to be affected by VAD. VAD is responsible for 1–2 million deaths, 500,000 cases of irreversible blindness and millions of cases of xerophthalmia annually, children and pregnant women are at highest risk. Vitamin A is supplemented orally and by injection in areas where the diet is deficient in Vitamin A. Lot of research effort have been put forth to enrich the produce of staple food crops like rice, with vitamin A, which led to the development of golden rice in order to help children who suffer from VAD. The end product of the biotechnologically engineered pathway is lycopene, but if the plant accumulated lycopene the rice would be red. Recent analysis has shown that the plant's endogenous enzymes process the lycopene to beta-carotene in the endosperm, giving the rice the distinctive yellow colour after which it is named (Anon., 2010b).

Under this background, fruit and vegetables known as protective foods can be quite a good choice of research for making it nutritionally enriched. A good number of under-utilized or under-exploited fruits have been already suggested as a solution for such problem. Efforts in this direction are taken up even in commercial fruit crops. One such nutritionally wonder fruit is guava with protective features interacting with the bio-chemistry of human being. Lot of genetic variability exists among the guava genotypes with respect to nutritional quality of the fruits. Propagation of the crop by seeds was common practice earlier days which gave rise to considerable variability and was utilized both by growers and horticulturists for selection of better types, and thus a large number of varieties came into existence. Some of these types were later propagated vegetatively for commercial cultivation. On account of the vegetative propagation though layers clonally propagated seedling progenies have become established in many commercial orchards. One such type, Navalur guava is an excellent eco-type from Navalur region, Dharwad district, Karnataka, like Allahabad Safeda.

Pinkish colouration in the pulp is an attractive, characteristic and nutritionally appreciable feature observed in many of these selections. Lycopene was attributed as the main reason for pink colouration in the fruit pulp of guava. The pigment besides making the fruit attractive also work as antioxidant and anti-carcinogenic to avoid prostate cancer and skin problems. Under this background, the present investigation was taken up with the following objectives.

1. To evaluate pink pulped Navalur guava selections with reference to growth, yield and quality.
2. To identify the best clone having deep pink pulp with less and soft seeds.

2. REVIEW OF LITERATURE

There are many guava varieties cultivated around the world. Most of them can be broadly grouped on the basis of fruit shape as round, oval and pear shaped. They are also classified as white pulped and pink pulped varieties, when pulp is taken as basis. In general guava varieties were grouped on the basis of physical parameters of fruit like skin colour, pulp colour, seediness and seed hardness in view of consumption of fruit either raw or processed. Names of varieties have been derived either from their place of origin or the demonstrated guava zone where they have been cultivated over a long period. Some work has been carried out, either to classify the varieties or to evaluate their performance at different locations, which is reviewed and given below:

2.1 Growth parameters

2.1.1 Plant height

Phadnis (1970) evaluated nine guava selections under Pune conditions and found that plant height ranged between 8.1 m (Seedless) and 4.2 m (Lucknow-49). Pandey *et al.* (1997) evaluated seven years old guava cultivars under Rewa (M.P.) condition and reported that plant height varied from 4.35 m in Cv. Seedless to 3.48 m in Cv. Gwalior-27. Under Sabour conditions of Punjab, Dubey *et al.* (2000) evaluated ten guava cultivars and found that the plant height ranged between 2.09 m (R₄P₅ variety) and 2.99 m (Cv. Allahabad Safeda).

Girwani *et al.* (2005) evaluated 28 accessions, among which Seedless-1, Seedless-2, Sabdana Badri, Lucknow 46-1 and Kohir Safeda were found superior with respect to growth attributes, while Chinese guava and Apple form were comparatively dwarf after four years of planting. Athani *et al.* (2007) evaluated 19 guava cultivars under Arabhavi conditions and observed average plant height ranged between 183.67 cm (Cv. CIW-3) and 466.5 cm (Cv. Chittidar).

At UAS, Bangalore, Marak and Mukunda (2007) evaluated ten seedling progenies of Cv. Apple Colour and found that plant height ranged from 3.22 m in A.C.Seln.10/2 to 1.98 m in A.C.Seln.6/10. Patel *et al.* (2007) evaluated six genetically diverse hybrids /cultivars under Meghalaya conditions and found that tree height varied from 2.80 m in Hybrid-2 to 1.71 m in L-49. Pandey *et al.* (2007) evaluated eleven guava cultivars and found that plant height ranged between 3.97 m (Hybrid-21) to 2.29 m (Arka Mridula).

2.1.2 Plant spread

Phadnis (1970) evaluated nine guava selections of 25 years old under Pune conditions and found that plant spread varied from 8.4 m (N-S) and 9.9 m (E-W) in Sel. Seedless to 4.8 m (N-S) and 6.6 m (E-W) in Sel. Lucknow-46. Pandey *et al.* (1997) evaluated nine guava varieties under Rewa (M.P.) conditions and reported that plant spread ranged between 5.46 m (N-S) and 4.94 m (E-W) in Cv. Chittidar to 3.96 m (N-S) and 4.21 m (E-W) in Allahabad Safeda.

Marak and Mukunda (2007) evaluated ten seedling progenies of Cv. Apple Colour and recorded that plant spread ranged from 3.30 m (N-S) to 3.82 m (E-W) in A.C. Seln.12/10 to 1.92 m (N-S) and 2.22 m (E-W) in control (Allahabad Safeda). In an evaluation study on 11 guava cultivars, plant spread varied from 4.17 m (N-S) and 4.20 m (E-W) in Hybrid-21 to 2.90 m (N-S) and 2.97 m (E-W) in Hisar Safeda under Lucknow conditions (Pandey *et al.*, 2007).

2.1.3 Time taken from flowering to maturity

Under Pune conditions, Sastry (1965) observed that Lucknow-49 took four to five months for complete development of fruit from the time of flowering, whereas under Uttar Pradesh conditions, it took about five months for complete fruit development from the date of flowering (Teaotia *et al.*, 1968). Srivastav and Srivastav (1965) evaluated two guava cultivars

under Lucknow conditions and reported that Cv. Allahabad Safeda needed 65-72 days from flowering to fruit maturity while Cv. Red Fleshed required 65-75 days.

Under Delhi conditions, Mukherjee and Dutta (1967) reported that Lucknow-49 variety took about 106 to 138 days for fruit maturity while Cv. Red-Fleshed took 110 days. Number of days from flowering to fruit maturity varied between 121.33 (Cv. GR-1) and 125.93 (Cv. CIW-5) in an evaluation study conducted by Deshpande (2006) under Arabhavi conditions. Milan (2007) observed variation among the various guava hybrids with respect to number of days required from flowering to maturity and reported that it varied between 105 days to 124 days.

2.2 Yield parameters

2.2.1 Number of fruits per plant

Athani *et al.* (2007) evaluated different guava cultivars under Arabhavi conditions and revealed that Cv. SR-2 recorded the highest number of fruits per plant (359.02 and 364.33 during years 2001-02 and 2002-03, respectively). Number of fruits per plant varied from 128 (A.C.Seln.10/3) to 61 (Allahabad Safeda) in an evaluation study of six year old Apple Colour progenies, conducted under Bangalore conditions (Marak and Mukunda, 2007). Babu *et al.* (2007) studied performance of eight years old guava selections under Meghalaya conditions and concluded that number of fruits per tree ranged between 184 (Selection-1) and 78.66 (Selection-13).

2.2.2 Total weight of fruits per plant

Mitra *et al.* (1983) evaluated eleven guava cultivars of four years age and reported that total weight of fruits per plant varied from 21.1 kg in Cv. Lucknow-49 to 3.2 kg in Cv. Seedless under West Bengal conditions. The weight of fruits per plant ranged between 145 kg (Var. Nasik) and 44.8 kg (Var. E. C. 6550) in an evaluation study on 25 varieties under Basti (Uttar Pradesh) conditions (Singh, 1988). Singh (2003b) studied yield variability of cultivar Red Fleshed under different seasons of Bihar and observed that total weight of fruits per plant varied from 78.91 kg (rainy season of year 1997) to 6 kg (spring season of the year 1999).

Aulakh (2005) evaluated 13 guava cultivars of 12 years age under Punjab conditions and found that weight of fruits per tree ranged from 75.34 kg in Cv. Lucknow-49 to 44.63 kg in Cv. Seedless. The total weight of fruits varied between 20.14 kg/tree (Allahabad Safeda) and 9.83 kg/tree (Selection-13) under Meghalaya conditions (Babu *et al.*, 2007). Gohil *et al.* (2006) evaluated 12 guava cultivars at an age of thirty years under Rahuri conditions and found that the total weight of fruits ranged from 104.70 kg/plant in Cv. Behat Seedless to 20.33 kg/plant in Cv. Seedless Basti.

The total weight of fruits per plant varied between 24.27 kg (Lalit) and 4.27 kg (Hybrid-21) in an evaluation study conducted by Pandey *et al.* (2007) under Lucknow conditions. Athani *et al.* (2007) evaluated 19 guava selections/cultivars under Arabhavi conditions and revealed that the weight of fruits ranged from 42 kg/tree in Cv. SR-2 to 1.6 kg/tree in Cv. GR-3. Whereas under Bangalore conditions the total weight of fruits per tree varied between 13.62 kg (A.C.Seln.10/3) and 5.28 kg (A.C.Seln.6/6) in an evaluation study on seedling progeny selections of Cv. Apple Colour (Marak and Mukunda, 2007).

2.2.3 Yield (q/ha.)

At UAS, Dharwad, Sadashivaiah (1989) conducted an experiment to evaluate pink and white pulped Navalur guava selections of six years age and observed that fruit yield ranged between 661 q/ha in Cv. CIW-4 to 94.3 q/ha in SWY-1, however under Ranchi conditions the fruit yield per ha ranged from 98.80 q in Lucknow-49 to 14.72 q in Cv. Apple Colour (Reddy *et al.*, 1999).

Under Tripura conditions the average fruit yield ranged from 101.90 q/ha in Lucknow-49 to 44.80 q/ha in Baraf Khana during the period from 1988 to 1993 (Singh, 2003a).

2.3 Quality parameters of fruits

2.3.1 Physical parameters

2.3.1.1 Fruit length

Phadnis (1970) evaluated nine guava selections of 25 years age under Pune conditions and found that fruit length ranged between 8.9 cm (Sel. Lucknow-46) and 6.2 cm (Sel. Dharwar-34), whereas under Hissar conditions fruit length varied from 7.62 cm (Cv. Seedless) to 5.05 cm (Cv. Banarasi Surkha) (Chundawat *et al.*, 1976). Prakash (1976) compared two guava cultivars for quality characters of fruit and revealed that Cv. Sardar recorded maximum fruit length (6.16 cm) than Cv. Dharwar (6.03 cm). Thonte and Chakrawar (1982) evaluated 11 guava strains under Parbhani conditions and revealed that minimum fruit length (6.44 cm) was recorded by BHR-2 and maximum (8.99 cm) by ABD-1. Mitra *et al.* (1983) evaluated eleven guava cultivars and reported that fruit length ranged between 5.8 cm (Cv. Lucknow-49 and Behat Coconut) and 4.2 cm (Cv. Seedless) under West Bengal conditions.

Under Lucknow conditions the fruit length varied from 6.64 cm in C.S.-5 to 5.1 cm in C.S.-3 (Ram *et al.*, 1997), whereas under Punjab conditions it varied from 6.40 cm (Cvs. Behat coconut and Seedless) to 4.73 cm (Cv. Strawberry) (Aulakh, 2005). Patel *et al.* (2007) evaluated six hybrids/cultivars under Meghalaya conditions and concluded that fruit length ranged from 6.56 cm in Lucknow-49 to 5.04 cm in Hybrid-2. Pandey *et al.* (2007) found that among 11 newly developed guava hybrids/selections the fruit length varied between 7.27 cm (Arka Amulya) and 5.83 cm (Lalit) in an evaluation study under Lucknow conditions.

The maximum fruit length was observed in TG selection 5/12 (5.71 cm) followed by TG selection 6/8 (5.70 cm) and minimum (4.48 cm) in TG selection 5/11 in an evaluation study under Bangalore conditions (Biradar and Mukunda, 2007). Babu *et al.* (2007) studied performance of eight years old guava selections under Meghalaya conditions and concluded that fruit length ranged from 62.80 mm (Allahabad Safeda) to 50.10 mm (Selection-1). Marak and Mukunda (2007) evaluated ten seedling progenies of Cv. Apple Colour under Bangalore conditions and found that maximum fruit length (5.65 cm) was recorded by Cv. Allahabad Safeda, followed by A.C.Seln.10/2 (5.43 cm) and A.C.Seln.6/6 (4.26 cm).

2.3.1.2 Fruit diameter

Phadnis (1970) evaluated guava selections at 25 years age under Pune conditions and found that fruit diameter ranged from 7.5 cm in Sel. Dholka-7 to 4.6 cm in Sel. Dharwar-34. Prakash (1976) compared two guava cultivars for quality characters of fruit and revealed that Cv. Sardar recorded maximum fruit diameter (6.19 cm) while it was minimum (5.85 cm) in Cv. Dharwar. Under Parbhani conditions, fruit diameter ranged from 5.83 cm in BHR-1 to 9.27 cm in ABD-1 (Thonte and Chakrawar, 1982). Mitra *et al.* (1983) evaluated four year old guava cultivars and reported that fruit diameter ranged from 6.4 cm in Cv. Lucknow-49 to 4.8 cm in Cv. Seedless under West Bengal conditions, while under Lucknow conditions Ram *et al.* (1997) reported that average fruit diameter ranged from 8.5 cm in C.S.-5 to 5.23 cm in C.S.-3. Fruit diameter varied between 5.80 cm (Cv. Seedless) and 4.60 cm (Cv. Strawberry) in an evaluation study under Punjab conditions (Aulakh, 2005).

Pandey *et al.* (2007) reported that among 11 guava cultivars, Pant Prabhat showed higher fruit diameter (7.13 cm), followed by IIHR Hybrid-21 (6.75 cm). Fruit diameter varied between 66.32 mm (Allahabad Safeda) and 55.52 mm (Selection-1) in an evaluation study of eight guava cultivars under Meghalaya conditions (Babu *et al.*, 2007). Patel *et al.* (2007) evaluated six genetically diverse hybrids/cultivars at five years age under Meghalaya conditions and found that fruit diameter ranged from 6.91 cm in Cv. Lucknow-49 to 5.63 cm in Hybrid-2.

Biradar and Mukunda (2007) evaluated ten seedling progenies of Cv. Taiwan guava under Bangalore conditions and revealed that maximum fruit diameter (6.52 cm) was found in control Allahabad Safeda followed by TG selection 6/10 (6.15 cm) while minimum (5.14 cm) in TG selection 5/11. Fruit diameter varied between 6.83 cm (A.C.Seln.10/2) and 5.30 cm (A.C.Seln.6/6) in an evaluation study under Bangalore conditions (Marak and Mukunda, 2007).

2.3.1.3 Fruit volume

Sadashivaiah (1989) evaluated twelve clonally propagated progenies of different white and pink pulped Navalur guava selections under Dharwad conditions and reported that fruit volume ranged from 150.83 ml in Cv. CIW-4 to 48 ml in Cv. GR-3.

Under Bangalore conditions fruit volume ranged from 119.40 ml in TG selection 6/8 to 69.20 ml in TG selection 5/5 among ten seedling progenies of Taiwan Guava (Biradar and Mukunda, 2007). Raghav and Tiwari (2008) studied 12 different guava cultivars under Pantnagar conditions and recorded variation in fruit volume ranging from 17.88 ml to 209.68 ml.

2.3.1.4 Fruit shape at stalk end

Phadnis (1970) evaluated nine guava selections at 25 years age under Pune conditions and reported that fruit shape varied from spherical in Lucknow-49 to bottle shape in Lucknow-46, globose in Sindh-63, pyriform in Nasik-88, pear shape in Kothrud-19, spherical to ovate in Lucknow-24 and ovate shape in Dholka-7 and Dharwar-34. Thonte and Chakrawar (1982) evaluated 11 guava strains under Parbhani conditions and revealed that fruit shape varied from round (ABD-1, ABD-2, ABD-3, ABD-4, BHR-1, BHR-2, BHR-6) to pyriform (BHR-3, BHR-4) and oval shape (BHR-7).

Sadashivaiah (1989) evaluated 12 clonally propagated pink and white pulped Navalur guava selections under Dharwad conditions and observed that fruits were pear shaped in selections CIW-3, CIW-4, GR-1, CW-1, GW-2, SR-1, SR-2, SW-2 and SWY-1 and pome shaped in selections CIW-5, Sardar guava, GR-3 and CIW-2.

Santos *et al.* (2008) characterized 119 accessions of guava sampled from Brazilian eco-regions and found difference among them with respect to fruit shape at the stalk end and grouped into classes as broadly rounded (15%), rounded (31%), truncate (2%), pointed (26%) and pointed and necked (26%).

2.3.1.5 Weight of fruit

Phadnis (1970) found that weight of fruit ranged from 198.4 g (Sels. Lucknow-49 and Dholka-7) to 85 g (Sel. Dharwar-34) in an evaluation study under Pune conditions. Prakash (1976) compared two guava cultivars for quality characters of fruit and revealed that Cv. Sardar recorded maximum fruit weight (171 g) than Cv. Dharwar (133 g). Thonte and Chakrawar (1982) evaluated 11 guava strains under Parbhani conditions and revealed that average weight of fruit ranged from 327 g in ABD-1 to 117.50 g in BHR-1. Under Lucknow conditions, weight of fruit ranged between 220.9 g (Cv. Guinness) and 118 g (Cv. White flesh) (Tandon *et al.*, 1983). Singh (1988) evaluated 25 guava cultivars under Basti (U.P.) conditions and found that the fruit weight ranged from 51.6 g in Cv. Florida Seedling to 220 g in Cv. Barafkhana. According to Das *et al.* (1995) the fruit weight among guava seedling populations ranged from 58.60 g to 148.30 g and from 68.70 g to 179.2 g during rainy and winter seasons respectively. Ram *et al.* (1997) evaluated 11 guava selections under Lucknow conditions and reported that average fruit weight ranged from 300 g in C.S.-5 to 75 g in C.S.-3.

Girwani *et al.* (2005) reported that the fruit weight ranged from 16 g in Chinese guava to 167.50 g in Red fleshed, whereas it was varied between 116 g (Cv. Baraf Khana) and 49.50 g (Cv. Lucknow-49) in an evaluation study conducted by Aulakh (2005) under Punjab conditions. Gohil *et al.* (2006) studied fruit weight of twelve guava cultivars under Rahuri conditions and found that it varied from 261.7 g in Cv. Seedless Basti to 105 g in Cv.

Chittidar. Fruit weight ranged between 152.50 g (Cv. Lucknow-49) and 97.7 g (Hybrid-2) under Meghalaya conditions (Patel *et al.*, 2007). Athani *et al.* (2007) evaluated 19 guava selections/cultivars under Arabhavi conditions and found that mean fruit weight ranged from 156.32 g in Cv. Sardar to 46.84 g in GW-3 and GR-3.

Marak and Mukunda (2007) evaluated ten seedling progeny selections of Cv. Apple Colour under Bangalore conditions and reported that fruit weight ranged from 176.76 g (A.C.Seln.2/11) to 59.21 g (A.C.Seln.6/6). Under Bangalore conditions fruit weight varied between 122.72 g (TG selection 6/10) and 67.28 g (TG selection 8/12) in an evaluation study on ten Taiwan Guava selections (Biradar and Mukunda, 2007). Babu *et al.* (2007) studied performance of eight year old guava selections under Meghalaya conditions and concluded that the fruit weight ranged from 144.20 g in Selection-11 to 90 g in Selection-10. Fruit weight varied from 275 g (Shweta) to 130 g (Hisar Safeda) under Lucknow conditions (Pandey *et al.*, 2007).

2.3.1.6 Weight of pulp

Mitra *et al.* (1983) evaluated eleven cultivars of guava at four years age and reported that weight of pulp ranged from 77.8 g in Cv. Lucknow-49 to 53.6 g in Cv. Seedless under West Bengal conditions. Gohil, *et al.* (2006) evaluated 12 guava cultivars under Rahuri conditions and revealed that the maximum pulp weight (261.7 g) was found in Cv. Seedless Basti, while minimum (76.0 g) in Cv. Pear shape.

Under Arabhavi conditions maximum pulp weight (131.67 g) recorded in Cv. Sardar followed by Cvs. CIW-4 (123.50 g) and SR-1 (94.67 g), while GR-1 showed minimum pulp weight (26.28 g) (Deshpande, 2006).

2.3.1.7 Pulp colour

The pulp colour was reported by Palaniswamy and Shanmugavelu (1974) that majority of the cultivars they studied, showed white pulp colour in varieties like Lucknow-46, Habshi and Chittidar, whereas other cultivars showed different colours like yellowish white (Cv. Seedless), slight yellowish (Cv. Bangalore), slight brownish yellow (Cv. Bapatla), light red (Cv. Red Fleshed), pale yellow (Cv. Allahabad), light brownish (Cv. Lucknow-49) and pale yellowish white (Cv. Anakapalle).

Preez and Welgemoed (1990) observed the variation in pulp colour from orange pink in selection-1 to pink in Selection-8 and dark pink in selection-2, 3 and 4 among five guava selections. Babu and Yadav (2002) evaluated seven guava hybrids and reported the pulp colours as white (Hybrid-1, 7, and 8), creamy white (Hybrid-3, 5 and 11) and pink (Hybrid-4).

Gohil *et al.* (2006) evaluated 12 guava cultivars under Rahuri conditions and observed variation in pulp colour from pink colour (in Cv. Red guava) to yellowish white (Cvs. Apple colour and Chittidar) and creamy white (Cvs. Allahabad Safeda and Nagpur Seedless). The most common colours of guava flesh were pale pink (29%), pink (20%), dark pink (18%) and cream (18%) among the 119 accessions of guava in 35 Brazilian eco-regions (Santos *et al.*, 2008).

2.3.1.8 Number of seeds per fruit

Number of seeds per fruit ranged from 19 in Sel. Seedless to 443 in Sel. Kothrud-19 under Pune conditions (Phadnis, 1970). In the evaluation study of guava cultivars Prakash (1976) found minimum seeds per fruit (126.9) in Cv. Dharwar, while it was maximum (331.8) in Cv. Sardar. Thonte and Chakrawar (1982) evaluated 11 guava strains under Parbhani conditions and revealed that average number of seeds per fruit ranged from 260 in ABD-1 to 100 in BHR-1.

Mitra *et al.* (1983) evaluated 11 cultivars of guava and reported that the number of seeds per fruit ranged from 28 in Cv. Seedless to 429 in Cv. Chittidar under West Bengal conditions. Das *et al.* (1995) found that Cv. Sardar guava had less number of seeds than that

of Chittidar and Allahabad Safeda. The number of seeds per fruit varied from 355 (Cv. Sardar) to 92 (Cv. Nagpur Seedless) under Rahuri conditions (Gohil *et al.*, 2006).

Marak and Mukunda (2007) evaluated ten seedling progenies of Cv. Apple Colour and recorded that the least number of seeds per fruit (142) was noticed in A.C.Seln.6/10, and highest number of seeds (450) was recorded in A.C.Seln.2/11. Whereas, the maximum seed count was recorded in Hybrid-11 (534) and minimum (171) in Hybrid-1 (Patel *et al.*, 2007).

2.3.1.9 Seed weight

Prakash (1976) compared two guava cultivars for quality characters of fruit and revealed that Cv. Sardar recorded minimum weight of hundred seeds (1.53 g), whereas Cv. Dharwar recorded highest seed weight (2.39 g). In an evaluation study on 15 *Psidium* species and varieties under Bangalore conditions Subramanyam and Dinesh (1992) conclude that the lowest weight of 100 seeds was found in *Psidium cattleianum* (0.50 g) and the highest (11.87 g) in *P. quadrangularis*, while in guava cultivars the seed weight ranged between 0.96 g (Selection-8) to 1.81 g (Sardar guava). Under Bangalore conditions, the weight of 100 seeds was found minimum in A.C.Seln.12/10 (1.30g) and maximum in A.C.Seln.2/11 and 5/5 (1.60g) (Marak and Mukunda, 2007).

Similarly, among Taiwan guava selections lowest weight of 100 seeds (0.71 g) was recorded in TG selection 5/5 and highest (1.21 g) in Allahabad Safeda (Biradar and Mukunda, 2007). The weight of 100 seeds ranged between 0.92 g (Cv. Allahabad Safeda) to 1.06 g (Hybrid-2) in an evaluation study under Lucknow conditions (Patel *et al.* 2007).

2.3.1.10 Seed hardness

Thonte and Chakrawar (1982) evaluated 11 guava strains under Parbhani conditions and differentiated seed hardness as soft (ABD-3, ABD-4 and BHR-5), medium hard (ABD-1, ABD-2, BHR-3, BHR-6, BHR-7) and hard (BHR-1, BHR-4, BHR-2). Under Dharwad conditions Sadashivaiah (1989) evaluated Navalur guava selections and revealed that SR-1 and SWY-1 had soft seeds, GR-3 had very hard seeds and other cultivars had only hard seeds.

Babu and Yadav (2002) studied seed hardness among seven guava hybrids under Barapani conditions and reported that Hybrid-1 and 7 had hard seeds, Hybrid-3,4 and 8 had medium textured seeds and Hybrid-11 had soft seeds. Gohil *et al.* (2006) evaluated twelve guava cultivars and concluded that the seed hardness was maximum (13.9 kg/cm²) in Cv. Sardar and minimum (6.4 kg/cm²) in Cv. Apple colour.

2.3.2 Bio-chemical parameters

2.3.2.1 Total soluble solids (TSS)

Ram *et al.* (1997) evaluated 11 guava selections under Lucknow conditions and reported that total soluble solids ranged from 12.60 in N-3 to 7.0 in C.B.-4. Aulakh (2004) evaluated six guava cultivars in winter season and revealed that TSS of fruit ranged between 13.5% (Cv. Lucknow-49) and 10% (Cv. Pear Shaped). Under Punjab conditions Aulakh (2005) evaluated 13 guava varieties and reported that higher TSS was recorded in fruits of Behat Coconut (11%) followed by Tehsildar (10.6%), Lucknow-49 (10.5%), Chittidar (10.4%) and Strawberry (10.4%).

TSS varied between 16.9⁰ Brix (Cv. Apple colour) and 10.4⁰ Brix (Cv. Chittidar) in an evaluation study on 12 guava cultivars under Rahuri conditions (Gohil *et al.*, 2006). Under Meghalaya conditions Babu *et al.* (2007) concluded that TSS ranged from 11⁰ Brix in Selection-11 to 8.5⁰ Brix in Selection-1.

Athani *et al.* (2007) evaluated 19 guava cultivars under Arabhavi conditions and reported that TSS ranged between 11.55⁰ Brix in Chittidar and 6.05⁰ Brix in GW-3. Biradar

and Mukunda (2007) evaluated ten selections of Taiwan Guava and observed maximum TSS in Allahabad Safeda as control (11.00° Brix) followed by TG selection 6/10 (10.80° Brix). Under Bangalore conditions among seedling progenies of Apple Colour selections, maximum TSS (13.8° Brix) was recorded in A.C.Seln.6/10, and minimum TSS was observed in A.C.Seln.10/3 (8.50° Brix) (Marak and Mukunda, 2007).

2.3.2.2 Titrable acidity

Prakash (1976) compared two guava cultivars for quality characters of fruit and revealed that Cv. Sardar recorded maximum titrable acidity (0.42%) than Cv. Dharwar (0.26%). Thonte and Chakrawar (1982) reported that average acidity in guava fruit ranged from 0.55% in ABD-2 to 0.08% in BHR-3 under Parbhani conditions. Mitra *et al.* (1983) evaluated four year old cultivars of guava and found that acidity ranged from 0.24% in Cv. Lucknow-49 to 0.38% in Cv. Behat coconut under West Bengal conditions. The acidity varied between 0.33% (Cv. Mirzapuri) and 0.45% (Cv. White fleshed) under Lucknow conditions (Tandon *et al.*, 1983). Singh (1988) evaluated 25 guava varieties under Sobour conditions and found that acidity ranged from 0.08% in variety Barafkhana to 1.68% in Florida Seedling. Under Punjab conditions acidity in guava pulp varied between 0.20% (Cv. Lucknow-49) and 0.46% (Cv. Behat coconut (Aulakh, 2005).

Gohil *et al.* (2006) revealed that the acidity of ripe fruit ranged from 1.08% in Cv. Chittidar to 1.98% in Cv. Nagpur seedless under Rahuri conditions. The titrable acidity content ranged between 0.70% (pink flesh Selection-1) to 0.28% (Selection-10) in a varietal evaluation study (Babu *et al.*, 2007). Under Bangalore conditions, Biradar and Mukunda (2007) reported highest acidity (0.27%) in TG selection 5/11 and 5/12, and the least acidity in TG selection 6/8 (0.20%) among ten seedling progeny selections of Taiwan Guava, whereas the maximum acidity was observed in A.C.Seln.6/10 and A.C.Seln.11/3 (0.37%) and minimum (0.26%) in A.C.Seln.11/2 under Bangalore conditions (Marak and Mukunda, 2007).

Pandey *et al.* (2007) reported that the acid content varied from 0.157% (Cv. Hisar Surkha) to 0.355% (Cv. Sangam). Patel *et al.* (2007) revealed that the acidity ranged between 0.33% (Hybrid-11) to 0.81% (Hybrid-2) among guava varieties and hybrids studied under Meghalaya conditions.

2.3.2.3 Ascorbic acid

Phadnis (1970) found that ascorbic acid content varied from 299 mg/100 g (Sel. Lucknow-24) to 148 mg/100 g (Sel. Kothrud-19) among nine guava selections under Pune conditions. Prakash (1976) compared two guava cultivars for quality characters of fruit and revealed that Cv. Sardar recorded highest quantity of ascorbic acid per 100 g of pulp (260 mg) than Cv. Dharwar (196.9 g). Mitra *et al.* (1983) evaluated 11 cultivars of guava at four years age and recorded that ascorbic acid content ranged from 132.5 mg/100 g (Cv. Lucknow-49) to 62.5 mg/100 g (Cv. Red fleshed) under West Bengal conditions. Ascorbic acid content ranged between 172 mg/100 g (Cvs. Surkha) and 145 mg/100 g (Cv. Chittidar) under Punjab conditions (Aulakh, 2005). Gohil *et al.* (2006) reported maximum ascorbic acid (121.84 mg/100 g) in Cv. Behat coconut and minimum (31.89 mg/100 g) in Cv. Seedless Basti among 12 cultivars.

The ascorbic acid content ranged between 295.7 mg/100 g (Cv. Behat coconut) and 58.2 mg/100 g (Cv. Guiness) under Lucknow conditions (Tandon *et al.*, 1983). Babu *et al.* (2007) reported that Selection-7 was found to be best for ascorbic acid (192.50 mg/100 g) content at eight years age. The content of ascorbic acid varied from 194.85 mg/100 g (A.C. Seln.6/10) to 109.50 mg/100 g (A.C.Seln.6/6) under Bangalore conditions (Marak and Mukunda, 2007). Patel *et al.* (2007) evaluated six guava hybrids/cultivars and concluded that highest content of ascorbic acid was found in Hybrid-1 (296 mg/100 g), followed by Hybrid-2 (267.8 mg/100 g), while lowest value (116.25 mg/100 g) was recorded in Hybrid-11.

Maximum ascorbic acid content was observed in TG selection 5/11 (280 mg/100 g) and minimum (202.40 mg/100 g) in TG selection 6/8 among the ten seedling progeny selections of Taiwan Guava (Biradar and Mukunda, 2007). Pandey *et al.* (2007) estimated the

ascorbic acid content among 11 cultivars/hybrids under Lucknow conditions and reported that it ranged between 243.75 mg/100 g in CISH-G-4 (Shweta) and 104.17 mg/100 g in Cv. Pant Prabhat. The ascorbic acid content was found maximum in Selection-11 (210.40 mg/100 g) followed by Selection-7 (192.50 mg/100 g) and it was minimum (104.50 mg/100 g) in Selection-1 (Babu *et al.*, 2007).

2.3.2.4 Reducing Sugars

Mitra *et al.* (1983) reported that percentage of reducing sugars ranged from 3.4 in Cv. Lucknow-49 to 2.6 in Cv. Apple colour among 11 cultivars of guava evaluated at four years age and under West Bengal conditions. The reducing sugars varied between 5.24% (Cv. Sardar) and 4.57% (Cv. Gwalior-27) in an evaluation study of nine guava cultivars under Rewa (M.P.) conditions (Pandey *et al.*, 1997). Gohil *et al.* (2006) conducted experiment on twelve guava cultivars and concluded that reducing sugar ranged from 7.29% in Cv. Seedless Basti to 4.55% in Cv. Apple colour.

Marak and Mukunda (2007) examined ten seedling progeny selections of Cv. Apple Colour and noticed that maximum quantity of reducing sugar (4.81%) was found in A.C.Seln.6/6 and the lesser quantity (4.08%) in control Allahabad Safeda. The maximum content of reducing sugar (4.03%) was found in TG selection 8/12 and minimum (3.40%) in TG selection 5/5, among ten seedling progeny selections under Bangalore conditions (Biradar and Mukunda, 2007). The percentage of reducing sugar varied from 2.67 in Hybrid-1 to 1.01 in Cv. L-49 under Meghalaya conditions (Patel *et al.*, 2007).

Pandey *et al.* (2007) estimated the content of reducing sugar among 11 guava varieties under Lucknow conditions and reported that it ranged between 6.4% in Cv. Hisar Surkha and in 4.41% CISH-G-31.

2.3.2.5 Non-reducing sugars

Phadnis (1970) evaluated nine guava selections at 25 years age under Pune conditions and reported that percentage of non-reducing sugars varied from 5.23% (Sel. Lucknow-49) to 1.14% (Sel. Nasik-88). The content of non-reducing sugars ranged between 5.13% (Allahabad Safeda) and 2.80% (Chittidar) in an evaluation study under Hissar conditions (Chundawat *et al.*, 1976). Mitra *et al.* (1983) evaluated 11 cultivars of guava at four years age under West Bengal conditions and reported that content of non-reducing sugars varied from 3.7% in Cv. Banarasi to 3.1% in Cv. Harijha.

Under Meghalaya conditions the maximum content of non-reducing sugar was found in Sardar variety (5.77%), while it was least in Cv. Red-fleshed (4.10%) among nine varieties of guava (Pandey *et al.*, 1997). Among the 12 cultivars evaluated under Rahuri conditions the highest content of non-reducing sugar (9.78%) was recorded in Cv. Behat coconut, while lowest (5.57%) in Cv. Seedless Basti (Gohil *et al.*, 2006).

Biradar and Mukunda (2007) evaluated 10 seedling progeny selections of Taiwan Guava and reported that maximum percentage of non-reducing sugar ranged between 3.73 (TG selection 5/13) and 3.06 (TG selection 6/8). Patel *et al.* (2007) evaluated six guava hybrids/cultivars under Meghalaya conditions and reported that non-reducing sugars ranged from 5.37% in Hybrid-1 to 2.67% in EC-12.

2.3.2.6 Total Sugars

Pandey *et al.*, (1997) carried out study on varietal evaluation of guava with nine varieties under Rewa (M.P.) conditions and concluded that maximum content of total sugars was found in Sardar variety (11.01%) whereas minimum in Cv. Red-fleshed (8.71%). Gohil *et al.* (2006) conducted experiment on 12 guava cultivars under Rahuri conditions and revealed that the total sugars ranged between 15.67% (Cv. Behat coconut) and 11.83% (Cv. Sardar).

The total sugar content varied from 7.48% in TG selection 5/13 to 6.72% in TG selection 7/2 among ten seedling progeny selections under Bangalore conditions (Biradar and

Mukunda, 2007). Under Bangalore conditions Marak and Mukunda (2007) evaluated ten seedling progeny selections of Cv. Apple Colour and reported the maximum percentage of total sugar in A.C.Seln.6/10 (8.27), followed by A.C.Seln.11/2 (8.14), and sleast in Allahabad Safeda.

Pandey *et al.* (2007) estimated 11 guava varieties and reported that the higher content of total sugar was found in Cv. Hisar Surkha (9.32%), while lower (6.67%) was found in. Hisar Safeda. Total sugars varied between 8.77% (Hybrid-1) and 4.20% (EC-12) in an evaluation study conducted under Meghalaya conditions (Patel *et al.*, 2007).

2.3.2.7 Sugar/acid ratio

The sugar/acid ratio ranged between 3.90 in Sel. Lucknow-49 and 1.75 in Sel. Nasik-88 among nine guava selections evaluated under Pune conditions (Phadnis, 1970). Mitra *et al.* (1983) evaluated four year old guava cultivars and reported that sugar/acid ratio varied from 28.3 in Cv. Lucknow-49 to 17.2 in Cv. Red fleshed under West Bengal conditions.

Sadashivaiah (1989) evaluated Navalur guava selections under Dharwad conditions and recorded higher sugar/acid ratio in Cv. GW-2 (24.18) followed by CIW-2 (18.37), SWY-1 (17.96), CW-1 (17.61), Sardar guava (17.52) and CIW-4 (16.92), however the lower sugar acid/ratio was observed in Cv. GR-1 (10.07).

Under Bangalore conditions Pandey *et al.* (1997) evaluated nine cultivars and observed that sugar/acid ratio ranged from 39.44 in Cv. Seedless to 24.86 in Cv. Chittidar. The sugar/acid ratio was maximum (31.12) in A.C.Seln.11/2 and minimum (19.67) in A.C.Seln.11/3 under Bangalore conditions (Marak and Mukunda, 2007).

2.3.2.8 Lycopene content

The presence of lycopene pigment was attributed as the reason for pink colouration in guava pulp (Jagtiani *et al.*, 1988). Nakasone *et al.* (1976) estimated lycopene content among pink and red pulped cultivars of guava and found that it was ranging from 4.78 to 6.90 mg per 100 g of fruit pulp.

Maximum lycopene content (3.61 mg/100 g) was noticed in A.C.Seln.6/10 while the minimum was in A.C.Seln.2/11 (2.66 mg/100 g). However white pulped fruits of Allahabad Safeda showed only minute quantities of lycopene pigment (0.82 mg/100 g) (Marak and Mukunda, 2005).

Chandrika *et al.* (2009) compared the lycopene contents of red pulped guava Cv. Horana Red and watermelon Cv. Sugar baby, and revealed that red pulped guava Cv. Horana Red estimated more lycopene (45.3 ± 8.0 µg/g FW) than watermelon Cv. Sugar baby (37.2 ± 4.0 µg/g FW). Budi *et al.* (2001) studied pigment contents among various Indonesian fruits and showed that among them guava was the richest in lycopene content (1150 µg/100 g) than cryptoxanthin and beta carotene (66 µg/100 g and 984 µg/100 g, respectively).

3. MATERIAL AND METHODS

A field study was carried out at the Silver Jubilee Orchard, Main Agricultural Research Station, UAS, Dharwad during the year 2009 with an objective of evaluating the pink pulped Navalur guava selections. The methods followed and the materials used are described hereunder.

3.1 Experimental site

The investigation was carried out in New block of Navalur guava in the Silver Jubilee Orchard, situated at 15°-16' Northern latitude, 70°-07' Eastern longitude and at altitude of 678 m above mean sea level. The soil was red loamy with moderate water holding capacity.

3.2 Climate

A total rainfall of 1140.4 mm was received during the year 2009 whereas the rainfall was 936.2 mm during the period under study (June to December). The monthly mean temperature ranged from minimum 15.4° C (December) to a maximum of 29.3° C (October). The mean relative humidity was highest during the month of July (88 %) and lowest in October (65 %). The data on meteorological parameters for the period of experimentation (June to December 2009) as against their average values over the last 58 years as recorded at the Meteorological observatory, Main Agricultural Research Station, Dharwad are presented in Appendix I.

3.3 Experimental details

3.3.1 Source of plant material

A number of orchards around Navalur village in Dharwad district of Karnataka were surveyed during 1994-95 and in each orchard, high yielding trees which produce good quality fruits having pink pulp, were marked on the basis of the information given by the growers. The selected seedling progenies of Navalur guava were clonally propagated through air layering and planted during the October, 1997. The distinguishing features of pink pulped Navalur guava cultivars are as follows.

3.3.2 Distinguishing features of pink pulped Navalur guava cultivars

The salient features observed among the guava progenies are presented below:

Selection 1

The plant was medium statured with semi-spreading and drooping type canopy with moderate bearing capacity. Leaves were medium to small in size and emerald green in colour. Fruits were round to pear shaped and medium in size. Pulp had deep pink colour and skin was chartreuse coloured at ripe stage.

Selection 3

The plant was large statured with spreading type canopy and of high bearing capacity with good growth even under stress conditions. Leaves were medium to large in size with meadow green colour. It shed its leaves during winter. Fruits were medium to large in size and round shaped. The skin and pulp of ripe fruit were mimosa and strawberry coloured respectively.

Selection 5

The plant was medium statured with semi-erect canopy. Leaves were medium to large in size with grass green colour. Pulp had old rose coloured. Fruits were big and pear



Plate.1. General view of tree of Selection-3



Plate.2. General view of tree of Selection-5



Plate.3. View (whole, L.S., C.S.) of fruits of selection-1 and section-3



Plate.4. View (whole, L.S., C.S.) of fruits of selection-5 and section-6



Plate.5: View (whole, L.S., C.S.) of fruits of selection-7 and section-9

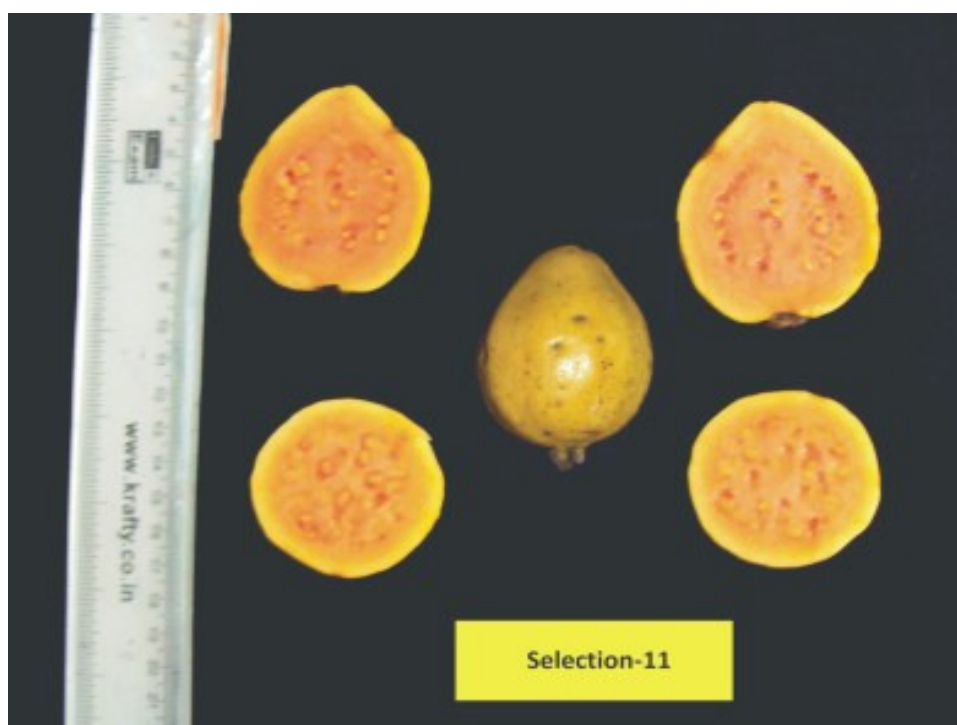


Plate.6: View (whole, L.S.,C.S.) of fruits of selection -11



Selection-1



Selection-3



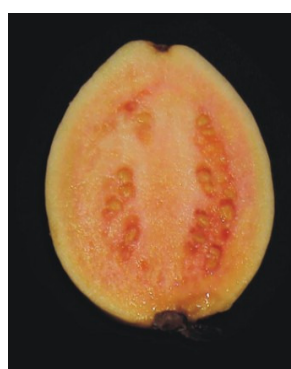
Selection-5



Selection-6



Selection-7



Selection-9



Selection-11

Plate.7: Photographs showing comparative pink colour of fruit pulp in guava selection

shaped with mimosa coloured skin and light pink coloured pulp. Plants exhibited a high bearing capacity.

Selection 6

The plant was large statured and spreading with more open type canopy. Leaves were small to medium in size with lettuce green colour. Fruits were small to medium in size and oval in shape with smooth appearance. The skin colour was canary at ripe stage and pulp was carmine coloured.

Selection 7

The plant had medium to small stature and erect canopy. Leaves were medium to large in size with pine green colour. On account persistent leaves, the plant was evergreen but produced lesser fruits, which were oval in shape. The colour of fruit skin and pulp at ripe stage was citron and shell pink respectively. This cultivar was found more susceptible to pests and diseases.

Selection 9

The plant was small to medium statured with semi-spreading canopy. Leaves were medium to large in size with emerald green colour. The cultivar was a moderate bearer and produced medium sized fruits with camellia coloured pulp and mimosa coloured skin at ripeness. It was less susceptible to pests and diseases.

Selection 11

The plant was dwarf statured, more branching with semi-erect canopy. Leaves were medium to small size and paris green in colour. Fruits were medium in size and oblong to oval in shape with smooth appearance. The colour of skin and pulp were canary and clear pink respectively.

3.3.3 Treatments

There were seven treatments consisting of pink pulped Navalur guava selections as mentioned below:

- | | |
|-----------------|----------------|
| 1. Selection-1 | 2. Selection-3 |
| 3. Selection-5 | 4. Selection-6 |
| 5. Selection-7 | 6. Selection-9 |
| 7. Selection-11 | |

The experiment was laid out in randomized block design with seven treatments and three replications. The map of layout of experiment is depicted in Fig. 1.

3.3.4 Date of planting

The layers were planted on 25th October, 1997.

3.3.5 Plant protection measures

The recommended plant protection measures were followed as per the package of practices prescribed by University of Agricultural Sciences, Dharwad (Anon., 2009).

→ N

Selection-5	Selection-11	Selection-1
Selection-1	Selection-9	Selection-3
Selection-3	Selection-6	Selection-5
Selection-9	Selection-7	Selection-6
Selection-11	Selection-3	Selection-7
Selection-6	Selection-1	Selection-9
Selection-7	Selection-5	Selection-11
R-I	R-II	R-III

Fig. 1. Layout map

3.4 Observations recorded

3.4.1 Growth Parameters

3.4.1.1 Plant height

Plant height was recorded by placing long bamboo pole on the soil surface near the trunk base to the top of the plant and the height was measured in meters.

3.4.1.2 Plant spread

The horizontal distance from one end of the canopy to the other end was recorded in two directions viz. North-South and East-West with the help of bamboo pole which was then measured in meters.

3.4.1.3 Time taken from flowering to maturity

Fully opened flowers were tagged and the date of tagging was recorded. The interval between tagging and date of fruit maturity was recorded in days.

3.4.2 Yield Parameters

Fruit yield per plant both on count basis and weight basis was recorded from each of the selected plants. The details of yield parameters recorded are mentioned below:

3.4.2.1 Number of fruits per plant

In each of the treatment the fruits were harvested at maturity stage and the number of marketable fruits was counted.

3.4.2.2 Total weight of fruits per plant

The harvested fruits were weighed, using a balance and the fruit yield was expressed in kilograms per plant.

3.4.2.3 Estimated fruit yield per ha.

Estimated fruit yield per ha was computed by the formula

$$\text{Fruit yield (q / ha)} = \text{Fruit yield (q / plant)} \times 277 \text{ (No. of plants per ha at 6 m} \times \text{6 m spacing)}$$

3.4.3 Quality Parameters of Fruit

3.4.3.1 Physical parameters

A total of ten mature fruits were sampled from each tree and observations so recorded were averaged.

3.4.3.1.1 Length of fruit

The fruit length was measured from the stalk end to calyx end using vernier calipers and expressed in cm.

3.4.3.1.2 Diameter of fruit

The fruit diameter was measured at the widest cheeks of fruit using vernier calipers and expressed in cm.

3.4.3.1.3 Volume of fruit

The volume of fruit was measured by the conventional water displacement method, expressed in ml.

3.4.3.1.4 Fruit shape at stalk end

The fruit shape at stalk end was described with the help of standard descriptor for guava prescribed by UPOV (International Union for the Protection of new Varieties of plants) (Anon., 1987).

3.4.3.1.5 Weight of fruit

The fruit weight was recorded by using electronic balance and expressed in grams.

3.4.3.1.6 Colour of pulp

The pulp colour was described with the help of Exotica horticultural colour guide (Graf, 1982).

3.4.3.1.7 Weight of pulp

The skin of freshly harvested fruits was peeled and pulp was separated and weighed by using electronic balance. Mean weight was computed and expressed in grams.

3.4.3.1.8 Number of seeds per fruit

The pulp of fruit was made into pieces and boiled in hot water for 15 minutes. Later, the seeds were separated by using ordinary sieve (< 20 mm) and were counted.

3.4.3.1.9 Hundred seed weight

A total of 100 seeds were sampled from the extracted seeds and their weight was recorded using an electronic balance.

3.4.3.1.10 Seed hardness

Seed hardness was observed organoleptically and classified into soft, medium hard, hard and very hard.

3.4.3.2 Chemical parameters

A total of four ripe fruits were sampled from each tree and the following chemical parameters of these fruits were estimated as detailed below:

3.4.3.2.1 Total soluble solids (TSS)

The TSS was determined by using 'Erma' hand refractometer (0-32⁰Brix) and was expressed in ⁰Brix.

3.4.3.2.2 Titrable acidity

Titration acidity was estimated by titrimetric method and expressed as per cent citric acid as described by Ranganna (1977).

3.4.3.2.3 Ascorbic acid

Ascorbic acid was estimated by volumetric method by using 2, 6-dichlorophenol indophenol dye as per the procedure suggested by Ranganna (1977) and expressed as mg/100 g pulp.

3.4.3.2.4 Reducing sugars

The reducing sugars were estimated by following Shaffer Somogi method as described by Ranganna (1977) and expressed as per cent.

3.4.3.2.5 Non-reducing sugars

The quantity of non-reducing sugars was computed by the following formula and expressed as per cent.

$$\text{Non-reducing sugars (\%)} = \text{Total sugars (\%)} - \text{Reducing sugars (\%)}$$

3.4.3.2.6 Total sugars

The total sugars were estimated by following Shaffer Somogi method as described by Ranganna (1977).

3.4.3.2.7 Sugar / Acid ratio

The sugar / acid ratio of guava fruit pulp was calculated by the following formula.

$$\text{Sugar / Acid ratio} = \frac{\text{Total sugar in the fruit pulp (\%)}}{\text{Titrate acidity in the fruit pulp (\% Citric acid)}}$$

3.4.3.2.8 Lycopene pigment

The fruit pulp was taken and squeezed in a muslin cloth by adding repeatedly acetone to extract the juice. One ml of extracted juice was then taken in 100 ml stoppered conical flask and 20 ml acetone was added and kept on mechanical shaker for 30 minutes. Forty ml of petroleum ether was added to this mixture and the absorbance was measured at 503 nm. Lycopene content (mg / 100 g) was calculated by using the below mentioned formula given by Ranganna (1977).

$$\text{Lycopene content} = \frac{3.1206 \times \text{O. D. of sample (\% absorbance)} \times \text{Volume made up (mg / 100 g of juice)}}{\text{Weight of fruit sample} \times 1000} \times 100$$

3.5 Statistical analysis

The data were subjected to statistical analysis of variance technique as given by Panse and Sukhatme (1967). The results were compared with five per cent level of significance.

4. RESULTS

The present investigation on evaluation of pink pulped Navalur guava selections was carried out at Silver Jubilee Orchard, MARS, UAS, Dharwad, during the year 2009. The results obtained on various growth, yield and quality parameters are presented below.

4.1 Growth parameters

The results on growth parameters, viz. plant height, plant spread, time taken from flowering to maturity are tabulated in Table 1.

4.1.1 Plant height

There were significant differences with respect to plant height among various selections. The plants of Selection-5 were significantly taller (5.29 m) when compared to Selection-7 (4.66 m). The plants in Selection-11 (3.90 m), recorded the least height.

4.1.2 Plant spread

The data given in Table 1 showed that plant spread differed significantly in both N-S and E-W directions among the various selections under study. In N-S direction, plant spread was highest (6.34 m) in Selection-5 followed by Selection-7 (4.78 m). However, in E-W direction, plant spread was highest in Selection-3 (6.40 m) which was on par with Selection -5 (6.22) and was significantly superior to Selection-7 (4.58 m).

The minimum plant spread was recorded in both N-S and E-W directions in Selection-11 (3.96 m and 4.33 m, respectively).

4.1.3 Time taken from flowering to maturity

It is evident from the data given in Table 1 that there were significant differences among the selections with respect to time taken from flowering to maturity. Selection-6 recorded the least number of days from flowering to fruit maturity (107.68), followed by Selection-9 (120.40 days). On the other hand, Selection-5 took maximum days to attain fruit maturity i.e. 135.72 days from flowering to fruit maturity.

4.2 Yield parameters

The results on yield parameters, viz. number of fruits per plant, total weight of fruits per plant and fruit yield per hectare are presented in Table 2.

4.2.1 Number of fruits per plant

Significant differences were noticed among the selections under study with respect to number of fruits per plant. Selection-5 recorded the highest number of fruits per plant (809) which was on par with Selection-3 (752.67 fruits per plant) and Selection-6 (744.67 fruits per plant). However, these selections showed significant superiority compared to Selection-1 (563.33 fruits per plant). On the other hand, the lowest number of fruits per plant (192.67) was recorded in Selection-11.

4.2.2 Total weight of fruits per plant

On perusal of data regarding total weight of fruits per plant there were significant differences among the selections. The maximum fruit yield in terms of weight of fruits per plant was recorded by Selection-5 (101.19 kg), which was on par with Selection-3 (91.62). Selection-11 recorded the minimum fruit yield with only 21.17 kg fruits per plant on par with Selection-7 (23.81 kg).

Table 1: Growth parameters of pink pulped Navalur guava selections

Selections	Plant height (m)	Plant spread (m)		Number of days from flowering to maturity
		N-S	E-W	
Selection-1	3.99	5.55	4.83	124.42
Selection-3	4.74	6.11	6.40	133.83
Selection-5	5.29	6.34	6.22	135.72
Selection-6	4.49	5.92	6.10	107.68
Selection-7	4.66	4.78	4.58	125.30
Selection-9	4.37	4.72	4.99	120.40
Selection-11	3.90	3.96	4.33	124.70
S.E. m $\pm$	0.19	0.30	0.26	2.45
CD (5%)	0.57	0.93	0.81	7.53

Table 2: Yield parameters of pink pulped Navalur guava selections

Selections	Fruit yield per plant		Fruit yield per ha (q)
	Number	Weight (kg)	
Selection-1	563.33	53.12	147.14
Selection-3	752.67	91.62	253.78
Selection-5	809.00	101.19	280.30
Selection-6	744.67	62.78	173.91
Selection-7	228.33	23.81	65.96
Selection-9	512.33	53.42	147.98
Selection-11	192.67	21.17	58.63
S.E. m $\pm$	24.13	3.79	10.49
CD (5%)	74.35	11.67	32.31

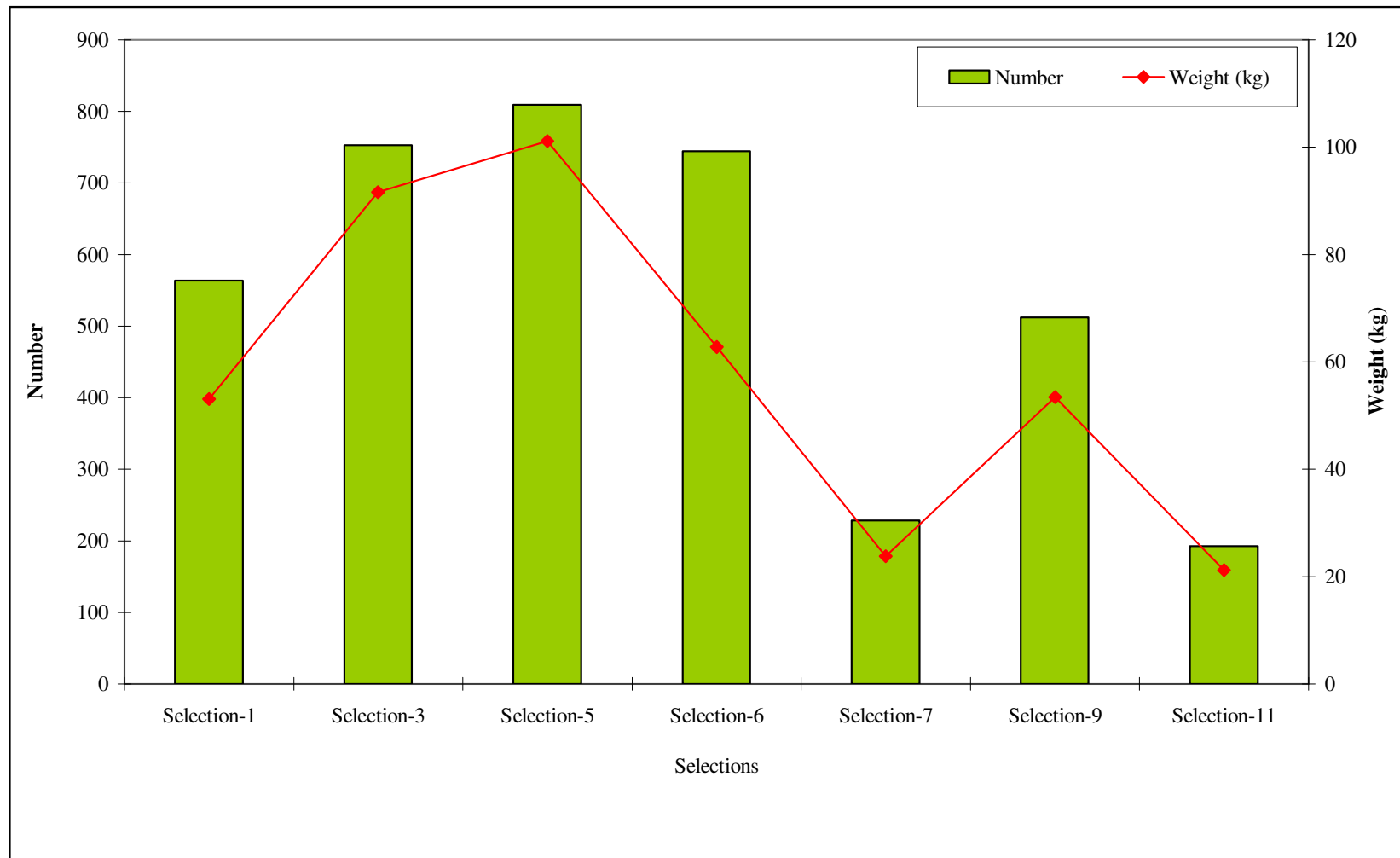


Fig. 2: Yield parameters of pink pulped Navalur guava selections

4.2.3 Fruit yield per ha

The differences noticed among the selections with respect to fruit yield per ha were found to differ significantly. Selection-5 recorded maximum fruit yield per ha (280.30 q) which was on par with Selection-3 which recorded a fruit yield of 253.78 q per ha. These were significantly superior to Selection-6 (173.91 q per ha). However, the lowest fruit yield per ha was recorded in Selection-11 (58.63 q).

4.3 Quality parameters of fruits

The results on physical and bio-chemical quality parameters of fruits harvested from the various selections under the present study are tabulated in Tables 3 and 4.

4.3.1 Physical parameters

The data obtained on physical quality parameters, viz. fruit length, fruit diameter and volume are presented in Table 3.

4.3.1.1 Fruit length

It is evident from the results that there were significant differences among the selections with respect to fruit length (Table 3a). Selection-5 recorded the maximum fruit length (7.73 cm), significantly superior to rest of the selections under study except Selection-1 (7.10 cm). However, the minimum fruit length was found in Selection-11 (6.62 cm).

4.3.1.2 Fruit diameter

There were significant differences among the selections with respect to fruit diameter (Table 3a). The fruit diameter was recorded at maximum (6.37 cm) in Selection-3 and minimum (4.94 cm) in Selection-6. The larger fruits harvested from Selection-3 were at par with those from Selection-5 with respect to their diameter (6.20 cm).

4.3.1.3 Fruit volume

The differences in fruit volume as recorded by various selections were found to be significant (Table 3a). Among them, Selection-5 recorded the maximum fruit volume (124.63 ml), which was on par with Selection-3 (122.76 ml). The lowest fruit volume (82.57 ml) was noticed in Selection-6.

4.3.1.4 Fruit weight

Fruit weight varied significantly among the selections (Table 3b). Selection-5 was observed to bear the heaviest fruits weighing 125.08 g per fruit which was on par with Selection-3 (121.71 g), but significantly superior to Selection-11 (109.67 g). The fruit weight was at minimum (84.34 g) in Selection-6.

4.3.1.5 Fruit shape at stalk end

The observations with regard to fruit shape indicated that there were differences in fruit shape among the selections (Table 3b). Fruits were round shaped in three selections (Selection-3, Selection-7 and Selection-9), whereas they were necked in two selections (Selection-1 and Selection-5) and pointed in the other two (Selection-6 and Selection-11).

4.3.1.6 Pulp weight

The data presented in Table 3b revealed that pulp weight differed significantly among the various selections. The highest pulp weight (58.27 g) was recorded by the fruits born by Selection-7 significantly superior to Selection-3 (45.64 g). The pulp weight was lowest (26.42 g) in the fruits of Selection-6.

Table 3: Physical quality parameters of pink pulped Navalur guava selections
a. Fruit length, fruit diameter and fruit volume

Selections	Fruit length (cm)	Fruit diameter (cm)	Fruit volume (ml)
Selection-1	7.10	5.85	97.76
Selection-3	6.70	6.37	122.76
Selection-5	7.73	6.20	124.63
Selection-6	6.70	4.94	82.57
Selection-7	6.88	5.77	99.23
Selection-9	6.96	5.71	104.78
Selection-11	6.62	5.40	107.00
S.E.m $\pm$	0.19	0.10	5.09
CD (5%)	0.58	0.32	15.69

Table 3: Physical quality parameters of pink pulped Navalur guava selections
b. Fruit weight, pulp weight, fruit shape at stalk end and pulp colour

Selections	Fruit weight (g)	Pulp weight (g)	Fruit shape at stalk end	Pulp colour (colour code)
Selection-1	94.29	57.42	Necked	Light pink
Selection-3	121.71	45.64	Rounded	Strawberry
Selection-5	125.08	57.84	Necked	Clear pink
Selection-6	84.34	26.42	Pointed	Strawberry
Selection-7	104.13	58.27	Rounded	Deep pink
Selection-9	103.48	51.34	Rounded	Shell pink
Selection-11	109.67	52.33	Pointed	Carmine
S.E.m $\pm$	3.32	2.78		
CD (5%)	10.22	8.57		

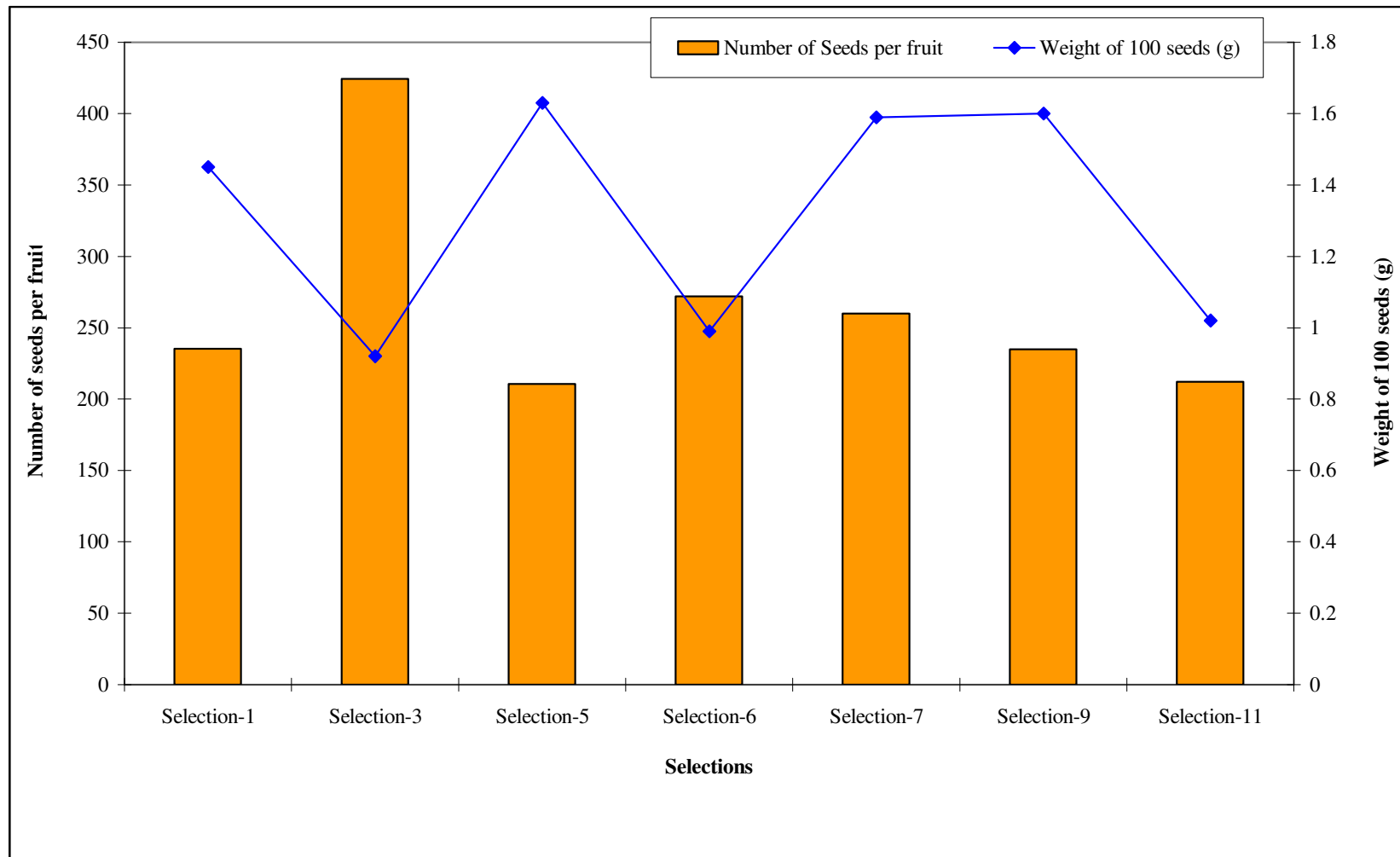


Fig. 3: Number of seeds per fruit and weight of 100-seeds in pink pulped Navalur guava selections

Table 3: Physical quality parameters of pink pulped Navalur guava selections

c. Number of seeds/fruit, weight of 100 seeds and seed hardness

Selections	Number of Seeds per fruit	Weight of 100 seeds (g)	Seed Hardness
Selection-1	235.11	1.45	Medium hard
Selection-3	424.40	0.92	Soft
Selection-5	210.39	1.63	Hard
Selection-6	272.11	0.99	Soft
Selection-7	259.99	1.59	Hard
Selection-9	235.07	1.60	Hard
Selection-11	212.07	1.02	Medium hard
S.E.m $\pm$	6.49	0.06	
CD (5%)	19.99	0.19	

4.3.1.7 Pulp colour

The pulp colour exhibited by the fruits among the selections was contrasting with varied shades (Table 3b). Strawberry coloured pulp was seen in the fruits of Selection-3 and Selection-6. Carmine coloured pulp was observed in Selection-11, whereas Deep pinkish pulp was noticed in Selection-7. The fruits pulps in Selection-5, Selection-1 and Selection-9 were showing Clear pink, Light pink and Shell pink colours, respectively.

4.3.1.8 Number of seeds per fruit

The data presented in Table 3c indicated that there were significant differences among the selections with respect to number of seeds per fruits. Selection-5 recorded the least count of seeds per fruit (210.39) which was on par with Selection-11 (212.07) but significantly different from Selection-9 (235.07). The highest number of seeds per fruit (424.40) was recorded by Selection-3 followed by Selection-7 having 259.99 seeds per fruit.

4.3.1.9 Weight of hundred seeds

The differences noticed among the weights of 100 seeds among the various selections were found significant. The minimum weight of 100 seeds (0.92 g) was recorded by Selection-3 followed by Selection-6 (0.99 g), whereas maximum weight of 100 seeds noticed in Selection-5 (1.63 g).

4.3.1.10 Seed hardness

The selections were found to vary with respect to seed hardness. The seeds were hard in three selections, viz, Selection-5, Selection-7 and Selection-9, medium hard in two (Selection-1 and Selection-11) and soft in the other two (Selection-3 and Selection-6).

4.3.2 Bio-chemical parameters

The results obtained on bio-chemical parameters of fruits, viz. total soluble solids, acidity, ascorbic acid, total sugars, reducing sugars, non reducing sugars, sugar-acid ratio and lycopene content are tabulated in Table 4 (a, b and c).

4.3.2.1 Total soluble solids (TSS)

Total soluble solids (TSS) differed significantly among the various selections (Table 4a). The highest value of TSS (12.87⁰ Brix) was recorded by Selection-3, which was significantly superior to Selection-5 (11.67⁰ Brix) whereas, the lowest TSS (9.70⁰ Brix) was observed in Selection-9.

4.3.2.2 Titrable acidity

On perusal of data presented in Table 4a, revealed that acid content among the fruits of various selections differed significantly. The titrable acidity was recorded minimum (0.22%) in Selection-1, followed by Selection-11 (0.33%). Maximum titrable acidity (0.41%) was noticed in the fruits of Selection-6 which was on par with Selection-9 (0.38%) but, significantly different from Selection-3 (0.37%).

4.3.2.3 Ascorbic acid

There were significant differences among the selections with respect to ascorbic acid content of the fruits (Table 4a). Selection-7 recorded maximum content of ascorbic acid per 100 g of pulp (232.02 mg), which was significantly superior over the other selections, followed by Selection-6 (218.05 mg per 100 g pulp). The minimum ascorbic acid content (109.26 mg per 100 g pulp) was recorded in Selection-5, followed by Selection-3 (137.49 mg per 100 g pulp).

Table 4: Chemical quality parameters of pink pulped Navalur guava selections

a. Total soluble solids, titrable acidity and ascorbic acid

Selections	TSS ($^{\circ}$ B)	Acidity (%)	Ascorbic Acid (mg/100g)
Selection-1	10.19	0.22 (0.27)	143.05
Selection-3	12.87	0.37 (0.35)	137.49
Selection-5	11.67	0.36 (0.35)	109.26
Selection-6	11.05	0.41 (0.37)	218.05
Selection-7	11.38	0.36 (0.34)	232.02
Selection-9	9.70	0.38 (0.35)	165.27
Selection-11	11.21	0.33 (0.33)	208.25
S.E.m $\pm$	0.29	0.01	4.70
CD (5%)	0.90	0.02	14.47

Note: Figures in parenthesis are arcsine values.

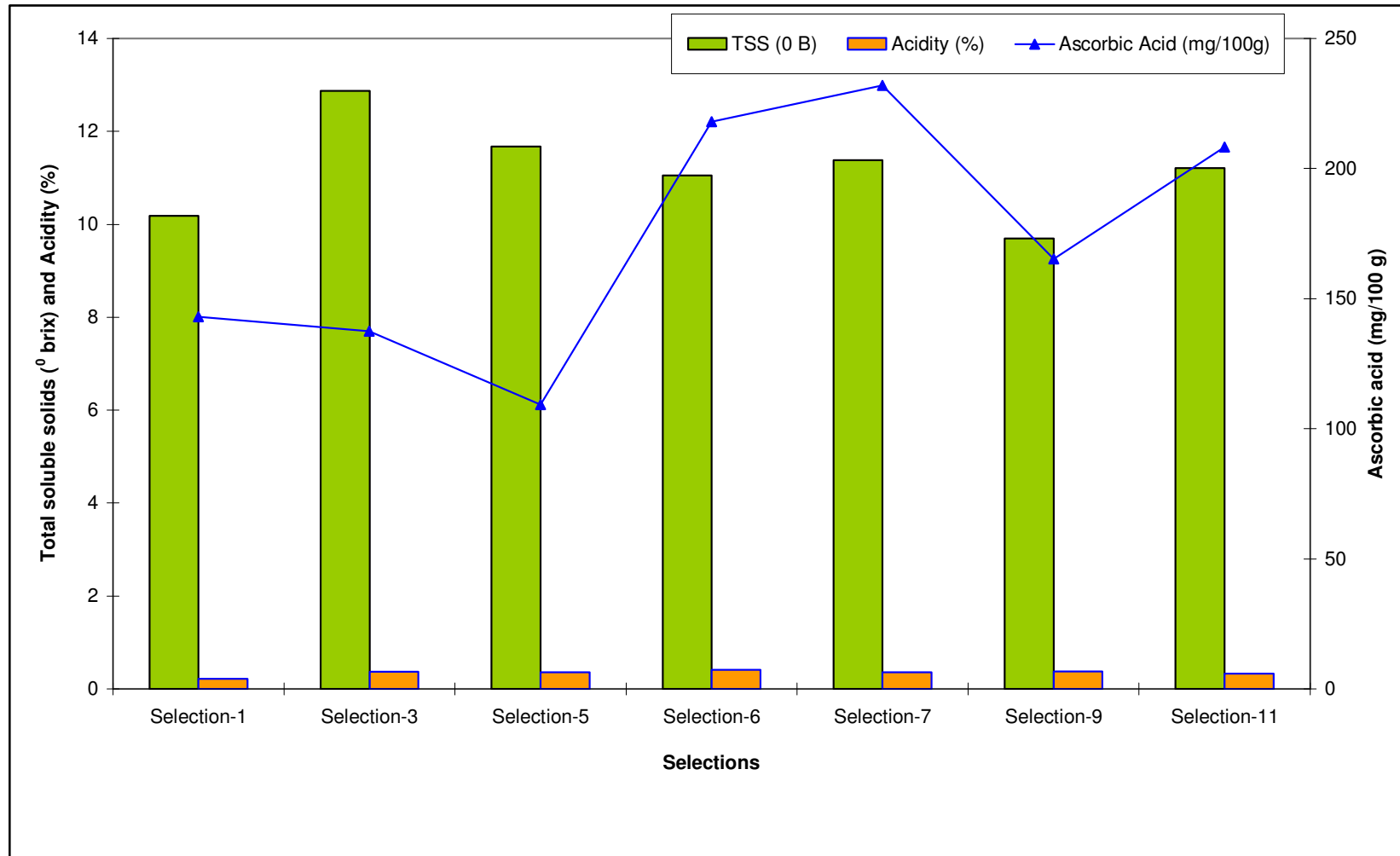


Fig. 4: Total soluble solids, titrable acidity and ascorbic acid in fruits of pink pulped Navalur guava selections

Table 4: Chemical quality parameters of pink pulped Navalur guava selections
b. Reducing sugars, non-reducing sugars, total sugars and Sugar/Acid ratio

Selections	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Sugar/Acid Ratio
Selection-1	3.72 (1.10)	3.21 (1.03)	6.93 (1.51)	32.96
Selection-3	4.76 (1.25)	4.61 (1.23)	9.37 (1.75)	25.51
Selection-5	4.61 (1.23)	4.10 (1.16)	8.71 (1.69)	24.07
Selection-6	3.31 (1.04)	2.51 (0.91)	5.82 (1.38)	14.18
Selection-7	3.92 (1.13)	3.72 (1.10)	7.64 (1.58)	21.54
Selection-9	3.15 (1.02)	3.25 (1.03)	6.40 (1.45)	16.78
Selection-11	3.16 (1.02)	2.64 (0.93)	5.80 (1.38)	17.55
S.E.m $\pm$	0.01	0.02	0.02	1.08
CD (5%)	0.02	0.05	0.05	3.33

Note: Figures in parenthesis are arcsine values.

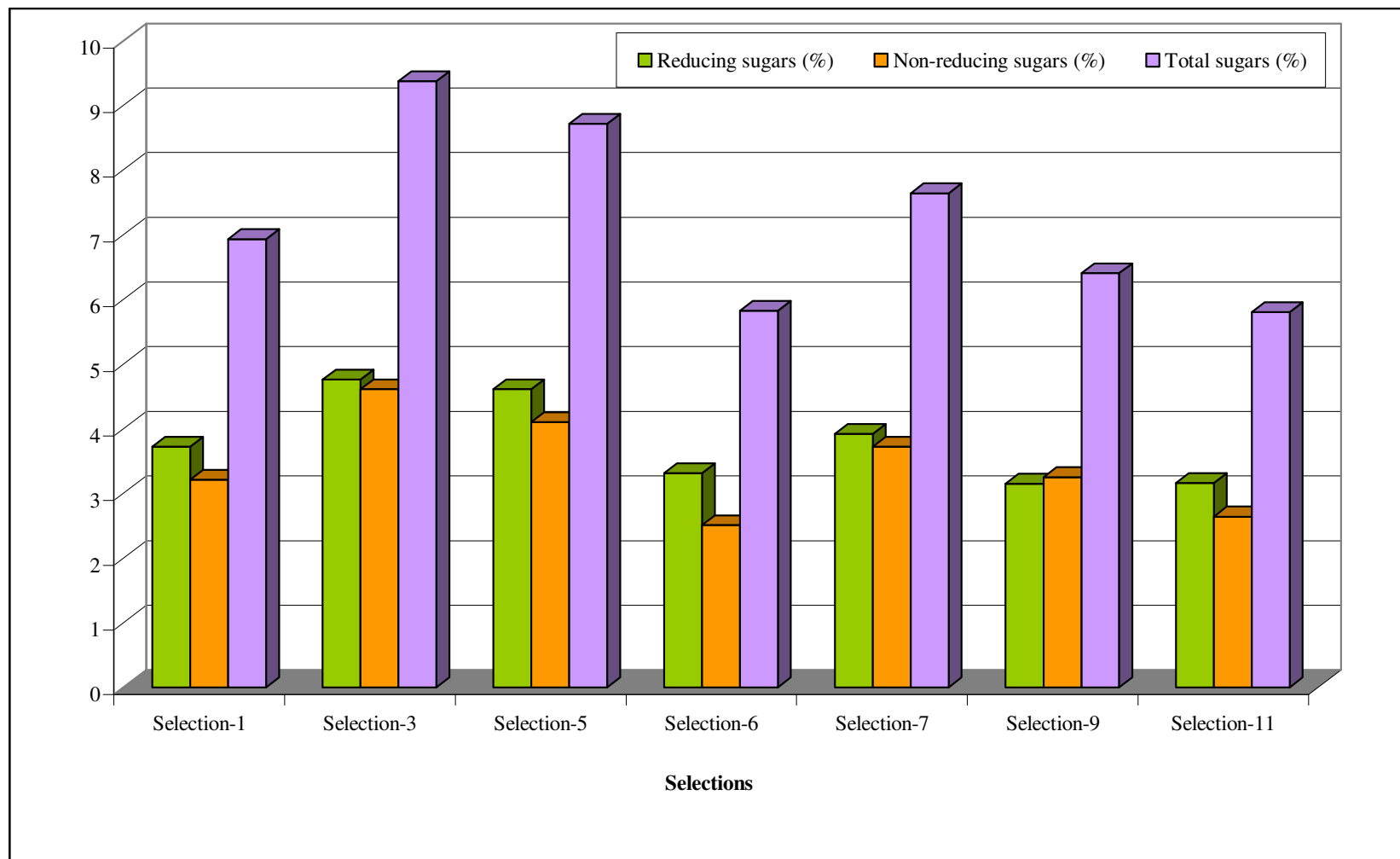


Fig. 5: Sugar content of pink pulped Navalur guava selections

Table 4: Chemical quality parameters of pink pulped Navalur guava selections
c. Lycopene content

Selections	Lycopene (mg 100 g ⁻¹)
Selection-1	1.84
Selection-3	5.10
Selection-5	2.52
Selection-6	3.72
Selection-7	2.83
Selection-9	1.70
Selection-11	3.14
S.E.m ±	0.09
CD (5%)	0.28

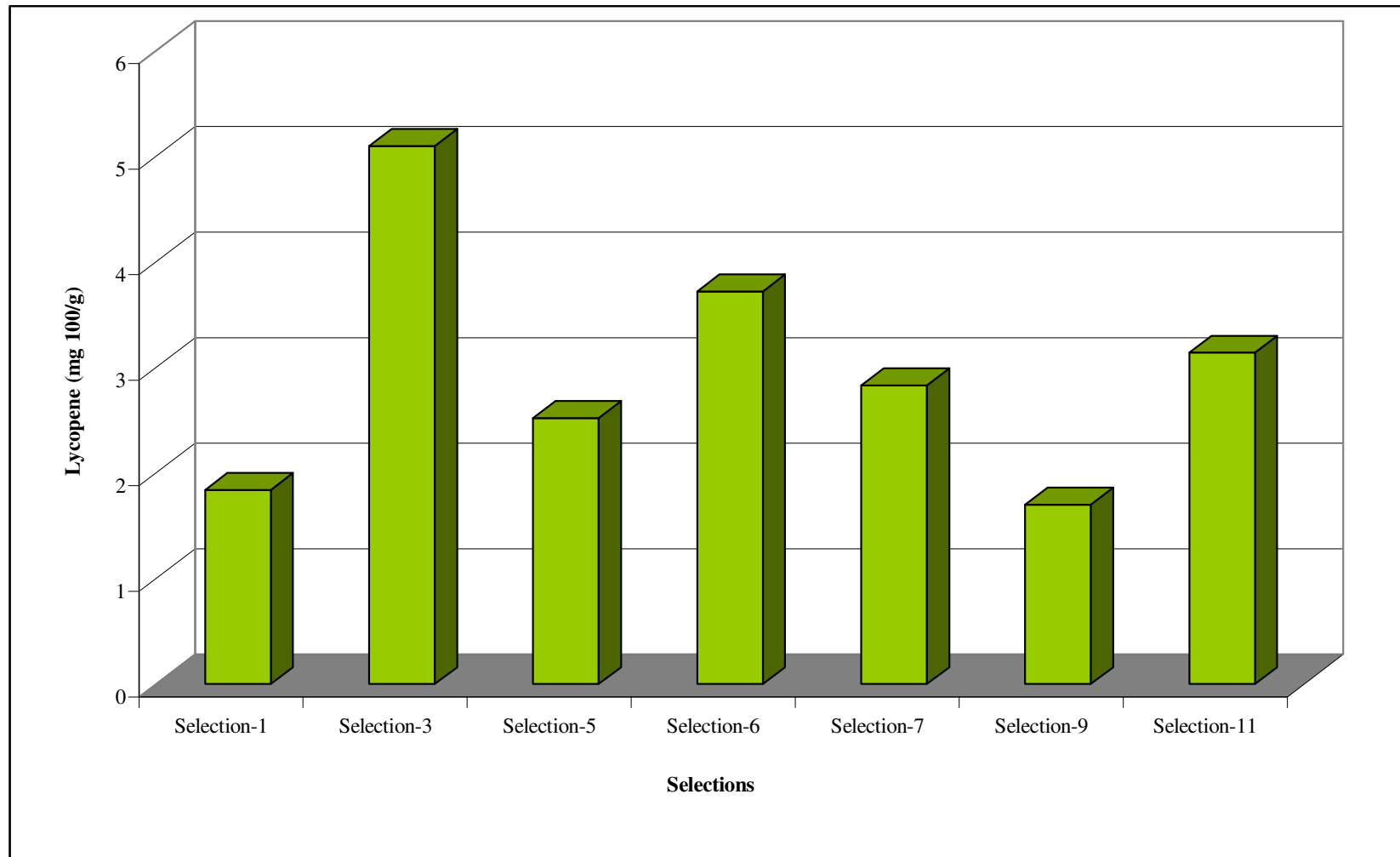


Fig. 6: Lycopene content of pink pulped Navalur guava selections

4.3.2.4 Reducing sugars

It was evident from the data (Table 4b) that there were significant differences among the various selections. The highest content of reducing sugars (4.76%) was observed in Selection-3 which was on par with Selection-5 (4.61%) but significantly different from Selection-7 (3.92%). Selection-9 showed the lowest content of reducing sugars (3.15%), followed by Selection-1 (3.72%).

4.3.2.5 Non-reducing sugars

The content of non-reducing sugars differed significantly among the guava selections. Selection-3 recorded the highest content of non-reducing sugars (4.61%) which was significantly superior to Selection-5 (4.10%). Selection-2 recorded the lowest content of non-reducing sugars (2.51%) which was followed by Selection-11 (2.64%).

4.3.2.6 Total sugars

The differences among the various selections with respect to the total sugar content of fruits were found to be significant (Table 4b). The maximum content of total sugars (9.37%) was recorded by Selection-3, which was significantly superior to Selection-5 having 8.71% of total sugars. However, Selection-11 showed the minimum value of total sugars (5.80%), followed by Selection-6 (5.82%).

4.3.2.7 Sugar-Acid ratio

The values of sugar-acid ratio exhibited significant differences among selections (Table 4b). Sugar-acid ratio was found to be highest (32.96) in Selection-1. It was significantly superior to Selection-3 (25.51). The minimum value of sugar-acid ratio (14.18) was recorded by the fruits of Selection-6.

4.3.2.8 Lycopene content

It was evident from the data tabulated in Table 4c that there were significant differences among the selections with respect to lycopene content of fruit pulp. Maximum lycopene content of 5.10 mg per 100 g pulp was recorded by Selection-3, which was significantly superior to Selection-6 (3.72 mg). Selection-9 recorded the minimum lycopene content of 1.70 mg per 100 g of pulp (1.70 mg) which was on par with Selection-1 (1.84 mg).

5. DISCUSSION

The present investigation on the evaluation of clonally propagated pink pulped Navalur guava selections, viz. Selection-1, Selection-3, Selection-5, Selection-6, Selection-7, Selection-9 and Selection-11 was undertaken at Silver Jubilee Orchard, University of Agricultural Sciences, Dharwad with an objective of selecting high yielding selection that produce dark pink pulp having only few soft seeds. The selections were evaluated with respect to various growth and yield parameters as well as physical and chemical quality parameters of fruits. The results from this evaluation study are discussed in this chapter.

5.1 Growth parameters

Plant height varied significantly among the selections and it was observed maximum in Selection-5 which was on par with Selection-3, while dwarf plant stature was found in Selection-11. The variations in plant height may be attributed to the presence of strong apical dominance in the Selections 3 and 5. Similar views were expressed by Pandey *et al.* (1997), Sadashivaiah (1989) and Athani *et al.* (2007) in their studies.

The plant spread was also found to differ among the selections significantly. Selection-3 recorded wider spread in N-S direction, but Selection-5 showed more spread in account of both (N-S and E-W) directions. So the spread was found uniform in Selection-5. Whereas, the plants of Selection-11 were found to have minimum plant spread.

Out of seven pink pulped Navalur guava selections three selection showed plagiotropic and drooping plant nature followed by plagiotropic and orthotropic types. Selection-1, Selection-6 and Selection-9 showed plagiotropic and drooping nature. The plagiotropic nature was found in Selection-3 Selection-5 and Selection-11, whereas orthotropic plant nature was observed with Selection-7.

The number of days taken from flowering to fruit maturity was found to vary significantly and in association with the size of fruits. The maximum days required for maturity was found in Selection-5 and Selection-3 which recorded maximum fruit weight and fruit volume. Least number of days were recorded in Selection-6 from flowering to fruit maturity, which may be due to the small size of fruits as seen in this selection. Days required from flowering to maturity were found to be moderate in Selection-1, Selection-7, Selection-9 and Selection-11 which produced medium sized fruits. Hence, it can be inferred from the present study that more the amount of assimilates to be diverted to the fruits more the time taken for the attainment of full size and *vice versa*. The similar results were also observed by Sastry (1965) and Deshpande (2006).

5.2 Yield Parameters

The genetic makeup of the plant plays a vital role in the productivity of the plant. Yield is known to be a polygenic character. Besides, care and management of orchard, age of plant and season are the other important factors influencing the yield. In present study it was observed that among the clonally propagated seedling progenies of pink pulped Navalur guava selections, the highest number of fruit per plant was recorded in Selection-5, followed by Selection-3, whereas lowest number of seeds was observed in Selection-11. It might be due to the reason that the different seedling progenies had significant variations with respect to their genetic makeup. This is in conformity with the findings of Marak and Mukunda (2007), Athani *et al.* (2007) and Babu *et al.* (2007).

Among the selections, the total weight of fruits per plant was found to vary significantly closely following the number of fruits per plant recorded by them. Such association between the total weight of fruits per plant and the number of fruits produced per plant among various guava selections was also reported by Singh (1988), Aulakh (2005) and Gohil *et al.* (2006).

5.3 Quality parameters of fruits

5.3.1 Physical parameters

Length, diameter, weight and volume of fruit were the major components of fruit size under the present study. In general there was a wide variation in these physical parameters among the clonally propagated progenies of pink pulped Navalur guava selections and these differences were found statistically significant. The maximum fruit length was observed in Selection-5 and minimum in Selection-11. The variation in fruit length can be attributed to genetic constitution of the seedlings. Similar findings were reported by Sadashivaiah (1989) and Pandey *et al.* (2007).

Selection-3 recorded maximum fruit diameter followed by Selection-5 (6.20 cm) whereas minimum diameter was observed in Selection-6. This variation may be due to phenotypic and genotypic interactions among the selections. Similar variations were observed by Phadnis (1970), Thonte and Chakrawar (1982) and Biradar and Mukunda (2007).

The individual fruit weight and pulp weight are important constituents during crop improvement programme in fruit crops while making selections. Among the various pink pulped Navalur guava selections under the present study a significant variation with respect to fruit weight and pulp weight was noticed (Table 3b). The maximum fruit weight was recorded in Selection-5, while minimum was noticed in Selection-6. Similarly the highest weight of fruit pulp was found in Selection-7 followed by Selection-3, while minimum in Selection-6. Other selections had medium fruit and pulp weight. This may be due to phenotypic and genotypic influence over the different selections which is in conformity with the findings of Singh (1988), Ram *et al.* (1997) and Deshpande (2006).

There were significant differences among the selections with regard to fruit volume. The fruit volume ranged from 82.57 ml in Selection-6 to 124.63 ml in Selection-5. The fruit volume is closely proportionate with fruit weight. Similar findings were observed by Biradar and Mukunda (2007) in TG Selections and also by Raghav and Tiwari (2008).

The fruit shape is one of the important characters from the view point of marketability and packaging of the fruits. There were significant differences among the various selections with regard to fruit shape in the present study. Selection-1 and Selection-5 had necked type of fruits, whereas Selection-3, 7 and 9 showed round fruits. Among them Selection-5 and Selection-3 had larger fruits as evident from the data on fruit length, diameter and volume. This variation may be due genetic character of the seedling progenies. This is in conformity with the findings of Phadnis (1970), Thonte and Chakrawar (1982) and Santos *et al.* (2008).

The dark pink colour of pulp is one of the important characteristics of the fruit in the view of attracting consumers and it is also a demanding quality parameter in processing industry. The pink pulped Navalur guava selections varied with regard to pulp colour. In present investigation the dominant strawberry colour was noticed in the fruits of Selection-3 and Selection-6, while Selection-9 showed inferior shell pink colour. This variation may be due to genotypic constitution that allowed a higher synthesis of lycopene pigment. Similar opinion of pink colouration being associated with pigment composition like lycopene and similar results were also expressed by Jagtiani *et al.* (1988), Preez and Welgemoed (1990) and Santos *et al.* (2008).

Seediness is the major problem in many fruit crops and more so in guava. It is also known in guava that complete seedlessness will result in deformed and misshapen fruits accompanied by reduction in fruit size. In guava, presence of a higher number of hard seeds per fruit is thought to be major drawbacks in any variety. Since the presence of seeds determine shape and size of the fruit, it is desirable to have cultivars with few and soft seeds. From the present study it was observed that in general there was a wide variation with respect to these seed characters among the clonally propagated pink pulped Navalur guava selections and these differences were found to be statistically significant. Minimum number of seeds per fruit was observed in Selection-5, whereas maximum seed count was recorded in

Selection-3 with lowest seed weight and much soft nature (Table 3c). Such variation among the selections in seed characters may be attributed to genetic makeup of the plants. Seed number is known to be a function of value fertility and effective fertilization. Variations in seed characters of guava fruit were also observed in Apple Colour selections by Marak and Mukunda (2007). Similar results were also recorded by Sadashivaiah (1989), Prakash (1976) and Patel *et al.* (2007).

5.3.2 Bio-chemical parameters

Among the different factors influencing fruit quality, bio-chemical components in guava fruit are of utmost concern to assess the fruits either for dessert purpose or for fruit processing. Total soluble solids indicates higher sugar content in the fruits and is considered as one of the important criterion for dessert quality whereas lycopene content which causes pink colouration is important determinant of processing quality.

In the present study, Selection-3 established its supremacy for total soluble solids (TSS), sugars and lycopene content over the other selections. Selection-3 and Selection-5 contained higher TSS while lower TSS was recorded by Selection-9. It may be due to phenotypic and genetic constitution among the selections which might had necessitated consumption of nutrients and sinking more carbohydrates into the fruits, thus producing larger fruits with more TSS. Also the seasonal conditions were more favourable in these selections for good fruit development. This is in conformity with the findings of Ram *et al.* (1997), Athani *et al.* (2007) and Marak and Mukunda (2007).

The sugars present in the fruit impart the sweetness while sugars and organic acids present in the fruit influence its taste and flavour. Moderate acid content coupled with a high total sugar content as observed in the Selection-3 appeared to be favouring good taste and flavour of its fruits, whereas high acidity (0.41%) in Selection-6 resulted in the poor acceptability of its fruits in market. The wide variation in titrable acidity may be attributed to the genetic makeup. This is in conformity with the findings of Tandon *et al.* (1983), Aulakh (2005) and Babu *et al.* (2007).

Guava fruits are consumed for the nutritive value offered by ascorbic acid content promoting their dessert quality. Higher ascorbic acid content was observed in Selection-7 and Selection-6, while Selection-3 and Selection-5 produced fruits with lower ascorbic acid content. Higher ascorbic acid content was found to be associated with total acidity and *vice versa* among the various selections in the present study. The larger variation in ascorbic acid content may be attributed as a varietal character and due to favourability of seasonal conditions. Similar trend was also reported by Gohil *et al.* (2006), Pandey *et al.* (2007) and Biradar and Mukunda (2007).

Entire guava fruit is edible when ripe and freshly harvested will have pleasant taste with higher sugar content. Also sugar is one of the important constituent in the preparation of any product out of guava fruits. Selection-3 scored very well with regard to both reducing and non-reducing sugars and thus recording a higher amount of total sugars per unit of fruit pulp. Selection-11 recorded the lowest total sugars, while Selection-9 recorded the least content of reducing sugars. The significant variation in sugar contents in the fruits of pink pulped Navalur guava selections might have occurred due to genetic or phenotypic features.

The sugar-acid ratio showed wide variations among selections. The sugar-acid ratio was found at maximum in Selection-1 followed by Selection-3 indicating better dessert quality. Selection-6 recorded minimum sugar-acid ratio. This variation may be a varietal character associated with total sugar content and titrable acidity of the fruits. Similar findings were also reported by Sadashivaiah (1989) and Marak and Mukunda (2007) in guava selections.

Lycopene pigment imparts pink colouration to the fruit pulp in guava. However, there was a wide variation, in lycopene pigment among the pink pulped Navalur guava selections. In general, these values corresponded with the intensity of pulp colour. The highest value of lycopene content was recorded in the fruit pulp of Selection-3 which showed dominant strawberry colour, while it was least in Selection-9 where the intensity of colour was faint.

Such variation in lycopene content may be attributed to genetic makeup of the seedling progenies. This is in conformity with the findings of Nakasone *et al.* (1976), Marak and Mukunda (2005) and Chandrika *et al.* (2009).

5.4 Future line of work

The study also indicates the necessity for more research on

1. Pink pulped Navalur guava Selection-3 can be studied for processing into various products like jelly, jam, guava puree, RTS and dehydrated fruits.
2. Selection-3 exhibited excellent physical and biochemical quality parameters and hence can be used in crop improvement programme.
3. Identification and incorporation of lycopene gene into elite cultivars of guava.
4. The red pulp colour of guava is preferable, unlike in golden rice. Selection-3 has excellent quantity of lycopene which can be used as rich source of vitamin-A. The only constraint is the lack of *lyc* (lycopene cyclase) gene which can be incorporated by using biotechnological tools to convert the available lycopene into β -carotene i.e. pro-vitamin-A and further vitamin-A.

6. SUMMARY

A field experiment was carried out at the Silver Jubilee Orchard, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, during the year 2009 to study the performance of pink pulped Navalur guava selections in relation to growth, yield and quality (physical and bio-chemical) parameters and to identify the genotype which is rich in lycopene content having dark pink coloured pulp with soft and less seeds. The pink pulped Navalur guava selections studied were Selection-1, Selection-3, Selection-5, Selection-6, Selection-7, Selection-9 and Selection-11. The results obtained are summarized below.

Significantly higher plant height was recorded in Selection-5, which was on par with Selection-3. Selection-11 had dwarf plant stature, while other selections recorded medium plant height. Plant spread was found higher in Selection-5 and Selection-3 while Selection-11 had less spreading nature. Maturity was attained earlier by the fruits of Selection-6, while Selection-5 showed maximum delay in attaining fruit maturity and produced bigger fruits.

Selection-5 recorded significantly higher number of fruits per plant and also produced maximum yield per plant and per hectare on weight basis, which was on par with Selection-3. Whereas Selection-11 recorded inferior in various yield attributes like, number of fruits per plant, total weight of fruits per plant and per hectare.

The maximum fruit length and fruit diameter was observed in Selection-5 and Selection-3, respectively. Selection-11 recorded minimum fruit length, while Selection-6 noticed minimum fruit diameter. Selection-5 recorded significantly higher fruit weight and fruit volume while these were at lowest in Selection-6. Fruits were round shaped in Selection-3, Selection-7 and Selection-9, necked in Selection-1 and Selection-5 and pointed in Selection-6 and Selection-11. The highest pulp weight was recorded by Selection-7 and lowest was recorded by Selection-6. The pulp colours exhibited by the fruits among the selections were strawberry (dark pink) colour in Selection-3 and Selection-6, shell pink (faint pink) in Selection-9.

Selection-3 recorded the highest number of seeds per fruit but seeds were lighter with soft texture, whereas Selection-5 produced least number of seeds per fruit which were heavy and of hard texture.

The content of total soluble solids (TSS) was highest in Selection-3 and was lowest in Selection-9. Significantly minimum titrable acidity was recorded in Selection-1 and highest content of titrable acidity was noticed in Selection-6. Selection-7 recorded maximum content of ascorbic acid per 100 g of pulp. The minimum ascorbic acid content (109.26 mg per 100 g pulp) was recorded in Selection-5. Selection-3 was found superior in total, reducing and non-reducing sugars content, whereas Selection-11, Selection-9 and Selection-6 were recorded lower amount of total sugars, reducing sugars and non-reducing sugars respectively. Sugar-acid ratio was found to be highest in Selection-1. The minimum value of sugar-acid ratio was recorded by the fruits of Selection-6. Maximum lycopene content was recorded by Selection-3. Selection-9 recorded the minimum lycopene content.

It is inferred from the present study that among the various pink pulped Navalur guava selections, Selection-3 had good growth and produced round fruits with dark pink pulp colour containing lighter as well as softer seeds. It was also found to be the best in terms of sugar content, acidity, sugar-acid ratio and lycopene content. Selection-5 was the highest yielder but produced fruits with hard seeds.

REFERENCES

- Anonymous, 1987, *Int. union for the protection of new varieties of plants. Guidelines for the conduct of tests for distinctness, homogeneity and stability in Guava (Psidium guajava L.)*. Geneva: UPOV. pp. 27.
- Anonymous, 2009, *Package of Practices for Horticultural Crops*, Univ. Agric. Sci., Dharwad. pp. 36-40.
- Anonymous, 2010a, Vitamin-A deficiency. <http://en.wikipedia.org/wiki/Vitamin_A_deficiency> accessed on 25. 05. 2010.
- Anonymous, 2010b, Golden rice. <http://en.wikipedia.org/wiki/Golden_rice. mht> accessed on 25. 05. 2010.
- Athani, S. I., Patil, P. B., Swamy, G. S. K., Sabarad, A. I. and Gorabal, K. R., 2007, Studies on growth parameters and fruit characters in guava cultivars. *Acta Hort.*, **735**: 271-275.
- Aulakh, P. S., 2004, Effect of seasonal variation on yield and fruit quality of some promising guava cultivars under arid irrigated region of Punjab. *Haryana J. Hort. Sci.*, **33** (3-4): 170-171.
- Aulakh, P. S., 2005, Performance of different guava cultivars under the arid irrigated conditions of Punjab. *Prog. Hort.*, **37**(2): 328-330.
- Babu, K. D. and Yadav, D. S., 2002, Screening guava hybrids for yield and quality traits. *South Indian Hort.*, **50**(1-3): 190-194.
- Babu, K. D., Patel, R. K. and Yadav, D. S., 2007, Comparative evaluation of guava selection under North Eastern region of India. *Acta Hort.*, **735**: 99-103.
- Biradar S. L. and Mukunda, G. K., 2007, TG Seln. 5/12 – A promising genotype of Taiwan Guava from Bangalore. *Acta Hort.*, **735**: 85-89.
- Budi Setiawan, Ahmad Sulaeman, David W. Giraud, and Judy A. Driskell., 2001, Carotenoid content of selected Indonesian fruits. *J. Food Composition and Analysis*, **14**: 169-176.
- Chandrika, U. G., Fernando, K. S. S. P. and Ranaweera, K. K. D. S., 2009, Carotenoid content and *in vitro* bioaccessibility of lycopene from guava (*Psidium guajava*) and watermelon (*Citrullus lanatus*) by high-performance liquid chromatography diode array detection. *Int. J. Food Sci. and Nutrition*, **60**(7): 558–566.
- Chundawat, B. S., Gupta, O. P. and Singh, H. K., 1976, Variations in physico-chemical qualities of rainy and winter season guava (*Psidium guajava* L.) fruits. *Haryana J. Hort. Sci.*, **5** (3-4): 154-159.
- Das, B. C., Chakraborty, A., Chakraborty, P. K., Mandal, S. and Ghosh, S., 1995, Comparative performance of guava cultivars under red and lateritic soils of West Bengal. *Hort. J.*, **8**(2): 141-146.
- Deshpande, R. S., 2006, Varietal evaluation and influence of vermicompost in guava. *M. Sc. (Agri.) thesis*, Univ. of Agric. Sci., Dharwad.
- Dubey, P. S., Hoda, M. N. and Singh, S., 2000, Studies on growth behavior of guava germplasm under Sobour conditions for rainy season fruiting. *Indian J. Hort.*, **57** (4): 326-328.

- Girwani, A., Padmavathamma, A.S., Prabhakar Reddy, I., Vanajalatha, K. and Madhavi, A., 2005, Evaluation of guava germplasm for different horticultural traits. *First International guava symposium*, CISH, Lucknow. Abstract No. 2.P.17, pp. 20.
- Gohil, S. N., Garad B. V., Shirsath H. K. and Desai U. T., 2006, Study on physico-chemical constituents in guava (*Psidium guajava*) under sub-arid zone of Maharashtra. *Scientific Hort.*, **10**: 139-147.
- Graf, A. B., 1982, *Exotica Int. Pictorial Cyclopedia exotic plants*. Rochrs Company, East Rutherford, New Jersey USA., Series 4, Vol. II. pp. 1836-1837.
- Jagtiani, J., Harvey, T., Chan, Jr. and William, S. S., 1988, *Tropical fruit processing*. Academic Press Inc. (London) Ltd., pp. 21.
- Marak, J. K. and Mukunda, G. K., 2007, Studies on the performance of open pollinated seedling progenies of guava cv. Apple Colour. *Acta Hort.*, **735**: 79-84.
- Menzel, C. M. and Paxton, B. F., 1985, The pattern of growth, flowering and fruiting of guava varieties in sub-tropical Queensland. *Australian J. Expt. Agric.*, **26**: 123-127.
- Milan, A. R., 2007, Breeding of *Psidium* species for root knot nematode resistance in Malaysia. *Acta Hort.*, **735**: 61-69.
- Mitra, S. K., Maiti, S. C., Sen, S. K. and Bose, T. K., 1983, Physico-chemical characters of some guava varieties of West Bengal. *South Indian Hort.*, **31**: 62-69.
- Mukherjee, S. K. and Dutta, M. N., 1967, Physico-chemical changes in Indian guavas (*Psidium guajava* L.) during fruit development. *Curr. Sci.*, **36**: 674-675.
- Nakasone, H. Y., Brekke, J. E. and Cacaletto, C. G., 1976, Fruit and yield evaluation of ten clones of guava (*Psidium guajava* L.). *Res. Rept. Hawaii Agric. Exp. Stn.*, No. 218. pp. 17.
- NHB, 2009, NHB Database-2009. <http://nhb.gov.in/database_2009.pdf> accessed on 23.01.2010.
- Palaniswamy, K. P. and Shanmugavelu, K. G., 1974, Physico-chemical characteristics of some guava varieties. *South Indian Hort.*, **22**: 8-11.
- Pandey, K. K., Sharma A. B. and Patel M. P., 1997, The varietal evaluation of guava (*Psidium guajava* L.). *Adv. Plant Sci.*, **10** (1): 157-163.
- Pandey, D., Shukla, S. K., Yadav, R. C. and Nagar, A. K., 2007, Promising guava (*Psidium guajava* L.) cultivars for North Indian conditions. *Acta Hort.*, **735**: 91-94.
- Panse, V. C. and Sukhatme, P. V., 1967, *Statistical Methods for Agricultural Workers*. ICAR., New Delhi. pp. 199-210.
- Patel, R. K., Yadav, D. S., Babu, K. D., Singh, A. and Yadav, R. M., 2007, Growth, yield and quality of various guava (*Psidium guajava* L.) Hybrids / cultivars under mid hills of Meghalaya. *Acta Hort.*, **735**: 57-59.
- Phadnis, N. A., 1970, Improvement of guava (*Psidium guajava* L.) by selection in Maharashtra. *Indian J. Hort.*, **27**: 99-105.
- Prakash, N. A., 1976, Studies on growth and fruiting in Sardar guava (*Psidium guajava* L.). *M. Sc. (Agri.) Thesis*, Univ. Agric. Sci., Bangalore, Karnataka (India).
- Preez R. J. and Welgemoed C. P., 1990, Variability in fruit characteristics of five guava selections. *Acta Hort.*, **275**: 351-360.

- Ram, R. A., Pandey, D. and Sinha, G. C., 1997, Selection of promising clones of guava cv. Allahabad Safeda. *Haryana J. Hort. Sci.*, **26** (1-2): 89-91.
- Ranganna, S., 1977, Manual of analysis of fruits and vegetable products, Tata Mc Graw Hill publication Company Ltd., New Delhi, India.
- Raghav, M. and Tiwari, J. P., 2008, Genetic variability and correlation analysis in guava. *Indian J. Hort.*, **65** (3): 263-270.
- Reddy, N. N., Gangopadyay, K. K., Mathura Rai and Ram Kumar, 1999, Evaluation of guava cultivars under rainfed sub-humid region of Chhotanagpur plateau. *Indian J. Hort.*, **56** (2) : 135-140.
- Sadashivaiah, K. N., 1989, Studies on physico-chemical characteristics of Navalur guava (*Psidium guajava* L.) cultivars in relation to fruit yield and quality. *Ph. D. thesis*, Univ. of Agric. Sci., Dharwad.
- Santos, C. A. F., José, M. C. C., Flavio, F. S., Aloísio, A. V., Francisco, R. F., Juliano, G. P., Rita, M. E. B., Rosa, L. B., Aparecida, G. C. and Marciene, A. R., 2008, Preliminary characterization of *Psidium* germplasm in different Brazilian ecogeographic regions. *Pesq. agropec. bras.*, Brasília, **43**(3): 437-440.
- Sastry, M. V., 1965, Biochemical studies in the physiology of guava, Part II-Major chemical changes. *Indian Fd Packer*, **19**: 5-10.
- Singh, M., 1988, Performance of some cultivars of guava (*Psidium guajava* L.) with special reference to their commercial significance in the central gangetic plains. *Punjab Hort. J.*, **28** (3-4): 50-55.
- Singh, I. P., 2003a, Performance of different guava (*Psidium guajava* L.) cultivars under Tripura climatic conditions. *Prog. Hort.*, **35** (1): 55-58.
- Singh, S., 2003b, Effect of season on the vegetative and reproductive attributes of guava Cv. Red Fleshed. *Ann. Agric. Res. New Ser.*, **24** (1): 31-35.
- Srivastava, R. P. and Srivastava, R. K., 1965, Physico-chemical studies on Allahabad Safeda and Red Fleshed guavas. *Punjab Hort. J.*, **5**: 12-15.
- Subramanyam, M. D. and Dinesh, M. R., 1992, Varietal evaluation and floral biology studies in the genus *Psidium*. *Acta Hort.*, **321**: 211-219.
- Tandon, D. K., Kalra, S. K., Singh, H. and Chadha, K. L., 1983, Physico-chemical characteristics of some guava varieties. *Prog. Hort.*, **15** (1-2): 42-44.
- Teaotia, S. S., Pandey, I. C., Dubey, P. S. and Awasthi, R. K., 1968, Description of Red fleshed varieties of guava, *Punjab Hort. J.*, **8**: 127-133.
- Thonte, G. T. and Chakrawar, V. R., 1982, Physico-chemical characters of the certain types/ strains of guava (*Psidium guajava* L.). *Prog. Hort.* **14**(4): 269-272.

APPENDIX

Appendix I: Monthly meteorological data during crop growth period (2009-10) and the average of 58 years (1950-2008) at Main Agricultural Research Station, UAS, Dharwad

Months	Rainfall (mm)		Temperature (°C)				Relative humidity (%)	
	2009-10	1950-2008	Mean maximum		Mean minimum		2009-10	1950-2008
			2009-10	1950-2008	2009-10	1950-2008		
April	52.8	49.3	36.5	37.3	21.1	19.8	81.0	75.6
May	91.6	80.2	35.5	33.7	21.5	21.3	84.0	66.2
June	144.8	114.2	30.3	28.8	20.9	22.4	77.0	81.1
July	256.8	152.4	26.0	29.1	20.9	21.0	88.0	87.1
August	72.2	98.5	28.1	26.9	20.6	20.0	80.0	86.0
September	229.0	104.9	28.5	28.5	20.6	19.9	83.0	82.1
October	141.0	126.9	29.3	30.0	18.8	18.4	65.0	75.8
November	46.0	33.0	28.6	30.1	18.0	15.9	69.0	68.0
December	76.4	5.2	28.6	29.3	15.4	12.5	66.0	63.2
January	0.8	0.1	28.2	29.6	13.4	14.6	63.0	63.1
February	0.4	1.1	32.4	31.2	17.3	16.3	50.0	51.5
March	0.0	2.3	35.6	32.4	20.3	19.5	49.0	56.0
Total	1111.8	768.4						

EVALUATION OF PINK PULPED NAVALUR GUAVA SELECTIONS

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ABSTRACT

A field experiment was carried out at the Silver Jubilee Orchard, MARS, UAS, Dharwad, during the year 2009 to study the performance of pink pulped Navalur guava selections in relation to growth, yield and quality parameters and to identify the genotype which is rich in lycopene content having dark pink coloured pulp with soft and less seeds. Among seven pink pulped Navalur guava selections, Selection-5 was found vigorous exhibiting higher plant height and spread. It also produced the highest number of fruits (809), yield per plant (101 kg) as well as yield per ha (280 q) but took maximum days to attain fruit maturity from flowering.

Fruits were round shaped in Selection-3, Selection-7 and Selection-9, necked in Selection-1 and Selection-5. The highest pulp weight was recorded in Selection-7 (58.27 g). Selection-3 recorded the highest number of seeds per fruit but seeds were soft as they were light in weight. The highest total soluble solids (12.87⁰B) was significantly recorded in Selection-3. Significantly minimum titrable acidity (0.22%) was recorded in Selection-1. Selection-7 recorded maximum content of ascorbic acid (232.02 mg/100 g of pulp). Selection-3 was found superior in total (9.37%), reducing (4.76%) and non-reducing (4.61%) sugars content. Sugar-acid ratio a criteria for taste was found to be highest (32.96) in Selection-1. Maximum lycopene content (5.10 mg/100 g pulp) was recorded in Selection-3 which recorded strawberry coloured pulp. It is inferred from the present study that Selection-3 had good growth and found to be the best in terms of physical and biochemical quality parameters, though Selection-5 was best with respect to yield.