

**Studies on physico-chemical changes during fruit  
growth and development in different varieties of  
guava (*Psidium guajava* L.)**

**A  
THESIS  
SUBMITTED TO THE  
ANAND AGRICULTURAL UNIVERSITY  
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS  
FOR THE AWARD OF THE DEGREE**

**OF**

**Master of Science  
(Horticulture)**

**IN  
FRUIT SCIENCE**

**BY  
MOCHA AJANG**

**B. Sc. (Hort.)**

**DEPARTMENT OF HORTICULTURE  
B. A. COLLEGE OF AGRICULTURE  
ANAND AGRICULTURAL UNIVERSITY**

**ANAND - 388110**

**2014**

**(Reg. No. 04-1955-2012)**

**Studies on physico-chemical changes during fruit growth and development in different varieties of guava (*Psidium guajava* L.)**

**Name of student:**  
Mocha Ajang

**Major Guide:**  
Dr. R. G. Jadav

**HORTICULTURE WING  
B. A. COLLEGE OF AGRICULTURE  
ANAND AGRICULTURAL UNIVERSITY  
ANAND – 388110**

---

**ABSTRACT**

The present investigation entitled “ Studies on physico-chemical changes during fruit growth and development in different varieties of guava (*Psidium guajava* L.) ” was conducted at the Horticulture Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand, during 2013. The experiment was laid out in Completely Randomized Design (CRD). Three varieties of guava viz., Allahabad Safeda, L-49 and Red Guava were selected for the study. The mrig bahar flowering in guava which gives economical yield in winters was taken for the study.

The results revealed that the fruits took about 140 days to reach harvestable maturity from flowering and throughout the entire

fruit development period there was an increase in various physical parameters and chemical parameters viz., fruit weight, fruit volume, fruit length, fruit diameter and TSS, total sugars, reducing sugars, non reducing sugars, ascorbic acid, moisture contents, respectively. But parameters like specific gravity, firmness and acidity showed a decreasing trend with maturity. Fruits exhibited a sigmoid growth curve with three distinct phases of fruit development based on change in diameter, length, weight and volume of the developing fruit.

Among the guava varieties, variety Allahabad Safeda, recorded the highest fruit yield (22.16 kg/tree), higher number of fruits per plant (149.00) with significantly highest value for physical parameters like, fruit weight (151.3 g), volume (152.7 ml), length (6.9 cm), diameter (7.32 cm), pulp weight (140.03 g) as well as chemical parameters like moisture content (75.42 % ), TSS (13.58 °Brix), total sugar (12.37 % ) , reducing sugar (7.99 %), non reducing sugar(4.53 %) and ascorbic acid (282.3 mg/ 100g pulp) as compared to L-49 and Red Guava having eight year old plant. Allahabad Safeda had significantly the highest leaf area (209.7 cm<sup>2</sup>) and low acidity (0.39 %) as compared

to Red Guava (170.37cm<sup>2</sup> and 0.46%) and L-49 (192.07 cm<sup>2</sup> and 0.35%), respectively.

Variety Red Guava, recorded significantly highest number of fruits per plant (174.66), second higher producer of fruit (21.83kg/tree) and physical parameters like fruit weight (127g), volume (129.5 ml), length (6.48 cm), diameter (6.71cm), pulp weight (114.96 g) as compared to L-49. While it recorded the lowest value of chemical parameters like moisture content (71.08%), TSS (11.66 °Brix) reducing sugar(6.96 %), non reducing sugar(3.39 %) and ascorbic acid (227.0 mg/100g pulp). Red Guava had significantly the highest acidity (0.46 %) as compared to Allahabad Safeda (0.39 %) and L-49 (0.35 %).

L-49 variety of guava recorded the lowest yield (17.83 kg/tree), number of fruits per plant (137) and physical parameters like fruit weight (115 g), minimum volume (118.8 ml), length (5.93 cm), diameter (6.31cm) as compared to varieties Allahabad Safeda and Red Guava. However, in comparison to Red Guava it recorded higher chemical parameters like moisture content (72.96%), TSS (13.18 °Brix), total sugar (11.69 %), reducing sugar (7.58 %), non reducing sugar (4.13%) and ascorbic acid (261.5 mg/ 100 gm).



The external appearance of fruit like colour, shape, size can be used by the growers as an index of maturity. The first visible signs of change in colour were seen when the fruit was 100 days old, when the skin became perceptibly lighter in colour. The light green colour of the skin then changed to greenish yellow followed by pale greenish yellow at maturity in variety Allahabad Safeda and L-49. While in Red Guava the fruit turned pale greenish yellow with red tinge at maturity. At maturity the sized is increased and fruit length and diameter increased to 6.90 cm and 7.32 cm in Allahabad Safeda, 5.93 cm and 6.31cm in L-49 and 6.48 cm and 6.71 cm in Red Guava, respectively. Moisture content along with fruit firmness, size, colour and chemical indices like TSS and sugar content can also be used as maturity indices. The moisture increased at maturity and it ranged between 71.08 to 75.42% in matured Guava fruits. Fruit firmness decreased at maturity and ranged between 1.51-1.52 kg/cm<sup>2</sup> for matured fruits. Chemical parameters like TSS and total sugar increased at maturity. Allahabad Safeda recorded TSS (13.58°Brix) and total sugar (12.37 %), while L-49 recorded TSS (13.18°Brix) and total sugar (11.69 %) and Red Guava recorded TSS (11.66°Brix) and total sugar (10.31 %) at maturity.



On the basis of experimental results it can be concluded that the variety Allahabad Safeda ranked first and performed better in most of the growth and physical parameters as well as chemical composition followed by variety L-49, while Red Guava variety was poor in chemical composition and most of the growth parameters.

**Dr. R. G. Jadav**  
Professor & OSD  
Horticulture Wing  
B. A. College of Agriculture  
Anand Agricultural University  
Anand – 388 110, Gujarat (India)



## CERTIFICATE

This is to certify that the thesis entitled “ **Studies on physico-chemical changes during fruit growth and development in different varieties of guava (*Psidium guajava* L.)**” submitted by **Mocha Ajang** Reg. No. **04-1955-2012** in partial fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE (Horticulture) in Fruit Science** of the Anand Agricultural University is a record of bonafide research work carried out by her under my guidance and supervision and no part of the thesis has previously formed on the basis for the award of any degree, diploma or other similar title.

Place: Anand  
Date: / /2014

**(Dr. R. G. Jadav)**  
Major Advisor

## DECLARATION

---

This is to certify that whole of the research work reported in the thesis in partial fulfillment of the requirement for the award of the degree of **Master of Science (Horticulture) in Fruit Science** is the result of investigation done by undersigned under the direct guidance and supervision of **Dr. R. G. Jadav**, Professor & OSD, Horticulture Wing, B. A. College of Agriculture, Anand Agricultural University, Anand and no part of the research work has been submitted for any other degree so far.

Place: Anand

Date:     /     / 2014

(Mocha Ajang)

**Counter signed by**

**Dr. R. G. Jadav**  
Professor & OSD  
Horticulture Wing  
B. A. College of Agriculture  
Anand Agriculture University  
A. A. U., Anand - 388110

## ***ACKNOWLEDGEMENT***

---

*This unprecedented occasion evokes a desire to extend a thankful gesture to those who have bestowed this venture its destination.*

*It is with profound sense of gratitude and reverence that I express my sincere thanks to my major advisor, **Dr. R. G. Jadao**, Professor and OSD Horticulture wing, B. A. College of Agriculture, Anand Agricultural University, Anand for his valuable guidance and constant encouragement with constructive suggestions throughout the course of investigation.*

*A special debt of gratitude is owned to **Dr. J. C. Chavda**, Research Scientist, Bidi Tobacco Research Station, for his enormous help for my research work through his busy schedule and made me oriented towards my study and research work. His guidance helped me to become self confident and made me think logical which supported me throughout preparation and completion of my thesis work.*

*I am greatly thankful to the **Dr. K. B. Kathiriya**, Director of Research & Dean PG Studies, AAU, Anand. **Dr. K. P. Patel**, The Principal, B.A. College of Agriculture, AAU, Anand, for providing necessary guidance and facilities throughout the period of studies.*

*My thanks are also due to **Dr. H. C. Patel**, Professor and Head, Department of Horticulture, BACA, AAU, Anand, and **Dr. J. S. Patel**, Professor and Head, Dept. of Agriculture Statistics, B.A. College of Agriculture, Anand for their kind consent to serve as members of my Advisory Committee.*

*I am greatly indebted to staff members of Dept. of Agriculture Statistics, B.A. College of Agriculture, Anand for their guidance in statistical procedures and analysis of experimental data.*

*I would be unworthy if I do not express my cordial thanks to my seniors Thupten Tsomu, Prabhakar Kore and Rajni Thakkar for their help and inspiration received during the course of my study.*

*My heartfelt thanks are due to my friends Deepa Joshi, Sanju Kumawat, Aido Taloh, Mumtak Lego, Chonpenthung Ngullie, Onima Mize and others who helped me directly or indirectly during the course of my study.*

*Finally, my felicitousness overwhelms to express my deepest sense of reverence and indebtedness to my beloved my dearest father **Shri Banwang Ajang** and mother **Smt. Danya Ajang**, dear brother **Mongsen** and loving sisters **Zincha**, **Wikim** and **Linsen** who have always inspired me, for their love, encouragement and prayers who sustained my spirit at every critical juncture of my educational career.*

*PLACE: ANAND*

*DATE: / / 2014*

*(Mocha Ajang)*

# CONTENT

CHAPTER NO.	PARTICULARS	PAGE NO.
<b>I</b>	<b>INTRODUCTION</b>	<b>1 - 5</b>
<b>II</b>	<b>REVIEW OF LITERATURE</b>	<b>6 -29</b>
	2.1 Growth parameters	6
	2.2 Physical parameters	10
	2.3 Chemical parameters	19
<b>III</b>	<b>MATERIALS AND METHODS</b>	<b>30-43</b>
	3.1 Experimental site	30
	3.2 Experimental detail	31
	3.3 Methodology	34
	3.4 Statistical analysis	42
<b>IV</b>	<b>EXPERIMENTAL RESULTS</b>	<b>44-68</b>
	<b>4.1 Growth parameters</b>	<b>45</b>
	4.1.1. Flower bud development (days)	45
	4.1.2. Leaf area (cm <sup>2</sup> ) and number of leaves / shoot	46
	4.1.3 No. of fruits and fruit yield (kg)/ plant	47
	4.1.4. Pulp and seed weight per fruit (g) as well as pulp: seed ratio and number of seeds per fruit.	48
	<b>4.2 Physical parameters</b>	<b>49-58</b>
	4.2.1. Weight of fruit (g)	49
	4.2.2. Volume of fruit (ml)	50
	4.2.3. Specific gravity	52
	4.2.4. Length of fruit (cm)	53
	4.2.5. Diameter of fruit (cm)	55

	4.2.6. Length : Diameter ratio	56
	4.2.7. Colour of fruit (from colour chart)	57
	4.2.8 Fruit firmness (kg / cm <sup>2</sup> )	58
	<b>4.3. Chemical parameters</b>	<b>59-68</b>
	4.3.1. Moisture content (%)	59
	4.3.2. Total soluble solids (%)	60
	4.3.3. Total sugars (%)	62
	4.3.4. Reducing sugar (%)	63
	4.3.5. Non reducing sugar (%)	64
	4.3.6. Acidity (%)	65
	4.3.7. Ascorbic acid (mg/100 g)	67
<b>V</b>	<b>DISCUSSION</b>	<b>69-78</b>
	5.1 Growth parameters	69
	5.2 Physical parameters	71
	5.3 Chemical parameters	74
<b>VI</b>	<b>SUMMARY AND CONCLUSION</b>	<b>79-85</b>
	<b>6.1 Summary</b>	<b>79-83</b>
	6.1.1. Growth parameters	79
	6.1.2. Physical parameters	80
	6.1.3. Chemical parameters	83
	<b>6.2 Conclusion</b>	<b>84</b>
	<b>REFERENCES</b>	<b>i-ix</b>
	<b>APPENDIX-I</b>	<b>i</b>

**❧ LIST OF TABLES ❧**

Table No.	Title	Page No.
4.1.1.	Days required for bud emergence to full bloom of different varieties of guava .	46
4.1.2.	Leaf area and number of leaves /shoot in different varieties of guava	47
4.1.3.	No. of fruits and fruit yield (kg/ tree) of different varieties of guava ( Age: 8 yrs)	48
4.1.4.	Pulp and seed weight per fruit (g), Pulp : seed ratio and number of seeds per fruit in different varieties of guava .	49
4.2.1.	The periodical weight (g) of guava fruit in different varieties during their growth and development stages	50
4.2.2.	The periodical volume (ml) of guava fruit as influenced by different varieties during their growth and development stages	51
4.2.3.	The periodical specific gravity of guava fruit as influenced by different varieties during their growth and development stages	53
4.2.4.	The periodical length (cm) of guava fruit as influenced by varieties during their growth and development stages	54
4.2.5.	The periodical diameter (cm) of guava fruit as influenced by varieties during their growth and development stages	56
4.2.6.	The periodical length : diameter ratio of guava fruit as influenced by different varieties during their growth and development stages	57
4.2.7.	Colour of guava fruits as influenced by different varieties during their growth and development stage	58
4.2.8.	Fruit firmness ( kg/cm <sup>2</sup> ) of guava fruits as influenced by different varieties during their growth and development stages	59

4.3.1.	The periodical moisture content (%) of guava fruit as influenced by different varieties during their growth and development stages	60
4.3.2.	The periodical total soluble solids (°Brix) of guava fruit as influenced different varieties during their growth and development stages	62
4.3.3.	The periodical total sugar (%) of guava as influenced by different varieties during their growth and development stages	63
4.3.4.	The periodical reducing sugar (%) of guava fruit as influenced by different varieties during their growth and development stages	64
4.3.5.	The periodical non-reducing sugar (%) of guava fruit as influenced by different varieties during their growth and development stages	65
4.3.6.	The periodical acidity content (%) of guava fruit as influenced by different varieties during their growth and development stages	66
4.3.7.	The periodical ascorbic acid (mg/100 g pulp) of guava fruit as influenced by different varieties of guava during their growth and development stages	68

**☞ LIST OF FIGURES ☜**

Fig No.	Title	After Pg. No.
4.2.1.	The periodical weight (g) of guava fruit in different varieties during their growth and development stages	50
4.2.2.	The periodical volume (ml) of guava fruit as influenced by different varieties during their growth and development stages	51
4.2.4.	The periodical length (cm) of guava fruit as influenced by varieties during their growth and development stages	54
4.2.5.	The periodical diameter (cm) of guava fruit as influenced by varieties during their growth and development stages	56
4.3.1.	The periodical moisture content (%) of guava fruit as influenced by different varieties during their growth and development stages	60
4.3.2.	The periodical total soluble solids (°Brix) of guava fruit as influenced different varieties during their growth and development stages	62
4.3.3.	The periodical total sugar (%) of guava as influenced by different varieties during their growth and development stages	63
4.3.4.	The periodical reducing sugar (%) of guava fruit as influenced by different varieties during their growth and development stages	64
4.3.5.	The periodical non-reducing sugar (%) of guava fruit as influenced by different varieties during their growth and development stages	65

4.3.6.	The periodical acidity content (%) of guava fruit as influenced by different varieties during their growth and development stages	66
4.3.7.	The periodical ascorbic acid (mg/100 g pulp) of guava fruit as influenced by different varieties of guava during their growth and development stages	68

**❧ LIST OF PLATES ❧**

Plate no.	Title	After Pg. No.
1	General view of experimental plot	30
2a	Developmental stages of different varieties of guava	68
2b	Developmental stages of different varieties of guava	

## LIST OF ABBREVIATIONS AND SYMBOLS

---

<b>Abbreviations</b>	<b>Meaning</b>
%	Per cent
/, <sup>-1</sup>	Per
<sup>o</sup> C	Degree Celsius
A. A. U.	Anand Agricultural University
AAU	Assam Agricultural University
Anon.	Anonymous
BCKV	Bidhan Chandra Krishi Vishwavidhyalaya
CCS	Chaudhary Charan Singh
C. D.	Critical difference
cm	Centimetre
C. V.	Co-efficient of variance
Cv.	Cultivar
DAFS	Days after fruit setting
<i>et al.</i>	Et alibi, and others
etc.	Etcetera and rest, So on
Fig.	Figure
g	Gram
HAU	Hisar Agricultural University
ha	Hectare
H.P.	Himachal Pradesh
i.e.	That is
IGAU	Indira Gandhi Agricultural University
kg	Kilo gram

m	Meter
Max.	Maximum
mg	Milli gram
ml	Milli liter
mm	Milli meter
MPKV	Mahatma Phule Krishi Vidyapith
MT	Metric tonne
NDUAT	Narendra Deva University of Agriculture & Technology
No.	Number
NS	Non significant
NHB	National horticultural board
PAU	Punjab Agricultural University
RH	Relative humidity
S.Em. <sub>±</sub>	Standard error of mean
Temp	Temperature
TSS	Total soluble solids
Var	Variety
Viz.	Namely
W.B.	West Bengal

## I. INTRODUCTION

---

India is endowed with diverse agro-climatic conditions permitting the cultivation of a large number of tropical, subtropical and temperate fruit crops. Fruit cultivation in India is a source of high economic returns to the farmers and a prominent business sector for exporting merchandise, earning a good amount of international revenue for the country. Research efforts and concern for improving the productivity has resulted in many-fold increase in area and production. In late fifties, estimated production of the fruit was only 7.4 million tonnes from 1.22 million ha. During 2012-2013, a total of 2660.76 thousand MT fruits were produced from 234.05 thousand ha area. Around 10% of the world fruit production is accounted by India. India is the second largest producer of fruits after China (Anon. 2012-13).

Guava (*Psidium guajava* L.) the apple of the tropics is one of the most common fruit in India. It claims to be the fourth most important fruit in terms of area and production after mango, banana and citrus. It was introduced in the early 17<sup>th</sup> century in India and gradually became a crop of great commercial significance. (Bose *et al.*, 2001)

Botanically, guava belongs to the family *Myrtaceae* and has basic chromosome number  $n=11$ . It is a large family and it includes

several tropical species like clove, nutmeg, jamun and eucalyptus. Guavas originated in tropical America and since have been growing from Mexico to Peru. At present, the major guava producing countries are located in South Asia, Hawaiian Islands, Cuba and India. It is believed to have been introduced in India during the early 17<sup>th</sup> century, and it occupies nearly 234.05 thousand ha producing 2660.76 thousand MT. Although it is successfully grown all over India, the most important guava growing states are Uttar Pradesh, Bihar, Karnataka and Maharashtra. Uttar Pradesh is, by far, the most important guava producing state in India holding about 50 % of the total area under cultivation. Allahabad has the reputation of growing the best guava in the country. In Gujarat 10.61 thousand ha area is under guava cultivation producing 158.05 thousand M.T, mainly cultivated in Bhavnagar, Ahmedabad, Mehsana, Kheda districts(Anon. 2012-13).

The guava is grown widely in tropical and sub-tropical regions and succeeds under a varied of climatic conditions. It favours distinct winters and tolerates high rainfall and drought conditions. Fruit setting and fruit development are poor if the temperature is high and humidity is low. The guava is grown on heavy clay soils to very light sandy soils as well as on those, which are commonly considered

suitable for fruit production. The trees are hardy and can stand against the high E.C. and pH. However, well drained condition is necessary for survival as well as good production.

Guava is small tree of 33 ft (10 m) high, with spreading branches. The leaves, aromatic when crushed, are evergreen, opposite, short-petioled, oval or oblong-elliptic, somewhat irregular in outline. Faintly fragrant, the white flowers, borne singly or in small clusters in the leaf axils, are 1" (2.5 cm) wide, with 4 or 5 white petals which are quickly shed, and a prominent tuft of perhaps about 250 white stamens tipped with pale-yellow anthers.

The immature fruit (berry) until ripening is green, hard , very astringent and on ripening exudes a strong, sweet, musky odor, may be round, ovoid, or pear-shaped, 2 to 4" (5-10 cm) long, with 4 or 5 protruding floral remnants (sepals) at the apex; and thin light-yellow skin. Next to the skin is a layer of somewhat granular flesh, 1/8 to 1/2" (3-12.5 mm). The central pulp, is juicy and normally filled with very hard seeds, though some rare types have soft, chewable seeds. Actual seed counts have ranged from 112 to 535 but some guavas are seedless or nearly so. According to Phandis (1970) guava contains 82.50% water, 2.45% acidity, 4.45% reducing sugar, 2.23% non-reducing sugar, 9.73 % total soluble solids, 0.48% ash and 260 mg vitamin C per 100 g of fruit

pulp, and these constituents may differ with the cultivar, stages of maturity and season. It is a rich source of vitamin C (260 mg/100g of fruit pulp) and a single guava fruit contains about four times the amount of vitamin C as an orange. In general, cultivars with pink coloured flesh are poorer in vitamin C content than the white fleshed ones.

Guava (*Psidium guajava* L.) trees show recurring flowering during most of the year. This characteristic has important practical implication, because the fruits harvested during November-February are more valuable (Singh *et al.*, 1989) than those harvested during the rainy season. The spring flowering that tends to fruit during rainy season can be avoided to maximize the yield and improve fruit quality during winter season. Many techniques have been used to induce new growth (on which flowers are borne) by cultural manipulation and thereby controlling the time of flowering and subsequent fruit production during winter season.

The information on physico-chemical changes during growth and development of guava fruits are scanty and it is an essential factor to evaluate the different varieties. Plant growth, yield and physico-chemical attributes are important parameters to study the variability among the different fruit crops (Aulakh 2005, Pandey *et al.*

2007, Patel *et al.* 2007).Therefore present investigation “Studies on physico-chemical changes during fruit growth and development in different varieties of guava (*Psidium guajava* L.)” is being undertaken with the following objectives.

### **OBJECTIVES**

1. To study the pattern of fruit growth and development in different varieties of guava viz., Allahabad Safeda, L-49 and Red Guava
2. To study the physico-chemical changes during the fruit development of guava .
3. To determine the most appropriate time for harvest based on physical change.

## II. REVIEW OF LITERATURE

---

The present investigation “ Studies on physico-chemical changes during fruit growth and development in different varieties of guava (*Psidium guajava* L.)” was undertaken at Horticultural Research Farm, B. A. College of Agriculture, Anand Agriculture University, Anand during the year 2013. The review of literature is presented in this chapter under the following heads.

2.1 Growth parameters

2.2 Physical parameters

2.3 Chemical parameters

2.1 GROWTH PARAMETERS

Ojha *et al.* (1986) studied the floral biology of guava cultivars under Tarai conditions of Uttar Pradesh. The flower buds of guava cultivars Sardar and Allahabad Safeda required similar duration to come into flowering.

The floral biology of guava cultivar Allahabad Safeda and Lucknow-49 was studied by Kahlon *et al.* (1987) at Khalsa college , Amritsar, Punjab. In these cultivars flower bud passed through eight arbitrary stages from dormant to fully opened stage and took 38 to 43 days to complete all the stages in autumn and spring, respectively.

Ojha *et al.* (1987) carried out an investigation on seasonal variation in the physico-chemical composition of guava cultivars Sardar and Allahabad Safeda at Horticulture Research Centre, Pattarchatta(U.P). The size and weight of fruit was less in rainy season crop. Sardar produced lesser number of seeds per fruit than Allahabad Safeda during both the seasons i.e. 230, 208 and 290, 249, respectively.

The performance of 5 year old trees of guava varieties viz. Allahabad Safeda, Red Fleshed and Seedless was studied by Shridhar and Singh (1997) in South Andaman at Garacharma farm of Central Agricultural Research Institute, Port Blair. The variety Allahabad Safeda showed superiority over other varieties with respect to yield and yield attributes. It produced the highest yield (16678 q/ha) followed by Red Fleshed (144.9 q/ha) due to higher fruit weight (153.3 g) size and volume (155 cc) while the maximum no. of fruits/ plant were recorded in Red Fleshed but yield was low due to smaller size as well as volume of fruits.

Reddy *et al.* (1999) evaluated 5 year old trees of six guava cultivars, viz., Lucknow-49, Allahabad Safeda, Apple Colour, Red Fleshed, Chittidar and Arka Mridula at Central Horticultural Experiment Station, Ranchi for 5 years. The higher fruit yield per plant

was observed in Lucknow-49 (277.92 q/ ha), followed by Allahabad Safeda (238.12 q/ha).

Dubey *et al.* (2000) studied the growth parameters on 7 year old trees of 10 genotypes viz., Safed Jam, Kohir Safeda. Hybrid-1, Selection 8, Allahabad Safeda , R<sub>4</sub>P<sub>5</sub>, R<sub>5</sub>P<sub>3</sub>, R<sub>5</sub>P<sub>8</sub>, R<sub>8</sub>P<sub>4</sub>, R<sub>10</sub>P<sub>5</sub> at Bihar Agricultural University, Sabour. The result showed significant differences in respect to new leaves/shoot, maximum being in Allahabad Safeda and Selection 8 i.e 16.88 leaves in both the cultivars. The leaf area was maximum in Allahabad Safeda (436.66 cm<sup>2</sup>) followed by genotype R<sub>5</sub>P<sub>3</sub>. (417.66 cm<sup>2</sup>).

Evaluation of 10 varieties viz., Apple Colour, Allahabad Safeda, Behat Coconut, Chittidar, Allahabad Surkha, Surkh Chitti, Sevial Gudia, Nasik, Red Fleshed and Lucknow 49 for quality characters was carried out by Singh and Singh (2000) at Department of Horticulture BHU Varanasi. Allahabad Safeda was found to have the highest total seed weight per fruit and Behat Coconut had the highest pulp to seed ratio.

An experiment was carried out by Aulakh (2004) at the experimental orchard of Regional Research Station, Abohar (Punjab) to see the performance of six guava cultivars viz. Apple Colour, Allahabad Safeda, Behat Coconut, Pear Shaped, Red Fleshed and Lucknow 49. The

maximum yield per tree was obtained in lucknow-49 (82 kg) followed by Allahabad Safeda (65 kg).

The performance of thirteen guava cultivars viz., Apple Colour, Allahabad Safeda, Baraf Khana, Behat Coconut, Chittidar, Lucknow 49, Mishri, Pear Shaped etc which were 12 years old was investigated by Aulakh (2005) at the experimental orchard of Regional Research Station, Bhatinda (Punjab). The maximum yield per tree was obtained in Lucknow-49 (73.34 kg) followed by Chittidar (71.33 kg).

A trial was conducted by Dubey *et al.* (2009) at the New Horticultural Area of Bihar Agricultural College, Sabour in which seven year old plants of 10 genotypes viz., Safed Jam, Kohir Safed, Hybrid-1, Selection-8, R<sub>4</sub>P<sub>5</sub>, R<sub>5</sub>P<sub>3</sub>, R<sub>5</sub>P<sub>8</sub>, R<sub>8</sub>P<sub>4</sub>, R<sub>10</sub>P<sub>5</sub> and Allahabad Safeda were compared. Yield as well as fruit weight were found to be maximum in Allahabad Safeda and Safed Jam i.e. 36.5 kg/plant, 215 g and 34.7 kg/plant, 205 g, respectively. Allahabad Safeda had least number of seeds(302 seeds/fruit).

Patel *et al.* (2011) studied variability in Guava (*Psidium guajava* L.) Genotypes viz., RCG-1, RCG-2, RCG-3, RCG-11, RCGH-1, RCGH-4, RCGH-7, Allahabad Safeda, L-49, Lalit and Sangam for growth, yield and quality attributes at mid-hills of Meghalaya. The number of leaves / shoot varied from 36.83 in RCGH - 4 to 45.50 in

RCG - 3. The maximum fruit yield was obtained in RCGH-1 (14.18 kg/tree) followed by Lalit (14.12 kg/tree), whereas, minimum in Sangam (5.40 kg/tree) followed by RCG-11 (7.44kg/tree).

## 2.2 PHYSICAL PARAMETERS

Rodriguez, *et al.* (1971) carried out an experiment at Central Food Technological Research Centre, Lucknow to investigate physical and chemical changes in Safeda guava accompanying maturation and ripening. They concluded that fruit weight was increased with maturity except during the last stage of growth. Fruit volume also behaved similarly except that there appeared to be a lesser tendency for fruit volume increase to slow down near fruit ripeness. Fruit firmness readings were possible 100 DAFS and showed declining values with ripening.

Biochemical studies on growth and ripening of guava cultivar Allahabad Safeda) was carried out by Gangwar (1972) at Govt. Fruit Research Station, Barti. A continuous increment was observed in the weight of fruit with age. While specific gravity showed a declining trend. The changes in colour, texture and specific gravity was found closely related with the maturity of fruits.

Gulhane and Gupta (1974) studied the physico- chemical changes in the developing Lucknow-49 fruit. A gradual increase in

volume, weight, length and diameter of the fruits was recorded throughout the period.

Chundawat *et al.* (1976) carried out research on eight cultivars viz., Banarasi Surkha, Seedless, Allahabad Safeda, Tehsilder, Apple Colour, Chittidar, Misri and L-49 grown at the experimental orchard of Department of Horticulture, HAU Hissar. They found that fruit length, width, volume and weight varied significantly with variety. Fruit width and volume were maximum in Seedless followed by Tehsilder and Lucknow-49 with smallest in Banarasi Surkha.

An experiment was carried out at College of Agriculture, Calcutta by Datta and Mukherjee (1980) to observe the physical parameters of two guava cultivars Allahabad Safeda and Red fleshed Pyriform. They observed that the weight and volume of fruit was increased during fruit development in three different phases. Specific gravity was decreased at maturity.

Tandon *et al.* (1983) studied the physico-chemical characteristics of eight guava varieties grown at the Experimental farm of Central Mango Research Station, Lucknow. The fruits of the variety Gunees were of the biggest size (220.9 g/fruit) whereas White Flesh was of the smallest (118 g/fruit).

Study on the development physiology of guava fruits of cultivars Allahabad Safeda and Sardar Guava was carried out by Dhillon, *et al.* (1987) at Punjab Agricultural University, Ludhiana with an objective to determine the most appropriate time for harvest on the basis of physical changes. Weight of fruit of both the cultivars continued to increase till maturity. The volume of the fruit of both the cultivars increased rapidly during stage 1(40 DAFS) and 3(80-130 DAFS) of the growth and slowly during stage 2(40-80 DAFS). The specific gravity of Allahabad safeda and Sardar guava cultivars decreased with advancement of maturity. The pattern of growth in both the cultivars followed a double sigmoid curve.

Kumar and Purohit (1989) studied the fruit growth and development of pomegranate. They observed that the fresh weight of fruits of all the 3 cultivars namely Bassein seedless, Ganesh and Alandi increased continuously from fruit set to harvest time and the growth pattern followed a simple sigmoid curve. Upto 20 days after fruit set, the rind weight was greater than seed weight, while between 20 - 40 days the weights were approximately the same and from 40 days onwards, seed weight was greater than rind weight.

Studies on the physicochemical changes during growth and fruit development of four cultivars viz., Alfred, Blenheim, Kaisha

and New Castle of apricot was carried out by Sharma and Sharma (1990) at Experimental Orchard, Solan (H.P). The fruit growth took place in three different phases. The first phase characterized by a rapid growth. The growth rate in the second phase was slow whereas during the third phase the growth rate was accelerated in respect to average length, diameter, weight and volume of the fruit.

Ojha and Pathak (1992) studied the changes in the physical parameters of five aonla cultivars viz. Banarasi, Chakaiya, Francis, Krishna and Chakaiya at Department of Horticulture, NDUAT, Faziabad. Cultivar Banarasi and Chakaiya showed the maximum and minimum fruit size and weight, respectively. A continuous gain in fruit weight and size were recorded right from the time of initiation of fruit growth upto maturity in all the cultivars. Inconsistent trend was observed with respect to specific gravity in all the cultivars.

Investigation on physico-chemical changes during growth and development of ber fruit was undertaken by Neog *et al.* (1993) at Department of Horticulture, AAU, Jorhat (Assam). They found that the fruit growth in terms of fruit weight, volume and diameter showed a double sigmoid curve. The interval between fruit setting and maturity was 130 days.

Ghanta *et al.* (1994) studied the fruit growth and development of papaya cv. Washington at Horticulture Research Station BCKV, Nadia (W.B). The fruit exhibited double sigmoid growth curve. The period from flowering to skin colour turning stage required 145-150 days and 160-165 days to reach ripening stage. Fruit weight and seed weight was increased throughout the period of fruit development.

A research was carried out by Bulk *et al.* (1995) to investigate physical changes in fruits of four guava cultivars during growth and development at University of Khartoum, Sudan. The skin colour of the fruit changed gradually from dark green to yellow for all cultivars. Fruits picked before day 106 after fruit set had a reading of more than 30 psi( 1 psi  $\approx$  7.9 kPa) and thereafter pressure declined rapidly in all cultivars. Fruit volume was increased rapidly with fruit development for all cultivars.

Supe *et al.* (1997) studied physical parameters of five aonla cultivars like Kanchan, Krishna, Chakaiya, NA-7 and Francis at MPKV, Rahuri. The results indicated that average weight and fruit size were maximum in cv. Francis followed by NA-7 and Kanchan. These varieties also recorded maximum pulp percentage with minimum seed content as compared to varieties Krishna and Chakaiya.

Silva *et al.* (1997) carried out research in selected orchards near Calvillo, Mexico on fruit development, harvest index and ripening changes of guavas produced at central Mexico at 20 days interval. Fruit development showed a double sigmoid curve with three characteristic stages. Fruit weight and diameter increased rapidly in stage 1(43 DAFS) ,slowly in stage 2(43-98 DAFS) and fruit attained the final size at stage 3(98-133 DAFS). Specific gravity increased till stage 2 and with the onset of stage 3 decreased gradually. Firmness was closely associated with the maturity stage. Mature green fruit had the highest penetration values and the yellow fruit had the lowest values.

The physicochemical changes occurring during the growth and development was studied by Rajput and Pandey (1998) in two mango cultivars viz. Langra and Sunderja and two hybrids namely Mallika and Amrapalli at Horticulture farm, IGAU Raipur. Fruit growth in terms of fruit weight, pulp weight and stone weight followed a sigmoid curve pattern and in general , growth was rapid between 30-90 days after fruit set. Fruits of Mallika and Sunderja registered higher pulp weight at harvest maturity. Specific gravity of the fruits showed a decreasing trend upto 45 days after fruit set and a linear increase in specific gravity was observed upto maturity of fruits in all cultivars.

Pandey and Singh (1998) studied the physico-chemical characters of four guava cultivars viz. Sardar (L-49), Allahabad Safeda, Apple colour and Sangam and evaluate their suitability to processing industry at Department of Horticulture, Faziabad. Fruit weight varied from 155 to 219.4 g, while pulp content varied from 91.10 to 94.10 g. Based on physico-chemical characters fruit of sardar (L- 49) guava showed better potentiality for processing industriess.

The physical fruit characteristics of fig were studied by Koyuncu *et al.* (1998). They studied the changes during fruit development in fig. In local fig cultivars are grown in Hilvan. The fruit weight was ranging between 9.00 - 38.37g; fruit width was recorded between 24.40 - 43.60 mm and fruit length between 22.00 - 39.80 mm. They also reported peel colour and peel thickness of the fruits.

Raval *et al.* (1999) observed that among the different varieties of Guava cv. Allahabad Safeda fruits recorded maximum physiological characters like fruit weight, volume, size, length and diameter as compared to fruits of cv. Sardar.

The physico-chemical changes that takes place during development and maturity of pear fruit cv. Patharnakh was studied by Dhillon *et al.* (1999) at Fruit Research Station, P.A.U. Gangian . The length and diameter of fruits were increased gradually throughout its

development, showing almost a linear pattern of growth. The growth pattern of fruit weight and volume showed a slow rate of increase during initial stages and then became linear through harvest.

The physical parameters of eight aonla cultivars like Anand-1, Gujarat Amla-1, Anand-3, Krishna, Kanchan, Chakaiya, LS-3 and NA-7 was studied by Patel (2001) at Anand. The physical parameters like fruit size, weight, stone weight, volume of juice, length and diameter were found significantly maximum in variety Krishna followed by NA-7, while it was minimum in variety LS-3.

An experiment was conducted by Chander *et al.* (2002) to study the physical changes during growth and development of Titron and Alubhukhara cultivars of plum at Experimental Orchard, HAU, Hissar. The fruit weight, fruit size and pulp-stone ratio continued to increase till maturity in both the cultivars. The fruit colour changed to deep purple red and yellowish with red tinge in cv. Titron and Alubhukhara, respectively.

Gupta *et al.* (2003) studied the physico-chemical changes during growth and development in aonla cultivars Chaikaiya and Deshi at the Department of Horticulture HAU, Kaul (Haryana). Physico-chemical analysis of the two cultivars revealed that a gradual increase in average fruit weight and pulp weight with the advancement of

maturity upto 5<sup>th</sup> November and then decreased continuously. The two cultivars differed in their parameters of physical and chemical constituents.

Dhillon and Kumar (2004) studied the changes in physical parameters of pomegranate cultivars Nabha, Kandhari and Ganesh during their growth and development stages. They reported that the variety Nabha had the highest fruit volume, weight and juice percentage. While variety Ganesh was highest in weight of aril in fruits.

Mirdehghan and Rahemi (2006) studied the changes occurring during fruit growth and development of Malas Yazdi pomegranate cultivar in Iran. Pomegranate fruit showed a sigmoid pattern of growth both on diameter and length basis.

Sharma *et al.* (2007) recorded the physical changes of ber fruit cultivar Umran and Kataphal during its development from 15<sup>th</sup> November to 1<sup>st</sup> fortnight of April at Haryana Agricultural University, Hissar. They reported that ber fruit growth took place in three distinct phases resulting into a double sigmoid curve. The fruits of cultivar Umran were found heavier than Kathaphal. The pulp weight, fruit: stone ratio, fruit volume and specific gravity were increased significantly during the initial stages of fruit growth and remained unchanged during later stages of maturity.

### 2.3 CHEMICAL PARAMETERS

Rodriguez *et al.* (1971) carried out research at Central Food Technological Research Centre, Lucknow to investigate physical and chemical changes in Safeda guava accompanying maturation and ripening. The soluble solids content was increased gradually with maturation, except during the end of the growth period. The total titratable acid was increased perceptibly with initial maturity but declined slightly during the later stages of ripening. Ascorbic acid, reducing and total sugars were increased gradually with maturation but decreased during fruit softening.

Gangwar (1972) conducted biochemical studies on growth and ripening of guava cultivar Allahabad Safeda at Govt Fruit Research Station, Barti. He concluded that at maturity stage, the starch began to hydrolyse into sugars, and ascorbic acid content shot up, increasing continuously till ripening. Total soluble solids, sugars, acidity and pectins showed an increasing trend, while starch and tannins a decreasing trend.

Joshi *et al.* (1974) compared the eight cultivars of grape and finally they concluded that chemical properties of cv. Magdeliene royale was found to be the best followed by Golden muscat.

The change in chemical parameters of grape cultivars during their growth and development was studied by Lodh and Selvaraj (1974). They reported that acidity of the developing fruits was increased upto 48 days in Bangalore blue cultivar. The concentration of vitamin C was in trace amount at early stage, while it was 1mg/ 100 g fruit at mature stage. TSS was increased with increased in berry development

An investigation was carried out to study the physico-chemical changes taking place during the development in Lucknow-49 fruit by Gulhane and Gupta (1974). Total sugar and TSS were increased gradually, while acidity decreased gradually upto 60 days after fruit set and then increased thereafter upto maturity. The ascorbic acid was increased upto 120 days after fruit set with successive decrease thereafter.

Evaluation of eight cultivars viz. Banarasi Surkha, Seedless, Allahabad Safeda, Tehsilder, Apple Colour, Chittidar, Misri and L-49 grown at the Experimental Orchard of Department of Horticulture , HAU Hissar was carried out by Chundawat *et al.* (1976).Among all the cultivars, TSS content was highest in Apple Colour followed by Allahabad Safeda and Banarasi Surkha. Acidity was highest in Chittidar, while lowest in seedless. Vitamin C content was highest in

Allahabad Safeda followed by Lucknow-49 and Tehsilder. Non reducing sugar was highest in Allahabad Safeda followed by Banarasi Surkha, whereas, reducing sugars was maximum in apple colour followed by Lucknow-49.

An experiment was carried out by Datta and Mukherjee (1980) to study the changes during growth and development in guava fruits of the cultivars Safeda and Red-Fleshed Pyriform and correlate such changes with maturity and ripening at College of Agriculture, Calcutta. Sugars, total nitrogen, total acids, total pectins, total soluble solids were found to show definite increasing trend during the growth and development of fruits. Total sugar and reducing sugar were increased gradually with maturity but showed a reduction in the final stage of harvest.

Tandon *et al.* (1983) studied the physico- chemical characteristics of eight guava varieties i.e Apple Colour, Behat Coconut, Chittidar, Guines, Karela, Lucknow-49, Mirzapuri and White Fleshed grown at the Experimental farm of Central Mango Research Station, Lucknow. Lucknow- 49 showed the maximum TSS (11.4 ° Brix), while minimum was registered by Chittidar and Apple Colour (9.96 °Brix) in both the cultivars. Among the cultivars analysed, Whitefleshed had the

highest acidity of 0.45 per cent, while Bihat Coconut was rich in vitamin C.

Khodade (1987) observed that TSS of the juice was increased; while the acidity was decreased with the growth of the fruit in both the selections of pomegranate namely G - 137 and P-23. The TSS and acidity of P-23 were higher than that of G - 137. The sugars, both reducing and total sugar were increased throughout the growth in both the selections, where as non reducing sugar content increased upto 120-135 days and then declined with the advancement of maturity. He further reported that tannin content of juice was decreased gradually in both the selections.

Sharma and Sharma (1990) studied the physico-chemical changes during growth and fruit development of four cultivars viz. Alfred, Blenheim, Kaisha and New Castle of apricot at Experimental Orchard, Solan (H.P). The TSS was increased throughout the growing period and it ranged from 12°Brix in New Castle to 18.3°Brix in Kaisha at fruit picking maturity. The acidity was increased initially with the development of fruit and then declined till the picking maturity.

According to, El-Nemr *et al.* (1990) studied the chemical composition of pomegranate juice and reported that the fresh juice

contained 85.4% moisture, 10.67% total sugars, 1.4% pectin, 0.1 mg/100ml total acidity (as citric acid) and 0.7 mg/100 ml ascorbic acid.

Ojha and Pathak (1992) observed the changes in the chemical parameters of five aonla cultivars viz. Banarasi, Chakaiya, Francis, Krishna and Chakaiya at Department of Horticulture, NDUAT Faziabad. A gradual increase in TSS and sugar were observed with increasing maturity and reached maximum at the time of harvest. Acidity was increased in the initial days but after November it decreased with maturity. Ascorbic acid was maximum in Banarasi and minimum in Kanchan.

Studies on the physico-chemical changes taking place during growth and development of ber fruit was done by Neog *et al.* (1993) at Department of Horticulture, AAU Jorhat (Assam). It was found that the total soluble solids, titratable acidity, reducing and total sugars in the fruit pulp were increased toward maturity, while ascorbic acid content was decreased.

Investigation on the changes taking place during fruit growth and development of papaya cv. Washington was done by Ghanta *et al.* (1994) at Horticulture Research Station BCKV, Nadia (W.B). The TSS as well as total and reducing sugar contents were low at early stages of maturity (upto 120 days) and thereafter increased

sharply during ripening. The concentration of titratable acidity was declined with the advancement of maturity.

A research carried out at University of Khartoum, Sudan by Bulk *et al.* (1995) to study the chemical changes in fruit of four guava cultivars during development and ripening. Guava fruits were analysed at three developmental stages for chemical composition like total sugars, ascorbic acid, total soluble solids etc. The total sugar contents and ascorbic acid were increased with fruit growth and development in all the cultivars. While, total soluble solids gradually increased with fruit development in all the cultivars.

At selected orchards near Calvillo, Mexico research was conducted by Silva *et al.* (1997), where they studied fruit development, harvest index and ripening changes of guava at an interval of 20 days. They observed that acidity was declined during development, while ascorbic acid and total soluble solid contents, increased during the last stage of growth.

Rajput and Pandey (1998) studied the physico-chemical changes occurring during the growth and development in two mango cultivars viz. Langra and Sunderja and two hybrids namely Mallika and Amrapalli at Horticulture farm, IGAU Raipur. Titratable Acidity increased after fruit set and slowly decreased towards maturity.

Ascorbic acid of the fruits was decreased after fruit set to maturity and maximum value was observed in Langra. However, TSS and total sugar content of the fruits were increased after fruit set to maturity and highest in Langra and Sunderja, respectively.

Pandey and Singh (1998) studied the physico-chemical characters of four guava cultivars viz. Sardar (L-49), Allahabad Safeda, Apple colour and Sangam and evaluate their suitability in processing industry at Department of Horticulture, Faziabad. TSS and acidity contents were varied from 12.10 to 14.20 per cent and 0.40 to 0.59 per cent, respectively. Total sugar content varied from 6.38 to 6.98 per cent, and vitamin C content of guava cultivars ranged from 149 to 250 mg/100 g of fruit pulp. Based on physico-chemical characters, fruit of Sardar (L- 49) guava showed better potentiality for processing industry.

Investigation on the fruit growth and development in Kinnow was carried out by Singh *et al.* (1998) at PAU, Ludhiana. The fruit growth showed sigmoid curve with 3 distinct phases from 15<sup>th</sup> May to 15<sup>th</sup> July: 15<sup>th</sup> august to 15<sup>th</sup> November and 29<sup>th</sup> November to 8<sup>th</sup> February. The TSS and sugars were increased, while juice acid decreased during the entire period of fruit growth. The ascorbic acid content was increased initially and then decreased with the advancement of fruit maturity.

A research was carried out by Selvaraj *et al.* (1999) at experimental orchard, Hessarghatta where they studied the changes in physico-chemical parameters associated with growth and ripening of Allahabad Safeda and Sardar cultivars. The growth of fruits followed a sigmoid curve. The data indicated that fruit density, total acidity, skin chlorophyll and skin carotenoids decreased, while pulp pH showed marginal changes. The TSS, vitamin C, Sucrose, Glucose and Fructose contents were increased during fruit maturation and ripening.

Dhillon *et al.* (1999) studied the physico- chemical changes that take place during development and maturity of pear fruit cv. Patharnakh at Fruit Research Station, P.A.U. Gangian. The TSS showed a gradual increase from the start of fruit development till harvest. However, the acid content of the fruit showed a reverse pattern to that of TSS

The physiological development of pear cv Bartlett and Flemish Beauty fruit and changes in chemical contents of developing fruits was studied by Sharma *et al.* (1999) at Solan H.P. The total and reducing sugar contents were increased throughout the fruit development. Sugar accumulation was gradual during fruit growth followed by sharp increase towards the maturity and onset of ripening. Flemish Beauty recorded significantly highest amount of sugars than

Bartlett. Titratable acids and sugar : acid ratio showed upward trend in commensuration with fruits growth. Bartlett recorded highest amount of titratable acidity and sugar : acid ratio than Flemish Beauty.

Hedge and Charria (2004) carried out an experiment on guava L-49 at Department of Horticulture, CCS Haryana Agriculture University, Hissar during winter season of 1999-2000. They found that TSS, total sugars and reducing sugars were increased significantly throughout development and ripening of fruits. The TSS (13.83), total sugars (9.24%) and reducing sugars(15.88%) were maximum at 155 days after fruit set. Acidity was increased continuously between 30 -135 days after fruit set and then decreased upto harvest stage i.e. 155 days after fruit set. Ascorbic acid was increased throughout development of the fruits.

Singh and Arora (2000) found that the chemical properties of peach fruits cv. Saharanpur and Prabhat had maximum TSS, total sugar, ascorbic acid with minimum acidity as compared to cv. Flordasun.

Patel (2001) studied the chemical parameters of eight cultivars of aonla at GAU, Anand. Among these, variety Krishna recorded highest TSS, acidity, ascorbic acid. While, highest fiber content was recorded in Gujarat Amla-1 followed by Anand-1.

Chander *et al.* (2002) studied the chemical changes during growth and development of Titron and Alubhukhara cultivars of plum at Experimental Orchard of CCS Haryana Agricultural University Hissar. Total soluble solids and sugars were increased throughout the sampling period and found maximum (i.e., 13.2% and 11.19 %, respectively) in titron. While acidity, ascorbic acid and chlorophyll contents were first increased and then decreased with the advancement of maturity in both the cultivars.

Gupta *et al.*(2003) studied the physico-chemical changes during growth and development in aonla cultivars Chaikaiya and Deshi at Department of Horticulture HAU, Kaul (Haryana). They revealed that a gradual increase in average TSS and ascorbic acid with the advancement of maturity upto 5<sup>th</sup> November and then decreased continuously. The two cultivars were differed in their amounts of physical and chemical constituents.

Studies on the chemical parameters in three cultivars of pomegranate were undertaken Dhillon and Kumar (2004). They observed highest organoleptic rating, acidity and TSS per cent in cv. Nabha, while ascorbic acid content was highest in cv. Ganesh.

Mirdehghan and Rahemi (2006) studied the changes occurring during fruit growth and development of Malas Yazdi

pomegranate cultivar in Iran. The TSS and pH in arils of fruits were increased, while total acidity was decreased throughout the growing season.

Dhillon *et al.* (2007) studied the biochemical changes in semi soft pear fruits of variety Punjab Beauty and Punjab Gold at Department of Horticulture PAU, Ludhiana. The results revealed that the TSS, total and reducing sugar were increased rapidly up to 100 to 110 days after full bloom and thereafter a slow increase was noted in both the cultivars. The total acidity in both the cultivars showed a slight increase up to 30 days after full bloom and then decreased until 100 days and rose slightly after 100 days. The final level of juice acid content was 0.22 % in Punjab Gold and 0.21 % in Punjab Beauty. The TSS : acid ratio was increased throughout the fruit development in both the cultivars.

A study on the chemical changes during ripening of four guava variety, namely, Mukundapuri, Kazipiara, Swarupakhi and Local was conducted at the Bangladesh Agricultural University by Nag *et al.* (2011). The percentage of titratable acidity of all the varieties decreased while moisture, ash, vitamin C, reducing sugar, non-reducing sugar, total sugar and total soluble solids content increased significantly total sugar during ripening.

### III. MATERIALS AND METHODS

---

To study the physico-chemical changes of guava fruit during its development, an experiment was conducted at the Research and Demonstration Farm and laboratory of Horticulture department, Anand Agricultural University, Anand during the year 2013. The details of materials used and methods adopted are described in this chapter.

The experiment was conducted in a Complete Randomized Design (CRD). There were three varieties with six repetitions for the growth and physico-chemical parameters. The *mrig bahar* flowering in guava which gives economic yield in winter was taken for the study. .

#### 3.1 EXPERIMENTAL SITE

##### 3.1.1 Geographical location of the experimental site

Geographically Anand is situated on the 22° 35' North latitude and 72° 56' East longitudes with an altitude of 45.11 meters above the mean sea level.

##### 3.1.2 Experimental materials

The uniform plants of three guava varieties viz., Allahabad Safeda, L-49 and Red Guava were selected for study which

were grown at Research and Demonstration Farm, Department of Horticulture, Anand Agricultural University, Anand.

### 3.1.3. Climate

Generally monsoon of middle Gujarat is warm and moderately humid. It commences by the middle of June and ends in middle of September. An average rainfall of this tract is about 762 mm. Monsoon in this area is often erratic and uncertain, both in respect to total rainfall and uneven distribution. Winter is fairly cool and dry, while summer is quite hot and dry. The temperature rises up to 42 °C during summers.

The meteorological data on maximum and minimum temperature and relative humidity were recorded at the meteorological observatory at the B. A. College of Agriculture, Anand Agriculture University, Anand during 2013 (during experimental period) are given in Appendix-I.

## **3.2 EXPERIMENTAL DETAILS**

3.2.1. Experimental Title: Studies on physico-chemical changes during fruit growth and development in different varieties of guava (*Psidium guajava* L.)

3.2.1.1. Crop and Varieties : Guava – Allahabad Safeda, L-49 and Red Guava

3.2.1.2. Season and Year : Rabi, 2013

3.2.1.3. Experimental design : Complete Randomized Design (CRD)

3.3.1.4. No. of repetitions : 6 (six)

3.2.1.5. Experimental unit : 5 fruits per treatment at an interval of 20 days.

3.2.1.6. Selection of fruits

There were six replications for each treatment and from each treatment five fruits were selected and evaluated at an interval of 20 days.

Observations to be recorded:

Observations were taken at 7 stages at an interval of 20 days starting from 20 days after fruit set.

Stages at which observations were recorded

Sr.No.	Observations	Days After Fruit Set (DAFS)
1	1 <sup>st</sup> observation	20
2	2 <sup>nd</sup> observation	40
3	3 <sup>rd</sup> observation	60
4	4 <sup>th</sup> observation	80
5	5 <sup>th</sup> observation	100
6	6 <sup>th</sup> observation	120
7	7 <sup>th</sup> observation	140



A. GROWTH PARAMETERS:

Following growth parameters were recorded during the experimental period.

1. Flower bud development (days)
2. Leaf area (cm<sup>2</sup>)
3. Number of leaves / shoot.
4. No. of fruits / plant
5. Fruit yield (kg/ tree)
6. Pulp and seed weight/ fruit (g)
7. Pulp: seed ratio
8. Number of seeds/ fruit

B. PHYSICAL PARAMETERS :

1. Weight of fruit (g)
2. Volume of fruit (ml)
3. Specific gravity
4. Length of fruit (cm )
5. width of fruit (cm)
6. Length: width ratio
7. Colour of fruit (visual observation)
8. Fruit firmness (Kg/cm<sup>2</sup>)



### C. BIOCHEMICAL PARAMETERS:

1. Total soluble solids (°Brix)
2. Total sugars (%)
3. Reducing sugars (%)
4. Non-reducing sugars(%)
5. Acidity (%)
6. Ascorbic acid (mg/100g pulp)

### **3.3 Methodology adopted in recording observations**

#### 3.3.1. GROWTH AND DEVELOPMENT PARAMETERS :

1. Flower bud development (days)

Five buds per tree, in six trees of the three varieties were tagged and time (number of days) taken from emergence to full bloom to petal fall was recorded.

2. Leaf area (cm<sup>2</sup>)

Leaf area of five individual leaf per treatment from each variety was measured with the help of leaf area meter in the laboratory of Department of Genetics and accordingly average leaf area was calculated.

3. Number of leaves / shoot

The number of new leaves per shoots during experimental period was recorded during the flowering season.



4. Number of fruits/ plant at harvesting

Mature fruits harvested from selected plants and numbers of fruits were counted.

5. Fruit yield/ plant at harvesting (kg)

Mature fruits harvested from selected plant and weights of fruits were recorded by weighing machine.

6. Pulp and seed weight (g)/ fruit

Pulp weight was measured by deducting the weight of removed seed from total weight of the fruit. Five ripe fruits were randomly selected per treatment from each variety.

Seed were removed from randomly selected five weighed ripe fruits per treatment from each variety, washed and weighed.

7. Pulp: seed ratio

Pulp: seed ratio was obtained from the values of pulp and seed weight.

8. Number of seeds/ fruit

Seed were removed from randomly selected five ripe fruits per treatment from each variety, counted and average was computed.

### 3.3.2. PHYSICAL PARAMETERS DURING GROWTH AND DEVELOPMENT

#### 1. Weight of fruit (g)

The weight of five fruits per replication from each variety was recorded in gram with the help of single pan balance with accuracy of  $\pm 0.5$  g and average value was computed

#### 2. Volume of fruit (ml)

Fruits were placed in measuring cylinder of 1 liter capacity filled with water. The replaced water was measured and the data were recorded as volume of fruits in ml then average value was computed.

#### 3. Specific gravity

The specific gravity of the fruit was determined by weighing fruits from each treatment of each replication in top pan balance and then recording displaced water after sinking fruits in water. The specific gravity was calculated by using the following formula

$$\text{Specific gravity} = \frac{\text{Weight of fruits (g)}}{\text{Volume of fruits (ml)}}$$

#### 4. Length of fruit (cm)

Fruit length was measured from apex to bottom portion of fruit with the help of Viernier caliper. Length of fruit was calculated in cm and average value was computed.

### 5. Diameter of fruit (cm)

Fruit diameter was measured from shoulder to shoulder portion of fruit with the help of Viernier caliper. Diameter per fruit was calculated in cm and average was computed.

### 6. Length: diameter ratio

The Length diameter ratio was calculated by using following formula

$$\text{Length: Diameter ratio} = \frac{\text{Length (cm)}}{\text{Diameter (cm)}}$$

### 7. Fruit colour

The fruit colour was observed and noted visually.

### 8. Fruit firmness (kg/ cm<sup>2</sup>)

Fruit firmness (fruit's pressure) was measured by means of a pocket Penetrometer in terms of pressure required for piercing through the fruit. The pressure required was recorded in kilogram per square centimeter.

## 3.3.3. CHEMICAL PARAMETERS

### 1. Moisture content (%)

The fresh fruit weight was recorded after immediate harvesting the fruit and then kept in oven at 90 °C temperature for 24 hrs. Allowed the sample to cool for half an hour in oven. Then put it in

the desiccator for further cooling. After the completion of these steps, the oven dry fruit weight was recorded. The moisture percentage was calculated by using the following formula.

$$\text{Moisture (\%)} = \frac{\text{Fresh fruit wt (g)} - \text{Dry fruit wt (g)}}{\text{Fresh fruit wt (g)}} \times 100$$

## 2. Total Soluble Solids (<sup>o</sup> Brix)

Total soluble solids (TSS) of fruit juice was recorded by using an Erma hand made refractometer. Drop of extracted guava juice was kept on hand refractometer prim and reading was recorded and expressed in terms of percentage as total soluble solids. Five readings were taken in each sample and their average value was computed.

## 3. Reducing Sugar (%)

The titrametric method of Lane and Eynon described by Ranganna (1979) was adopted for the estimation of reducing sugar.

### Principle of the method

Invert sugar of reducing sugars reduced copper in Fehling's solution to red cuprous oxide. The sugars in a sample were estimated by determining the volume of unknown sugar solution required to completely reduce a measured volume of standard Fehling's solution.

Twenty five gram of the homogenized pulp was taken and transferred to a 250 ml volumetric flask and 2 ml of 45 lead acetate solution was added for clarification. After 10 minutes, the solution was dealed by adding potassium oxalate crystals in excess (5 to 10 g) and volume was made up the distilled water. The contents were then centrifuged for about 10 minutes. The clear supernatant solution was taken in a burette and titrated with boiling Fehling's mixture( 5 ml of Fehling's solution A and 5 ml of Fehling's solution B ) till the blue colour faded. At the stage 1 ml of 1 % methylene blue indicator was added and the titration continued till content attained brick red colour. At this stage titration was stopped and the titre value noted from the burette. Percentage reducing sugars was calculated from the following formula.

$$\text{Reducing sugar (\%)} = \frac{\text{Glucose equivalent} \times \text{Total volume made up}}{\text{Titre value} \times \text{Weight of pulp}} \times 100$$

#### 4. Total sugar (%)

For estimation of total sugar, the filtrate obtained in the estimation of reducing sugar was used. The total sugars of the filtrate were estimated by using standardized Fehling's solution A and B using methylene blue indicator as per the procedure described below.



## Procedure

An aliquot (25 ml) from the filtrate was taken and one-fifth of its volume (5ml) and added hydrochloric acid (1:1) and the inversion was carried out at room temperature for 24 hours. Subsequently, the content was cooled and neutralized with 40 % sodium hydroxide using phenolphthalein as indicator and the final volume was made up to 100 ml. The solution was filtered through Whatman No. 1 filter paper and then titrated against boiling Fehling's mixture as described earlier.

The percentage of total sugars was expressed as invert sugar according to the formula.

$$\text{Total sugar (\%)} = \frac{\text{Glucose eq. of fehling solutions (0.05)}}{\text{Titre}} \times \frac{\text{Total volume made up}}{\text{Weight of pulp taken}} \times \frac{\text{Volume made up after inversion}}{\text{Aliquot taken for inversion}} \times 100$$

## 5. Non Reducing Sugar (%)

Non-reducing sugar is calculated by following formula:

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

## 6. Acidity (%)

The method described by Ranganna (1979) was adopted for estimation of the titrable acidity of fruits.

### Procedure

Ten gram of the homogenized pulp was transferred to 100 ml volumetric flask and the volume was made up with distilled water. The suspension was well mixed and filtered through Whatman No. 1 filter paper and the filtrate was used for titration. Five ml of the aliquot was taken from the filtrate and titrated against standard sodium hydroxide using phenolphthalein as an indicator. The titrable acidity was expressed as percentage based on citric acid equivalent adopting the following formula.

$$\text{Acidity (\%)} = \frac{T \times N \times Q \times E}{V \times W \times 1000} \times 100$$

Where,

T = Titre volume (ml)

N = Normality of alkali

Q = Volume made up (ml)

E = Equivalent weight of citric acid (g)

V = Volume of sample taken for estimation (ml)

W = Weight of sample (g)

### 7. Ascorbic acid (mg/100 g pulp)

Ascorbic acid (Vitamin C) was determined by using the titrimetric method described by Ranganna (1979). The 10 ml volume of homogenized juice was taken and transferred to a 100 ml volumetric flask. Volume was made up with 3 % metaphosphoric acid (HPO<sub>3</sub>) solution. The dye (2, 6- dichlorophenol indophenols) was standardized by titrating against standard ascorbic acid and the dye factor was calculated. The 10 ml volume of aliquot was taken in 100 ml conical flask and titrated against standard dye solution through a burette. Titration was continued till the light pink colour persisted for more than 15 seconds. The ascorbic acid content was calculated by using following formula:

$$\text{Ascorbic acid} = \frac{\text{Titre value} \times \text{dye factor} \times \text{volume made up}}{V \times W} \times 100$$

Where,

V = Aliquot taken for estimation (ml)

W = Volume of sample taken for estimation (g)



### **3.4. Statistical analysis**

The data obtained during the investigation were subjected to statistical analysis by making use of variance technique (Steel and Torrie, 1980). The method of analysis of variance for Completely Randomized Design (C.R.D.) was used for experiment. The appropriate standard error of mean (S. Em.  $\pm$ ) was calculated in each case. For the varieties and period which were found to be significant, the critical difference (C. D.) at 5 % level of probability was worked out to compare the three varieties over the periods. Coefficient of variation was calculated for judging the significances.

## IV. EXPERIMENTAL RESULTS

---

The present experiment "Studies on physico-chemical changes during fruit growth and development in different varieties of guava (*Psidium guajava* L.)." was carried out at Horticulture Research Farm, B.A. College of Agriculture, AAU, Anand, during the year 2013. The results obtained during the course of investigation are presented in this chapter under the following heads.

### 4.1 Growth parameters

4.1.1. Flower bud development (Days)

4.1.2. Leaf area (cm<sup>2</sup>) and number of leaves / shoot

4.1.3. No. of fruits / plant and Fruit yield (kg) / plant

4.1.4. Pulp and seed weight per fruit (g) as well as Pulp: seed ratio and number of seeds per fruit.

### 4.2 Physical parameters

4.2.1. Weight of fruit (g)

4.2.2. Volume of fruit (ml)

4.2.3. Specific gravity

4.2.4. Length of fruit (cm)

4.2.5. Diameter of fruit (cm)

4.2.6. Length : diameter ratio

4.2.7. Colour of fruit (visual observation)

4.2.8. Fruit firmness. ( kg/ cm<sup>2</sup>)



### **4.3 Chemical parameters**

4.3.1. Moisture content (%)

4.3.2. Total soluble solids ( ° Brix)

4.3.3. Total sugars (%)

4.3.4. Reducing sugar (%)

4.3.5. Non reducing sugar (%)

4.3.6. Acidity (%)

4.3.7. Ascorbic acid content (mg/100 g pulp)

### **4.1. Growth parameters**

#### **4.1.1. Flower bud development (days)**

The data on growth parameters i.e. number of days taken from bud emergence to full bloom was recorded in all the guava varieties and presented in Table 4.1.1.

All the three cultivars required almost similar duration for flower bud development. Flower shed their petals two days after anthesis in all the cultivars.



**Table 4.1.1. Days required for bud emergence to full bloom of different varieties of guava**

Varieties	Total number of buds observed	Bud emergence to full bloom(days)	Full bloom to petal shed(days)
Allahabad Safeda (V <sub>1</sub> )	30	38.83	2
L- 49 (V <sub>2</sub> )	30	39.16	2
Red Guava (V <sub>3</sub> )	30	38.16	2
S.Em.±	-	0.99	-
C.D. 0.05	-	NS	-
CV %	-	6.27	-

#### 4.1.2. Leaf area (cm<sup>2</sup>) and number of leaves / shoot

The data on growth parameters i.e. Leaf area and number of leaves / shoot were recorded at flowering stage in all the guava varieties and presented in Table 4.1.2

The leaf area was significantly influenced by the different varieties of guava. The data indicated significant differences among the varieties in which maximum leaf area was recorded by the variety Allahabad Safeda (209.70 cm<sup>2</sup>) followed by L-49(192.07cm<sup>2</sup>) and Red Guava (170.37cm<sup>2</sup>). However the number of leaves / shoot was not significantly influenced due to varieties.

**Table 4.1.2. Leaf area and number of leaves/shoot indifferent varieties of guava**

Varieties	Number of leaves / shoot	Leaf area(cm <sup>2</sup> )
Allahabad Safeda (V <sub>1</sub> )	15.66	209.70
L- 49 (V <sub>2</sub> )	15.50	192.07
Red Guava (V <sub>3</sub> )	15.00	170.37
S.Em.±	0.59	9.23
C.D. 0.05	NS	27.82
CV %	9.32	11.86

**4.1.3. No. of fruits and fruit yield (kg)/ plant**

The number of fruits and fruit yield per plant were significantly influenced by different varieties. The data are presented in Table 4.1.3.

The data indicated significant differences among the varieties in which maximum fruits per plant was recorded by the variety Red Guava (174.66) followed by Allahabad Safeda (149) and L-49 (137).

The variety Allahabad Safeda recorded higher fruit yield (22.16 kg/tree) as compared to L-49 (17.83 kg/tree) and remained at par with Red Guava (21.83 kg/tree).

**Table 4.1.3. No. of fruits and fruit yield (kg/ tree) of different varieties of guava(Age: 8 yrs)**

Varieties	No. of fruits/plant	Fruit yield (kg/tree)
Allahabad Safeda (V <sub>1</sub> )	149.00	22.16
L- 49 (V <sub>2</sub> )	137.00	17.83
Red Guava (V <sub>3</sub> )	174.66	21.83
S.Em.±	4.39	0.98
C.D. 0.05	13.23	2.95
CV %	7.00	11.65

**4.1.4. Pulp and seed weight per fruit (g) as well as pulp: seed ratio and number of seeds per fruit**

Pulp and seed weight per fruit (g), pulp: seed ratio and number of seeds per fruit as influenced by different varieties were recorded at maturity and presented in Table 4.1.4.

The pulp weight, seed weight and number of seeds per fruit were significantly influenced by the different varieties of guava except pulp to seed ratio. The variety Allahabad Safeda recorded significantly the highest pulp weight per fruit (140.03 g) as compared to varieties L49(110.5 g) and Red Guava (114.96 g) which remained at par with each other. Similarly seed weight per fruit was significantly highest in the variety Allahabad Safeda (4.22 g) as compared to L-49(3.26 g) and Red Guava (3.4 g), which were at par. However, pulp to seed ratio was not significantly influenced by the varieties. In case of number of seeds per

fruit, it was significantly highest in the variety Allahabad Safeda (298.7), followed by Red Guava (231.2) and L-49 (200.3).

**Table 4.1.4. Pulp and seed weight per fruit (g), Pulp: seed ratio and number of seeds per fruit in different varieties of guava**

Varieties	Pulp weight(g)/ fruit	Seed weight(g)/ fruit	Pulp/ seed Ratio	No of seeds/ fruit
Allahabad Safeda (V <sub>1</sub> )	140.03	4.22	33.23	298.7
L- 49 (V <sub>2</sub> )	110.50	3.26	33.89	200.3
Red Guava (V <sub>3</sub> )	114.96	3.40	33.76	231.2
S.Em.±	2.21	0.12	0.93	4.85
C.D. 0.05	6.65	0.37	NS	14.60
CV %	4.44	8.20	6.77	4.88

## 4.2 Physical parameters

### 4.2.1. Weight of fruit (g)

Weight of guava fruit as influenced by different varieties was recorded periodically at an interval of 20 days after fruit setting (DAFS).The results are presented in Table 4.2.1 and also graphically depicted in Fig. 4.2.1

There was a significant difference among the varieties, in which variety Allahabad Safeda recorded significantly highest fruit weight i.e. 6.31, 26.25 and 35.32 g at 20, 40 and 60 DAFS as compared to L-49 and remained at par with variety Red Guava. With the advancement of growth period, there was a gradual increase in fruit

weight and it was observed to be maximum at the time of maturity i.e. at 140 DAFS. After 80 DAFS the variety Allahabad Safeda recorded significantly highest fruit weight upto maturity as compared to rest of varieties at all the intervals. The results at maturity indicated that variety Allahabad Safeda recorded significantly the highest fruit weight (151.3g) followed by Red Guava (127g) and L-49 (115 g).

**Table 4.2.1. The periodical weight (g) of guava fruit indifferent varieties during their growth and development stages**

Varieties	Days After Fruit Setting (DAFS)						
	20	40	60	80	100	120	140
Allahabad Safeda (V <sub>1</sub> )	6.31	26.25	35.32	46.67	79.18	118.6	151.3
L- 49 (V <sub>2</sub> )	4.40	21.00	29.15	35.27	57.95	98.83	115.0
Red Guava (V <sub>3</sub> )	5.95	26.00	34.38	41.46	77.85	112.7	127.0
S.Em.±	0.09	0.60	0.95	2.10	0.50	1.93	2.42
C.D. 0.05	0.28	1.82	2.88	6.33	1.50	5.81	7.29
CV %	4.11	6.06	7.10	8.50	1.70	4.33	4.52

**4.2.2. Volume of fruit (ml)**

The data on volume of fruit as influenced by different guava varieties were recorded periodically at an interval of 20 days are given in Table 4.2.2 and graphically depicted in Fig. 4.2.2.

The volume of fruits among the varieties was found significant during all the growth and development stages. Initially at 20 days of fruit setting, the fruit volume was significantly highest in

the variety Allahabad Safeda (5.93ml) as compared to varieties Red Guava (5.60ml) and L-49 (4.06ml). With the advancement of growth period, there was a gradual increased in fruit volume and it was maximum at the end of experiment i.e at maturity. While, at 40-100 DAFS variety Allahabad Safeda recorded significantly the highest fruit volume as compared to variety L-49 and remained at par with variety Red Guava. The results at 120 and 140 DAFS indicated that variety Allahabad Safeda had significantly highest fruit volume (119.9 and 152.7 ml) followed by Red Guava ( 113.5 and 129.5ml) and L-49 ( 100.7 and 118.8ml).

**Table 4.2.2. The periodical volume (ml) of guava fruit as influenced by different varieties during their growth and development stages**

Varieties	Days After Fruit Setting (DAFS)						
	20	40	60	80	100	120	140
Allahabad Safeda (V <sub>1</sub> )	5.93	25.13	33.81	44.98	80.28	119.9	152.7
L- 49 (V <sub>2</sub> )	4.06	19.93	27.12	33.46	61.73	100.7	118.8
Red Guava (V <sub>3</sub> )	5.60	24.96	33.01	40.30	78.04	113.5	129.5
S.Em.±	0.10	0.64	0.92	1.67	2.26	0.96	1.01
C.D. 0.05	0.29	1.94	2.76	5.02	6.81	2.88	3.03
CV %	4.51	6.75	7.16	10.31	7.54	5.10	5.84



### **4.2.3. Specific gravity**

The data pertaining to the specific gravity of guava fruit as influenced by different varieties were recorded periodically at an interval of 20 days during the growth and development stages. The results are presented in Table 4.2.3

The data revealed that the differences in specific gravity was non significant among the varieties at most of the stages except at 40, 60 and 80 DAFS, where the results showed significant difference. At 20DAFS, it was highest in the variety L-49 (1.08); while at 60 and 80 DAFS it was highest in the variety Red Guava (1.05 and 1.07).

In all the three varieties the specific gravity ranged between 1.14- 1.00 up to 100 DAFS. After 100 DAFS i.e. at 120 and 140 DAFS the specific gravity ranged between 0.98- 0.97. The specific gravity of the fruits was decreased at maturity.



**Table 4.2.3. The periodical specific gravity of guava fruit as influenced by different varieties during their growth and development stages**

Varieties	Days After Fruit Setting (DAFS)						
	20	40	60	80	100	120	140
Allahabad Safeda (V <sub>1</sub> )	1.14	1.06	1.10	1.06	1.00	0.98	0.98
L-49 (V <sub>2</sub> )	1.14	1.08	1.04	1.04	1.01	0.97	0.97
Red Guava (V <sub>3</sub> )	1.14	1.06	1.05	1.07	1.00	0.99	0.98
S.Em.±	0.01	0.03	0.01	0.02	0.01	0.03	0.01
C.D. 0.05	NS	0.01	0.03	0.01	NS	NS	NS
CV %	1.45	2.02	2.45	1.09	3.22	7.77	2.20

#### 4.2.4. Length of fruit (cm)

The observation for the length of guava fruit was taken periodically at an interval of 20 days during its growth and development period. The results are presented in Table 4.2.4 and graphically depicted in Fig. 4.2.3. The difference in fruit length was significant among the varieties at all stages of growth.

The relative length of fruits increased with advancement of growth period in all the varieties of guava. At initial stage i.e. 20 days after fruit set there was non significant difference. However, after 40 days of fruit set the variety Allahabad Safeda registered significantly the highest value i.e. 2.43, 2.80, 3.24, 4.95, 6.20 and 6.90 cm at 40, 60, 80, 100, 120 and 140 days, respectively after fruit setting as compared to rest of the varieties except variety Red Guava at 60, 100, and 120 DAFS.

At maturity Allahabad Safeda recorded significantly the highest fruit length (6.9 cm) followed by Red Guava (6.48 cm) and L-49(5.93 cm).

At 40 days after fruit set, fruit length of variety Red Guava (2.04 cm) was found to be at par with L-49 (2.18 cm). While, L-49 noted minimum fruit length at rest of the growth stages (60- 140 DAFS) as compared to other varieties.

**Table 4.2.4. The periodical length (cm) of guava fruit as influenced by varieties during their growth and development stages**

Varieties	Days After Fruit Setting (DAFS)						
	20	40	60	80	100	120	140
Allahabad Safeda (V <sub>1</sub> )	1.11	2.43	2.80	3.24	4.95	6.20	6.90
L-49 (V <sub>2</sub> )	1.13	2.18	2.33	2.86	3.90	5.40	5.93
Red guava (V <sub>3</sub> )	1.04	2.04	2.67	2.95	4.67	5.88	6.48
S.Em.±	0.04	0.09	0.07	0.08	0.14	0.17	0.16
C.D. 0.05	NS	0.27	0.21	0.25	0.44	0.51	0.41
CV %	9.80	9.81	6.45	6.71	7.87	7.05	6.03



#### **4.2.5. Diameter of fruit (cm)**

The observation for the diameter of guava fruit was taken periodically at an interval of 20 days during its growth and development period. The results are presented in Table 4.2.5 and graphically depicted in Fig. 4.2.4. The difference in fruit diameter was significant among the varieties at all the stages of growth.

At the first growth stage i.e. after 20 days of fruit setting, there were non significant differences in the fruit diameter of all the varieties i.e. Allahabad Safeda (1.09 cm), L-49 (1.12) and Red Guava (1.01). However, after 40 DAFS the variety Allahabad Safeda had significantly highest fruit diameter i.e. 2.35, 2.75, 3.28, 5.23, 6.60 and 7.32 cm at 40, 60, 80, 100, 120, 140 DAFS, respectively as compared to rest of the varieties.

The other two varieties viz. Red Guava and L-49 were found to be differing significantly in fruit diameter at all the stages, except at 40 and 80 DAFS, were as the variety L-49 recorded fruit diameter (2.16 cm, 2.84 cm) which were at par with the variety Red Guava (2.03 cm, 2.99 cm). However, at 60, 100, 120 and 140 DAFS the variety Red Guava (2.61, 4.97, 6.11 and 6.71 cm) had significantly highest fruit diameter than L-49 (2.35, 4.31, 5.68 and 6.31 cm).

**Table 4.2.5. The periodical diameter (cm) of guava fruit as influenced by varieties during their growth and development stages**

Varieties	Days After Fruit Setting (DAFS)						
	20	40	60	80	100	120	140
Allahabad Safeda (V <sub>1</sub> )	1.09	2.35	2.75	3.28	5.23	6.60	7.32
L- 49 (V <sub>2</sub> )	1.12	2.16	2.35	2.84	4.31	5.68	6.31
Red Guava(V <sub>3</sub> )	1.01	2.03	2.61	2.99	4.97	6.11	6.71
S.Em.±	0.04	0.07	0.07	0.09	0.15	0.13	0.15
C.D. 0.05	NS	0.22	0.20	0.26	0.45	0.39	0.44
CV %	9.60	8.33	6.43	6.84	7.48	5.11	5.33

**4.2.6. Fruit length : diameter ratio**

The fruit length : diameter ratio was worked out on the basis of observation from length and diameter taken at an interval of 20 days after fruit setting. The data is presented in Table 4.2.6.

The result showed non significant differences in fruit length: diameter ratio among different varieties at all the growth stages. But length to diameter ratio was decreased at 80 days after fruit setting all the varieties, which indicated greater increased in fruit diameter than length. Till, 80 DAFS the rate of increment in length and diameter was almost similar so the ratio ranges from 0.98- 1.07, while it ranged from 0.92- 0.96 at 100, 120, 140 DAFS.



**Table 4.2.6. The periodical length: diameter ratio of guava fruit as influenced by different varieties during their growth and development stages**

Varieties	Days After Fruit Setting (DAFS)						
	20	40	60	80	100	120	140
Allahabad Safeda (V <sub>1</sub> )	1.04	1.06	1.01	0.98	0.96	0.93	0.94
L- 49 (V <sub>2</sub> )	1.04	1.05	1.01	1.02	0.92	0.94	0.95
Red Guava (V <sub>3</sub> )	1.06	1.07	1.01	1.05	0.93	0.96	0.96
S.Em.±	0.02	0.01	0.01	0.03	0.03	0.04	0.02
C.D. 0.05	NS	NS	NS	NS	NS	NS	NS
CV %	4.52	2.34	1.98	6.05	9.05	10.08	5.11

#### 4.2.7. Colour of fruits

The result on visual colour of guava fruit in different varieties is presented in Table 4.2.7.

The colour of guava fruit in all the three varieties viz. Allahabad Safeda , L-49 and Red Guava was recorded dark green at initial stage. The first visible signs of change in colour was seen when the fruit was 100 days old, when the skin became perceptibly lighter in colour. The light green colour of the skin then changed to greenish yellow followed by pale greenish yellow at maturity in variety Allahabad Safeda and L-49. While in Red Guava the fruit turned pale greenish yellow with red tinge at maturity.

**Table 4.2.7. Colour of guava fruits as influenced by different varieties during their growth and development stages**

Varieties	Days After Fruit Setting (DAFS)						
	20	40	60	80	100	120	140
Allahabad Safeda (V <sub>1</sub> )	D.G	D.G	D.G	D.G	L.G	G.Y	P.G.Y
L- 49 (V <sub>2</sub> )	D.G	D.G	D.G	D.G	L.G	G.Y	P.G.Y
Red Guava (V <sub>3</sub> )	D.G	D.G	D.G	D.G	D.G	G.Y	P.G.Y.R

D.G= Dark green

L.G= Light green

G.Y= Greenish yellow

P.G.Y= Pale greenish yellow

P.G.Y.R= Pale greenish yellow with reddish tinge

#### 4.2.8 Fruit firmness (kg / cm<sup>2</sup>)

The fruit firmness was taken at an interval of 20 days after fruit setting. The data are presented in Table 4.2.6.

The result showed non significant differences in fruit firmness among different varieties at all the growth stages. Fruit firmness was decreased at maturity. The immature fruit had very high texture that the readings could not be recorded with the available pressure tester. Therefore reading was possible after 100 DAFS.



**Table 4.2.8. Fruit firmness (kg/cm<sup>2</sup>) of guava fruits as influenced by different varieties during their growth and development stages**

Varieties	Days After Fruit Setting (DAFS)		
	100	120	140
Allahabad Safeda (V <sub>1</sub> )	13.13	8.08	1.52
L- 49 (V <sub>2</sub> )	13.34	7.93	1.51
Red Guava (V <sub>3</sub> )	13.23	7.98	1.52
S.Em.±	0.48	0.28	0.02
C.D. 0.05	NS	NS	NS
CV %	8.92	8.71	3.09

### 4.3. Chemical parameter

#### 4.3.1. Moisture content (%)

A perusal of data presented in Table 4.3.1 revealed that moisture content at an interval of 20 days during the growth and development period of guava fruit was significantly influenced by different varieties. It is also graphically depicted in Fig. 4.3.1.

At an initial stage i.e. 20 days after fruit setting there was non significant differences in the fruit moisture content of all the varieties i.e. Allahabad Safeda (19.01%), L-49 (18.32%) and Red Guava (19.09%). With the advancement of growth period, the moisture content was increased gradually and the variety Allahabad Safeda had significantly the highest moisture content i.e. 26.76, 34.60, 53.38, 64.43, 69.61 and 75.42% at 40, 60, 80, 100, 120 and 140 DAFS, respectively. At

40, 60, 80 and 100 days after fruit set the moisture content of L-49 and Red Guava were remained at par, which were recorded as 24.86, 32.05, 50.19, 61.42% and 23.58, 31.24, 48.51, 60.44%, respectively. However, at 120 and 140 days after maturity the variety L-49 (67.36 and 72.96 %) had significantly higher moisture content than Red Guava (66.26 and 71.08%).

**Table 4.3.1. The periodical moisture content (%) of guava fruit as influenced by different varieties during their growth and development stages**

Varieties	Days After Fruit Setting (DAFS)						
	20	40	60	80	100	120	140
Allahabad Safeda (V <sub>1</sub> )	19.01	26.76	34.60	53.38	64.43	69.61	75.42
L- 49 (V <sub>2</sub> )	18.32	24.86	32.05	50.19	61.42	67.36	72.96
Red Guava (V <sub>3</sub> )	19.09	23.58	31.24	48.51	60.44	66.26	71.08
S.Em.±	0.48	0.50	0.72	1.03	0.70	0.60	0.60
C.D. 0.05	NS	1.51	2.18	3.10	2.10	1.81	1.80
CV %	6.30	4.89	5.42	4.97	2.75	2.18	2.00

#### 4.3.2. Total soluble solids (° Brix)

The data on total soluble solids of guava fruit in different varieties was recorded periodically at an interval of 20 days after fruit setting to maturity and presented in table 4.1.2. It is also graphically depicted in Fig. 4.3.2.

The TSS content of guava fruits was found to be significantly differed among the varieties during their growth period. Initially at 20 and 40 DAFS there was non significant difference in the TSS contents in all the varieties i.e. Allahabad Safeda (6.03 and 6.03°Brix), Red Guava (5.98 and 6.03 °Brix) and L-49 (5.90 and 6.18 °Brix).With the advancement of maturity, the TSS content was increased and at 80, 100, 120, 140 DAFS significantly the highest TSS was observed in Allahabad Safeda as compared to Red Guava and L-49 at 80, 140 DAFS. However, at 100 and 120 DAFS the TSS of Allahabad Safeda (9.45 and 10.54) was remained at par with L-49 (9.30 and 10.50).

The variety Red Guava recorded significantly the minimum TSS i.e. 6.70, 7.46, 9.11, 9.42 and 11.66°Brix at 60, 100, 120 and 140 DAFS, respectively except at 80 DAFS when its TSS value (7.46°Brix) was at par with L-49 (7.51°Brix).



**Table 4.3.2. The periodical total soluble solids (°Brix) of guava fruit as influenced different varieties during their growth and development stages**

Varieties	Days After Fruit Setting (DAFS)						
	20	40	60	80	100	120	140
Allahabad Safeda (V <sub>1</sub> )	6.03	6.03	7.18	7.70	9.45	10.54	13.58
L- 49 (V <sub>2</sub> )	5.90	6.18	6.95	7.51	9.30	10.05	13.18
Red Guava (V <sub>3</sub> )	5.98	6.03	6.70	7.46	9.11	9.42	11.66
S.Em.±	0.06	0.08	0.07	0.06	0.06	0.17	0.40
C.D. 0.05	NS	NS	0.22	0.18	0.17	0.52	1.22
CV %	2.45	3.05	2.53	5.94	5.48	4.20	7.74

#### 4.3.3. Total sugars (%)

Total sugar contents of guava fruit as influenced by different varieties was significant at all the growth and development stages. Data on total sugars are given in Table 4.3.3 and graphically depicted in Fig. 4.3.3.

Initially at 20 and 40 days after fruit setting there was no significant differences in the total sugar contents of the three varieties. However, at 60, 80, 100, 120 and 140 DAFS the variety Allahabad Safeda recorded significantly the highest total sugars i.e. 2.00, 5.37, 6.43, 9.20 and 12.37 % as compared to Red Guava and L-49. However, it remained at par with L-49 (1.82%) at 60 DAFS i.e. 2%.

Significantly the minimum total sugar was recorded by the variety Red Guava at 60, 80, 120, 140 DAFS i.e. 1.19, 3.83, 7.76, 10.31

%respectively, except at 100 DAFS (5.25 %) where it remained at par with L-49 (5.96 %).

**Table 4.3.3. The periodical total sugar (%) of guava as influenced by different varieties during their growth and development stages**

Varieties	Days After Fruit Setting (DAFS)						
	20	40	60	80	100	120	140
Allahabad Safeda (V <sub>1</sub> )	0.65	1.04	2.00	5.37	6.43	9.20	12.37
L- 49 (V <sub>2</sub> )	0.65	1.02	1.82	4.92	5.96	8.88	11.69
Red Guava (V <sub>3</sub> )	0.61	1.01	1.19	3.83	5.25	7.76	10.31
S.Em.±	0.02	0.03	0.07	0.12	0.12	0.08	0.37
C.D. 0.05	NS	NS	0.21	0.37	0.36	0.25	1.10
CV %	7.91	8.36	10.03	6.42	4.91	2.38	7.82

#### 4.3.4 Reducing sugar (%)

Data regarding reducing sugar (%) during different growth and development period of guava fruits in different varieties found to be significant. The data are presented in Table 4.3.4 and also graphically depicted in Fig. 4.3.4.

After 40 and 60 days of fruit setting the highest reducing sugar (%) of fruit was recorded by the variety Allahabad Safeda (0.68 and 1.52%) followed by L-49 (0.66 and 1.43 %) and Red Guava (0.54 and 0.82%). With the advancement of fruit growth, there was a gradual increase in reducing sugar. At 80, 100, 120, 140 DAFS significantly the

highest reducing sugar was recorded by the variety Allahabad Safeda (3.53, 3.90, 5.33 and 7.99 %) followed by L-49 and Red Guava. The variety Red Guava had the lowest reducing sugar percentage at all stages of growth and development as compared to rest of the varieties.

**Table 4.3.4. The periodical reducing sugar (%) of guava fruit as influenced by different varieties during their growth and Development stages**

Varieties	Days After Fruit Setting (DAFS)						
	20	40	60	80	100	120	140
Allahabad Safeda (V <sub>1</sub> )	-	0.68	1.52	3.53	3.90	5.33	7.99
L- 49 (V <sub>2</sub> )	-	0.66	1.43	3.13	3.72	5.10	7.58
Red Guava (V <sub>3</sub> )	-	0.54	0.82	2.92	3.11	4.89	6.96
S.Em.±	-	0.01	0.03	0.07	0.05	0.07	0.08
C.D. 0.05	-	0.02	0.09	0.21	0.16	0.20	0.24
CV %	-	2.20	5.85	5.31	3.65	3.14	2.57

#### 4.3.5 Non reducing sugar (%)

Data regarding non reducing sugar during different growth and development period of guava fruits in different varieties, which was recorded periodically at an interval of 20 days, was found to be significant. The data are presented in Table 4.3.5 and also graphically depicted in Fig. 4.3.5.

Overall the result showed that Allahabad Safeda had significantly the highest non reducing sugar percentage at 40, 80, 100,

140 DAFS, i.e. 0.44, 1.82, 2.49, 4.53% respectively except at 60 and 120 DAFS ( 0.43 and 4.11%) where it was at par with L-49 (0.40 and 3.87%).

The variety Red Guava had the lowest reducing sugar percentage at all stages of growth and developments except at 100 DAFS (2.03 %) where it remained at par with L-49(2.18 %).

**Table 4.3.5. The periodical non-reducing sugar (%) of guava fruit as influenced by different varieties during their growth and development stages**

Varieties	Days After Fruit Setting (DAFS)						
	20	40	60	80	100	120	140
Allahabad Safeda (V <sub>1</sub> )	-	0.44	0.43	1.82	2.49	4.11	4.53
L- 49 (V <sub>2</sub> )	-	0.38	0.40	1.69	2.18	3.87	4.13
Red Guava (V <sub>3</sub> )	-	0.34	0.37	0.85	2.03	2.91	3.39
S.Em.±	-	0.01	0.01	0.01	0.05	0.08	0.05
C.D. 0.05	-	0.02	0.02	0.03	0.17	0.25	0.15
CV %	-	4.05	4.78	5.85	6.02	5.50	3.14

#### 4.3.6. Acidity (%)

Results presented in Table 4.3.6 indicated the acidity content of guava fruit as influenced by different varieties at an interval of 20 days after fruit setting to maturity of fruits. These results are also graphically depicted in Fig. 4.3.6.

Difference among the varieties for acidity per cent of guava fruit was found to be significant at all the growth and development period. Initially, after 20days of fruit setting, significantly the highest

acidity content of fruit was recorded by the variety Red Guava (0.39%) as compared to L-49 (0.30 %) and remained at par with Allahabad Safeda (0.38 %). With the advancement of fruit growth stages, there was a gradual increase in acidity but after 100 DAFS, the acidity was decreased. At 40, 60, 80, 100, 120 and 140DAFS significantly the highest acidity was recorded by the variety Red Guava i.e. 0.39, 0.41, 0.46, 0.52, 0.56, 0.49 and 0.46%, respectively followed by Allahabad Safeda and L-49.

**Table 4.3.6. The periodical acidity content (%) of guava fruit as influenced by different varieties during their growth and development stages**

Varieties	Days After Fruit Setting (DAFS)						
	20	40	60	80	100	120	140
Allahabad Safeda (V <sub>1</sub> )	0.38	0.39	0.40	0.46	0.49	0.43	0.39
L- 49 (V <sub>2</sub> )	0.30	0.31	0.36	0.39	0.42	0.39	0.35
Red Guava (V <sub>3</sub> )	0.39	0.41	0.46	0.52	0.56	0.49	0.46
S.Em.±	0.01	0.01	0.01	0.02	0.02	0.01	0.01
C.D. 0.05	0.03	0.03	0.04	0.05	0.05	0.04	0.04
CV %	6.13	7.20	8.55	8.02	7.75	8.00	8.42

#### **4.3.7 Ascorbic acid (mg/100 g pulp)**

Data regarding ascorbic acid content during different growth and development period in guava fruits of different varieties was recorded periodically at an interval of 20 days found to be significant. The data are presented in Table 4.3.7 and also graphically depicted in Fig. 4.3.7

After 20days of fruit setting the maximum ascorbic acid content of fruit was recorded by the variety Allahabad Safeda (25.00 mg/100 g pulp) followed by L-49(22.16mg/100 g pulp) and Red Guava(19.50 mg/100 g pulp). With the advancement of growth period, there was a gradual increased in ascorbic acid content and significantly the maximum ascorbic acid was recorded by the variety Allahabad Safeda, i.e.25.00, 48.58, 96.95, 133.4, 190.0, 253.0 and 282.3 mg/ 100 gm during 20, 40, 60, 80, 100, 120 and 140 days, respectively.

The variety Red Guava had the lowest ascorbic acid content. While, variety L-49 had significantly the highest ascorbic acid content at all the stages except at 60, 80 and 100 DAFS, when ascorbic acid content in fruit of L-49 variety (81.03, 122.8, 177.5 mg/ 100 gm)was found at par with Red Guava(78.47, 119.7, 158.2mg/ 100 gm).



**Table 4.3.7. The periodical ascorbic acid (mg/100 g pulp) of guava fruit as influenced by different varieties of guava during their growth and development stages**

Varieties	Days After Fruit Setting (DAFS)						
	20	40	60	80	100	120	140
Allahabad Safeda (V <sub>1</sub> )	25.00	48.58	96.95	133.4	190.0	253.0	282.3
L- 49 (V <sub>2</sub> )	22.16	46.43	81.03	122.8	177.5	235.3	261.5
Red Guava (V <sub>3</sub> )	19.50	41.92	78.47	119.7	158.2	218.8	227.0
S.Em.±	0.43	0.66	2.46	2.64	2.46	4.17	6.28
C.D. 0.05	1.28	2.00	7.42	7.94	7.42	12.56	18.94
CV %	4.70	3.57	7.05	5.15	3.44	4.33	5.99

## V. DISCUSSION

---

The results of the experiment entitled “ Studies on physico-chemical changes during fruit growth and development in different varieties of guava (*Psidium guajava* L.) ” as reported in experimental results chapter is being discussed meticulously in this chapter. All possible effort has been put to establish the causes and effects associated with the results by taking the support of available evidences and relevant literature. For better discussion the chapter has been divided into following heads.

### 5.1 Growth parameters

### 5.2 Physical parameters

### 5.3 Chemical parameters

### 5.1 Growth parameters

All the three cultivars required almost similar duration for flower bud development. Flower shed their petals two days after anthesis in all the cultivars. Similar results were also obtained by Ojha *et al.* (1986) in guava cultivar L-49 and Allahabad Safeda.

The leaf area was significantly influenced by the different varieties of guava. The data indicated significant differences among the varieties in which maximum leaf area was recorded by the variety Allahabad Safeda (209.70 cm<sup>2</sup>) followed by L-49 (192.07 cm<sup>2</sup>) and Red

Guava (170.37 cm<sup>2</sup>). Dubey *et al.*(2000) also reported that Allahabad Safeda had maximum leaf area as compared to other varieties.. Therefore it is concluded that leaf area character is dependent on varieties. The results revealed that there were non significant differences among the varieties for number of leaves / shoot. The number of leaves and leaf area are varietal characters but the number and size of leaves also depends on vigour and age of the plant (Dubey *et al.*, 2000).

The variety Allahabad Safeda recorded the highest fruit yield (22.16 kg/tree), which was at par with Red Guava (21.83 kg/tree) and minimum in L-49 (17.83 kg/tree). While, number of fruits per plant were significantly highest in variety Red Guava (174.66) followed by Allahabad Safeda (149) and L-49 (137). Similar results were obtained by Shridhar and Singh (1997) who compared Red fleshed and Allahabad Safeda and found that Allahabad Safeda had better yield as the fruit were bigger in size and each tree gave higher number of fruits. More number of leaves responsible for higher photosynthesis caused higher yield.

Significantly the highest pulp weight per fruit was recorded by the variety Allahabad Safeda (140.03 g), followed by L-49 (110.5 g) and Red Guava (114.96 g), which remained at par with each other. Seed weight per fruit was also maximum in variety Allahabad

Safeda (4.22 g), followed L-49(3.26 g) and Red Guava (3.40 g). Similarly number of seeds per fruit was maximum in the variety Allahabad Safeda (298.7), followed L-49(200.3) and Red Guava (231.2). This might be due to the genetical potential among the varieties for various growth parameters as stated by Shridhar and Singh (1997).

## 5.2 Physical parameter

There was significant variation in physical parameters among the varieties during fruit development stages of guava. The results indicated that variety Allahabad Safeda has significantly the highest fruit weight (151.3 g) followed by Red Guava (127g) and L-49 (115 g). Chundawat *et al.*(1976) reported that volume and weight varied with the type of cultivar.

The variety Allahabad Safeda recorded significantly the highest volume of fruit i.e. 5.93, 25.13, 33.81, 44.98, 80.28, 119.9 and 152.7 ml at 20, 40, 60, 80, 100, 120 and 140 DAFS, respectively followed by variety Red Guava and L-49.

At maturity of Allahabad Safeda fruit recorded significantly highest fruit length (6.9 cm) followed by Red Guava (6.48cm) and L-49 (5.93 cm). Similarly it also recorded significantly highest fruit diameter (7.32 cm) followed by Red Guava (6.71 cm) and L-49 (6.31 cm).

The fruits took about 140 days to reach harvestable maturity. During the entire fruit development period, it can be observed that there was increase in various physical parameters viz., fruit weight, fruit volume, fruit length and fruit diameter. All varieties showed a sigmoid curve with three distinct phases of fruit development. In stage 1 i.e. 20 to 40 DAFS, the fruit growth was linear and there was a rapid increase in diameter and weight of fruit. In Stage 2 i.e. between 40- 60 DAFS it was characterized by slow changes in diameter and weight while in stage 3 i.e. after 60 DAFS the growth was linear and the fruit attained final size. The slow growth in stage 2 in all the varieties was due to rapid development of seed, resulting in slow growth of pulp. Similar results for fruit growth have been also observed by Silva *et al.*(1997) and Selvaraj *et al.* (1999) .


The specific gravity was not significantly influenced by the varieties but it showed a decreasing trend with the advancement of maturity. In stage 1 and stage 2 i.e. till 100 DAFS, the specific gravity ranged between 1.14- 1.00. After 100 DAFS i.e. at 120 and 140 DAFS the specific gravity was decreased and ranged between 0.98- 0.97. Silva *et al.* (1997) obtained similar observations in guava. Dhillon *et al.* (1987) stated that the decrease in specific gravity might be due to lesser increase of fruit volume as compared to fruit weight. The increase in

volume may be due to an increment in intercellular space with advancement of fruit growth.

It is evident from the results of physical parameters that variety Allahabad Safeda was superior to Red Guava and L-49 with regard to weight, volume, length and diameter of fruits. These might be due to its varietal characters governed by genetical factors.

Skin chlorophyll content was decreased with advancement in maturity during fruit development. The immature guava fruit was dark green in colour, hard and woody in texture. The first visible signs of change in colour was seen between 100 DAFS, when skin became perceptibly lighter in colour. The light green colour of the skin then changed to pale greenish yellow followed by yellow at maturity. This change is attributed to the disappearance and unmasking of chlorophyll and appearance of carotenoid pigments with maturity. Similar observations were also recorded in guava by Rodriguez *et al.* (1971) and Silva *et al.* (1997).

Fruit firmness was decreased at maturity. The immature fruit had very high texture and so readings could not be recorded with the available pressure tester. Therefore reading was possible after 100 DAFS. Fruit showed declining values with progressive ripening but all the varieties exhibited non significant values in fruit firmness. Similar

.....*Discussion*  
results have been reported by Rodriguez *et al.* (1971). Bulk *et al.* (1995) observed that increase in moisture content with maturity contributes for softening of fruits. They have also suggested that cellulose, in addition to pectin enzymes may contribute to the softening of fruit. The breakdown of polymeric carbohydrate especially pectic substances and hemicelluloses weaken cell wall and cohesive forces cell together (Nag *et al.*, 2011)


### **5.3 Chemical parameters**

The moisture content in fruit was increased with the development of fruit in all the varieties and it was significantly highest in the variety Allahabad Safeda (75.42%) followed by Red Guava (72.96%) and L- 49(71.08%). The moisture content of fruit might be the factor which helps in the fruit growth and development, resulting in increase of average fruit weight and volume. The low percentage of moisture in the fruit during the early period of fruit development indicates the non accumulation of water in the young fruits. With the subsequent increase in fruit size there was greater accumulation of water, which increased the cell turgidity and cell size. The moisture content in the fruits is in agreement with the finding of Gulhane and Gupta (1974), Dhillon *et al.* (1987) and Silva *et al.* (1997).

It was evident from the results that there was a gradual

increase in TSS during fruit development period. Allahabad Safeda recorded significantly the highest TSS (13.58 °Brix) followed by L-49 (13.18 °Brix) and Red Guava (11.66 °Brix). The TSS at initial stage of fruit growth was less but with the advancement of growth period, there was gradual increase in TSS. Similarly rise in TSS was also observed in guava by Bulk (1995), Dubey *et al.* (2009) and in different fruits like pear by Dhillon *et al.*(1999) and Dhillon *et al.* (2007), pomegranate by Dhillon (2004), papaya by Ghanta *et al.* (1994). The increase in TSS could be attributed to the fact that the reserved food stored in the form of poly-saccharides is depolymerised and starch is converted to simple sugars. After the fruit attained its full size, the poly-saccharides started getting converted into soluble sugars by various hydrolysis enzymes, which helps to increase the TSS. Supe *et al.* (1997) reported that TSS content in the fruit was increased with the delayed in harvesting which attributed to the formation of more soluble sugars and other soluble compounds.

The total sugars content in fruit was less at the initial stage, and then showed an increasing trend with the development of the fruit. At maturity total sugars were highest in Allahabad Safeda (12.37 %) which was at par with L-49 (11.69 %) and the lowest in Red Guava (10.31 %). Total sugars might have increased due to hydrolysis of starch into sugars (Gangwar 1972). The results are in accordance with the

.....*Discussion*  
results reported by Bulk *et al.* (1995) in guava and Dhillon *et al.* (2007) in pear fruit.

There was an increase in reducing sugar content in fruit during its growth and development. At maturity stage significantly the maximum reducing sugar was recorded by the variety Allahabad Safeda (7.99%) followed by L-49 (7.58%) and Red Guava (6.96 %). Chundawat *et al.* (1976) reported similar results on comparison of eight cultivars. Increase in the reducing sugar can be attributed to enzymatic conversion of starch in to sugar and also conversion of some non-reducing sugar in to reducing sugar through the process of glucogenesis (Nag *et al.* 2011). Starch and sucrose are converted into glucose during fruit ripening. Datta and Mukherjee (1980) also found that reducing sugar was increased during fruit ripening in guava.

The non reducing sugar content was low at initially but with the advancement of fruit growth, there was a gradual increase in non reducing sugar and at maturity significantly the maximum non reducing sugar was recorded by the variety Allahabad Safeda (4.53%) followed by L-49(4.13 %) and Red Guava (3.39 %).

The titratable acidity was increased gradually upto 100 DAFS and then it exhibited a declining trend till the maturity. At maturity stage significantly the maximum acidity was observed in Red

Guava (0.46%) followed by Allahabad Safeda ( 0.39%) and L-49 (0.35%) which were at par. Similar behavior for acidity was recorded by Rodriguez *et al.* (1971) and Nag *et al.* (2011). The increment in acidity may be the formation of organic acid during maturation. This increment is associated with high concentration of undissociated organic acids, stored in the vacuole is used as respiratory substrate by the fruits. However, decrease in the acidity could be considered due to the dilution effect i.e. conversion of acid into sugar as the fruit increased in size as well as increase in juice content.

Ascorbic acid was low at initial development stages, and then increased with an advancement of fruit maturity and ripening. It appears that active synthesis of ascorbic acid during development and early ripening which might be attributed to inactivation of ascorbic acid oxidase due to high content of phenols (Hedge and Charria, 2004). At maturity, significantly the maximum ascorbic acid content was recorded by the variety Allahabad Safeda (282.3 mg/ 100 gm) followed by L-49 (261.5 mg/ 100 gm) and Red Guava (227.0 mg/ 100 gm). In general, cultivars with pink coloured flesh are poorer in vitamin C content than the white fleshed ones (Chattopadhyay, 2008). Chundawat *et al.*, (1976) reported similar results on comparison of eight cultivars. These results are in agreement with those of Rodriguez *et al.*(1971) and

Gangwar (1972), who reported that the ascorbic acid content for developing guava increased slowly during the initial growing period followed by a rapid increase during maturation and ripening. Similar results were also reported by Rodriguez *et al.* (1971) and Selvaraj *et al.* (1999) in guava.

## VI. SUMMARY AND CONCLUSION

---

The present investigation “**Studies on physico-chemical changes during fruit growth and development in different varieties of guava (*Psidium guajava* L.)**.” was carried out at the Horticulture Research Farm, Department of Horticulture, B. A. College of Agriculture, AAU, Anand, during 2013. The experiment was conducted in Complete Randomized Design with three varieties (Allahabad Safeda, L-49 and Red Guava) and six replications. The results obtained from the present investigation are summarized and concluded under the following heads.

### 6.1 Summary

#### 6.1.1 Growth parameters

All the three varieties (Allahabad Safeda, L-49 and Red Guava) have taken equal number of days from bud emergence to full bloom. Flower shed their petals after two days of anthesis in all the cultivars. The results on leaf area indicated significant differences among the varieties in which maximum leaf area was recorded by the variety Allahabad Safeda (209.70 cm<sup>2</sup>) followed by L-49 (192.07 cm<sup>2</sup>) and Red Guava (170.37 cm<sup>2</sup>).

The variety Allahabad Safeda recorded significantly highest fruit yield (22.16 kg/tree) as compared to L-49 (17.83 kg/tree) and remained at par with Red Guava (21.83 kg/tree). However, the number of fruits per plant was significantly highest in variety Red Guava (174.66) followed by Allahabad Safeda (149) and L-49(137).

The pulp weight, seed weight and number of seeds per fruit were significantly influenced by the different varieties of guava except pulp to seed ratio which was non significant. The results indicated significantly maximum pulp weight per fruit in variety Allahabad Safeda (140.035 g), followed L-49 (110.5 g) and Red Guava (114.968 g) which were at par. Similarly seed weight per fruit and number of seeds per fruit were maximum in variety Allahabad Safeda (4.216 g and 298.7 g), followed by Red Guava (3.4 g and 231.2 g) and L-49 (3.26 g and 200.3g)

### **6.1.2 Physical parameters**

The fruits took about 140 days to reach harvestable maturity from flowering. During the entire fruit development period, it was observed that there was an increased in various physical parameters viz., fruit weight, fruit volume, fruit length and fruit diameter. All varieties showed a sigmoid curve with three distinct

phases of fruit development. In stage 1 i.e. 20 to 40 DAFS, the fruit growth was linear and there was a rapid increment in diameter and weight. While stage 2 i.e. between 40- 60 DAFS, there was slow changes in diameter and weight and in stage 3 i.e. after 60 DAFS the growth was linear and the fruit attained maximum size.

Physical parameters like weight, volume, specific gravity, length, diameter, colour, pulp and peel weight of fruit were significantly influenced by the varieties of guava. The results on physical parameters of guava fruit as influenced by the varieties are as under.

The variety Allahabad Safeda recorded the highest fruit weight (151.3 g) followed by the Red Guava (127g), and minimum in L-49 (115 g). Similar trend was also noted for fruit volume, where the variety Allahabad Safeda had the highest fruit volume (152.7 ml) followed by Red Guava (129.5 ml) and minimum volume was observed in the variety L-49 (118.8 ml).

The specific gravity of fruit was non significantly influenced by the varieties at most of the growth stages. In stage 1 and stage 2 i.e. till 100 DAFS the specific gravity ranged between 1.14- 1.00. After 100 DAFS i.e. at 120 and 140 DAFS the specific gravity was

decreased and ranged between 0.98- 0.97.

At maturity Allahabad Safeda recorded significantly the highest fruit length (6.90 cm) followed by Red Guava (6.40 cm) and minimum in variety L-49(5.93 cm).

The data on fruit diameter were found significant and it was maximum in the variety Allahabad Safeda (7.32 cm) followed by Red Guava (6.71 cm) and L-49(6.31 cm).

The ratio of fruit length: diameter was found to be non significant during the entire growth and development period of all the guava varieties. The increment in the length and diameter of fruit in all the varieties were similar, so the ratio ranges between 0.98- 1.07 up to 80 DAFS. While, it ranged between 0.92- 0.96 after 80 DAFS till the maturity, which indicated greater increase in fruit diameter than length.

The first visible signs of change in colour was observed when the fruit attained 100 days old, the skin became perceptibly lighter in colour. The light green colour of the skin then changed to greenish yellow followed by pale greenish yellow at maturity in varieties Allahabad Safeda and L-49 as compared to Red Guava.

### **6.1.3 Chemical parameters**

Chemical parameters like moisture content, TSS, total sugar, reducing sugar, non reducing sugar and ascorbic acid contents were increased at maturity, except acidity.

Moisture content of fruits among the different varieties was significantly differed. It was highest in the variety Allahabad Safeda (75.42 %) followed by L-49 (72.96 %) and Red Guava (71.08%). Similarly total soluble solids was also highest in Allahabad Safeda (13.58 °Brix) followed by L-49 (13.18 °Brix) and Red Guava (11.66 °Brix).

Total sugars were highest in variety Allahabad Safeda (12.37 %) which were at par with L-49 (11.69 %) and the lowest in the Red Guava (10.31 %). Similarly reducing sugar was also highest in the variety Allahabad Safeda (7.99%) followed by L-49 (7.58) and Red Guava (6.95 %). Non reducing sugar also followed a similar trend and it was highest in the variety Allahabad Safeda (4.53%) followed by L-49(4.13 %) and Red Guava (3.39 %).

At maturity significantly minimum acidity (%) was recorded in the variety L-49 (0.35 %), while maximum acidity was recorded in the variety Red Guava (0.46%) followed by Allahabad Safeda (0.39 %).

The ascorbic acid content was maximum in the variety Allahabad Safeda (282.3 mg/ 100 g) followed by L-49 (261.5 mg/ 100 g) and Red Guava (227.0 mg/ 100 g) .

## **6.2 Conclusion**

The following conclusions could be drawn from the investigation, which may be useful for farming communities, processing industries, further research and helped in evaluating the guava varieties.

The guava fruits took about 140 days to reach harvestable maturity. During the entire fruit development period, it can be concluded that there was increment in various physical and chemical parameters viz. fruit weight, fruit volume, fruit length, fruit diameter as well as TSS, total sugars, reducing sugars, non reducing sugars, ascorbic acid and moisture content during the course of growth and development period. However, parameters like specific gravity, firmness and acidity showed a decreasing trend with maturity. All the three varieties showed a sigmoid growth curve with three distinct phases of fruit development based on diameter, length, weight and volume of fruit during its development.

The external fruit appearance like colour, shape, and size can be used by the growers as an index of maturity. Similarly internal factors like moisture content and fruit firmness as well as chemical contents like TSS and sugar can be used as maturity indices.

Considering the overall performance of the three different guava varieties (Allahabad Safeda, L-49 and Red Guava) during the course of present investigation, variety Allahabad Safeda performed better giving higher fruit yield with highest number of fruits, weight, volume, length, diameter, skin weight, pulp weight, moisture content, TSS, total sugar and ascorbic acid as compared to varieties L-49 and Red Guava.

Cultivar Red Guava, had attractive colour which could be used for preparation of value added products.

Cultivars L-49, recorded the minimum fruit weight, volume, length, diameter and pulp weight but it was slightly better than Red Guava in case of quality parameters viz. moisture, TSS, total sugar and ascorbic acid contents.

## REFERENCES

---

- Anonymous (2012-13) Indian Hort *Database*- National Horticulture Board.
- Aulakh, P. S. (2004) Effect of seasonal variation of 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.
- Bose, T.K., Mitra, S.K. and Sanyal, D. (2001). Tropical and subtropical fruits, 3<sup>rd</sup> edition., Naya Udyog, Calcutta.
- Bulk El, R.E., Babiker, E.F.E. and Tinay, A.H.E. (1995). Changes in chemical composition of guava fruits during development and ripening. *Food Chemistry*, Vol. **59**(3): 395-399.
- Chander, S., Singh D., and Rana M. K. (2002) Changes in physical characters of plum fruit cvs. Titron and Alubukhara during growth and development. *Haryana J. Hort. Sci.*, **31** (1-2): 10- 13.
- Chattopadhyay, T.K. (2008). Textbook of pomology, 2nd edition. Kalyani publishers, New Delhi.
- Chundawat, B. S., Gupta, O. P. and Singh, H. K. (1976) . Variations in physico-chemical qualities of rainy and winter season guava (*Psidium Guajava*) fruits. *Haryana J. Hort. Sci.*, **5** (3 & 4): 154-159.



- Datta, M. N. and Mukherjee, S. K. (1980). Studies on the changes during growth and development of guava (*Psidium guajava* L.) fruits. *Indian J. Hort.*, **37**(3):211-219.
- Dhillon, B. S., Singh, S. N. and Gill, S. S. (1987). Development physiology of guava 1. Physical characters. *Punjab Hort. J.*, **27**: 28 - 33.
- Dhillon, W. S. and Kumar, A. (2004) Some physico-biochemical changes during with fruit development in pomegranate. *Indian J. Hort.*, **61**(3): 219-222.
- Dhillon, W. S., Singh, A. and Singh, R. (2007) Biochemical changes in developing semi-soft pear fruits. *Indian J. Hort.*, **64** (1): 81-83.
- Dhillon, W. S., Singh, R., and Malhi, C. S. (1999) Fruit developmental studies in pear cv. Patharnarkh under submountainous conditions of Punjab. *Indian J. Hort.*, **56**(4): 314-316.
- Dubey, P.S., Hoda , M. N., Singh J. And Singh, S. K. (2009) Studies on physico-chemical properties of rainy season guava fruits. *Indian J. Hort.*, **66**(4): 522-523.
- Dubey, P.S., Hoda, M. N. and Singh, S. (2000) Studies on growth behavior of guava germplasm under Sabour conditions for rainy season fruiting. *Indian J. Hort.*, **57**(4): 326-328.

- El-Nemr, S. E., Ismail, I. A. and Ragab, M. (1990). Chemical composition of juice and seeds of pomegranate fruit. *Nahrung.*, **34** (7): 601- 606.
- Gangwar, B.M. (1972). Biochemical studies on growth and ripening of guava. *Indian Food Packer*, **26** :13-15.
- Ghanta, P. K., Dhua, R. S. and Mitra, S. K. (1994) Studies on fruit growth and development of papaya cv. Washington . *Indian J. Hort.*, **51**(3): 246-250.
- Gulhane ,A. R. and Gupta, P. K. (1974) Physico-chemical changes in the developing Lucknow-49 guava (*Psidium guajava* L.) fruits. *Haryana J. Hort. Sci.*, **3**( 3& 4): 134-139.
- Gupta, V. K., Devi, S. and Shvetambri (2003) Physico- chemical changes in aonla (*Embllica officinalis*) fruits during growth and development. *Haryana J. Hort. Sci.*, **32**(1& 2): 37-39.
- Hedge, M. V. And Charria, A. S. (2004) Developmental and ripening physiology of guava (*Psidium guajava* L.) fruit I. Biochemical changes. *Haryana J. Hort. Sci.*, **33**( 1& 2): 62-64.
- Joshi, N.D., Sinha, R.B., Kumar, R. and Hoda. M. N. (1974). Development and physico-chemical properties of grapes. *South India Hort.*, **22** (1 & 2) : 122-125.
- Kahlon, P. S., Sharma, P. K. and Rambadi, J. L. (1987) Studies on floral biology of guava ( *Psidium Guajava* L.) cultivar Allahabad Safeda and Lucknow- 49. *Haryana J. Hort. Sci.*,**16**(1-2): 65-73.

- Khodade, M. S. (1987). Physio-chemical changes during growth and development of pomegranate fruit (*Punica granatum* L.) M.Sc. (Agri.) thesis submitted to MPKV, Rahuri (Maharashtra).
- Koyuncu, M. A.; Aksoy, U.; Fergusson, L. and Hepaksoy, S. (1998). A study on some fruit characteristics in local fig cultivars grown in Hilvan. *Acta Hort.*, **480** : 83-85.
- Kumar, B. P. and Purohit, A. G. (1989). Studies on fruit growth and development in pomegranate. *J. of M.S. Agril Univ.*,**14** (2): 187-189.
- Lodh, S. B. and Selvaraj, Y. (1974). Biochemical changes associated with growth and development of grape var. Bangalore Blue. *Indian J. Hort.* ,**31** (3): 232-237.
- Mirdehghan, S. H. and Rahemi, M. (2006) Changes in physico-chemical attributes of pomegranate during fruit ripening and development. *Indian J. Hort.*, **63**(2): 122-125.
- Nag, A. K., Chatterjee, D.D., Roy, T., Hossain A. M. M. Z. and Haque A. (2011) Study on chemical changes of different guava varieties during different ripening stage. *Bangladesh Res. Pub. J.* **6**(2): 217-224.
- Neog, M., Mohan, N.K. and Barua, P. C. (1993) Physical changes during growth and development of local ber ( *Zizyphus jujube* L. ) fruit of Assam. *Haryana J. Hort. Sci.*, **22**(1): 121-125.

- Ojha, A. P., Tiwari, J. P. and Mishra, K. K. (1986) Studies on floral biology of guava (*Psidium guajava* L.) Cultivars under Tarai conditions of Uttar Pradesh. *Prog.Hort.*, **18**(3-4) : 308- 311.
- Ojha, A. P., Tiwari, J. P. and Mishra, K. K. (1987) A note on seasonal variations in the physic- chemical composition of guava ( *Psidium guajava*) cultivars Sardar and Allahabad Safeda under Tarai conditions of U.P. *Haryana J. Hort. Sci.*, **16**(1-2): 90-91.
- Ojha, C. M. and Pathak, R. K. (1992) Changes in chemical composition of aonla cultivars during growth and development of fruits. *Prog.Hort.*, **25**(1-2) : 42-46.
- Ojha, C. M. and Pathak, R. K. (1992) Changes in physical composition of aonla cultivars during growth and development of fruits. *Prog.Hort.*, **24**(3-4): 176-179.
- Pandey, A. K. and Singh, I. S. (1998) Physicochemical studies on utilization of guava cultivars. *Prog.Hort.*, **30**(1-2): 73-75.
- Pandey, D., Shukla, S.K., Yadav, R.C., Nagar, A.K. (2007). Promising guava (*Psidium guajava* L.) cultivars for North Indian condition. In: Proceedings of the first International guava Symposium (eds. Singh, G., Kishun, R. and Chandra, R.). *Acta Hort* **735**: 91-94.



- Patel, R. K. , Maiti, C.S. , Deka ,B. C., Deshmukh , N. A. and Roy, D. (2011) Variability Studies in Guava (*Psidium guajava* L.) Genotypes for Growth, Yield and Quality Attributes at mid-hills of Meghalaya. *Indian J. Hill farming*. **24**(1&2) : 24-26.
- Patel, R.K., Yadav, D.S., Babu, K.D., Singh, A., Yadav, R.M. (2007). Growth, yield and quality of various guava (*Psidium guajava* L.) hybrids/cultivars under mid hills of Meghalaya. In: Proceedings of the first International guava Symposium (eds. Singh, G., Kishun, R. and Chandra, R.). *Acta Hort*. **735**: 57-59.
- Patel, Y. G. (2001). Studies on fruit retention and physico-chemical changes during growth and development of different Aonla varieties (*Emblica officinalis*) M.Sc.(Agri.) thesis submitted to AAU, Anand (Gujarat) India.
- Phandis, N. A. (1970) Improvement of guava (*Psidium guajava* L.) by selection in Maharashtra. *Indian J. Hort.*, **27**: 99-105.
- Rajput, S. S. and Panday, S. D. (1998) Physicochemical changes associated with growth and development of mango ( *Mangifera indica* L.) fruit. *Prog.Hort.*, **30**(1-2): 21-27.
- Ranganna, S. (1979). Manual of analysis of fruit and vegetable products. Tata McGrew Hill Publication Co. Ltd., New Delhi
- Raval, R. D., Selvaraj, Y., Pal, D. K. and Edward, R. (1999). Changes in chemical composition of guava fruits during growth and development. *Indian J. Hort.*, **56** (1): 10-18.

- Reddy, N.N., Gangopadhyay, K. K., Rai M. and Kumar R. (1999)  
Evaluation of guava cultivars under rainfed sub-humid region of  
Chhotanagpur plateau. *Indian J. Hort.*, **56** (1): 135-140.
- Rodriguez, R., Agarwal, P.C. and Saha, S.K. (1971). Physicochemical  
changes during development of Safeda guava fruit. *Indian Food  
Packer.*, **25**:5-12.
- Selvaraj, Y., Pal, D.K., Raja, M.E., Rawal, R.D.(1999). Changes in  
chemical composition of guava fruits during growth and  
development. *Indian J. Hort.*, **56** (1): 10-18
- Sharma, R. M., Chopra, S. K. and Yamdagni, R. (1999 a). Developmantal  
physiology of pear ( *Pyrus communis* L.) fruits I. Changes in  
sugars and soluble protein contents of developing fruits. *Haryana  
J. Hort. Sci.*, **28**(3& 4): 161-163.
- Sharma, R. M., Chopra, S. K. and Yamdagni, R. (1999 b). Developmental  
physiology of pear (*Pyrus communis* L.) fruits I. Changes in  
acidity, sugar/acid ratio and free amino acid contents of  
developing fruits. *Haryana J. Hort. Sci.*, **28**(3& 4): 163-165.
- Sharma, S. R. and Sharma, S. D. (1990). Studies on the physico-chemical  
changes during fruit development of some cultivars of apricot  
(*Prunus Armeniaca* L.). *Haryana J. Hort. Sci.*, **19**(1-2): 33-38.

- Sharma, S., Sharma, R. K. and Goyal, R. K. (2007). Physical changes during growth and development of ber (*Zizyphus mauritiana* L.). *Haryana J. Hort. Sci.*, **36** (1 & 2): 3-5.
- Shridhar, and Singh, S.(1997). Performance of guava varieties of South Andaman. *Prog.Hort.*, **29**(3-4): 194- 195.
- Silva, E.M.S., Bautista, P.B. and Velesco, M.A.G.(1997). Fruit development, harvest index and ripening changes of guavas produced in central Mexico. *Postharvest Biology and Technology*, **13**: 143-150.
- Singh, A. and Singh, S. P.(2000). Evaluation of varieties for quality characters of guava under eastern Uttar Pradesh conditions. *Prog.Hort.*, **32**(2) : 190-196.
- Singh, B. and Arora, R.L.(2000). Changes in biochemical constituents in developing peach fruits. *Indian J.Hort.* **57**(1): 35-38.
- Singh, G., Rao O. P. and Mishra J. S. (1989). Chemical defoliation of guava with urea and NAA. *Prog. Hort.* **21**:49-50.
- Singh, P.P., Singh, S. N. and Dhatt, A. S.(1998). Studies on fruit growth and development in kinnow . *Indian J. Hort.*, **55**(3): 177-182.
- Steel, R. G. D. and Torrie, J. H. (1980). *Principal and Procedures of Statistics- A Biometrical Approach*. Mcgraw - Hill Kogakusha, Ltd., New Delhi.

Supe, V. S., Shete, M. B.; Chavan, U. D. and Kaulgud, S.N. (1997).

Physico-chemical analysis of different aonla cultivars under

Maharashtra conditions. *J. Maharashtra agric. Univ.* **22** (3) 310-312.

Tandon, D. K., Kalra, S. K., Singh, H. and Chadha, K.L.(1983).

Physicochemical characteristics of some guava varieties.

*Prog.Hort.*, 15(1-2) : 42-44.

## APPENDIX-I

### Meteorological observations during experimental period

Month	Std. Week	Bright Sunshine (hrs)	Rain Fall (mm)	Max. Temp. <sup>0</sup> C	Min. Temp. <sup>0</sup> C	Mean RH (%)
1	2	3	4	5	6	7
JULY.- 13	29	1.3	44.7	30.1	25.0	88.9
	30	2.3	13.9	33.0	26.1	82.7
AUG-13	31	2.3	15.6	32.7	25.9	83.8
	32	4.3	105.8	33.0	25.3	84.1
	33	0.6	147.1	30.4	25.4	92.2
	34	2.2	122.2	30.0	25.0	91.4
	35	1.9	113.3	31.0	25.5	87.8
SEP-13	36	2.5	114.8	31.4	24.9	91.8
	37	2.9	99.4	30.7	25.3	88.1
	38	3.5	11.1	31.1	25.0	86.4
	39	7.0	24.9	31.5	24.4	81.1
OCT-13	40	8.0	1.0	33.0	23.9	72.4
	41	9.2	0.0	34.3	23.8	64.4
	42	8.1	0.0	37.3	24.1	60.9
	43	8.6	0.0	37.9	22.0	53.6
	44	9.8	0.0	36.9	18.4	54.0
NOV-13	45	8.8	0.0	35.8	19.9	51.8
	46	9.4	0.0	36.1	19.1	53.6
	47	9.5	0.0	35.3	17.4	59.1
	48	9.7	0.0	33.7	15.9	55.4
DEC-13	49	7.9	0.0	31.6	19.0	57.9
	50	9.7	0.0	33.1	16.3	64.4
	51	9.4	0.0	30.0	12.9	58.4
	52	9.2	0.0	29.8	12.8	63.4

Source: Meteorological Observatory, Anand Agricultural University, Anand.

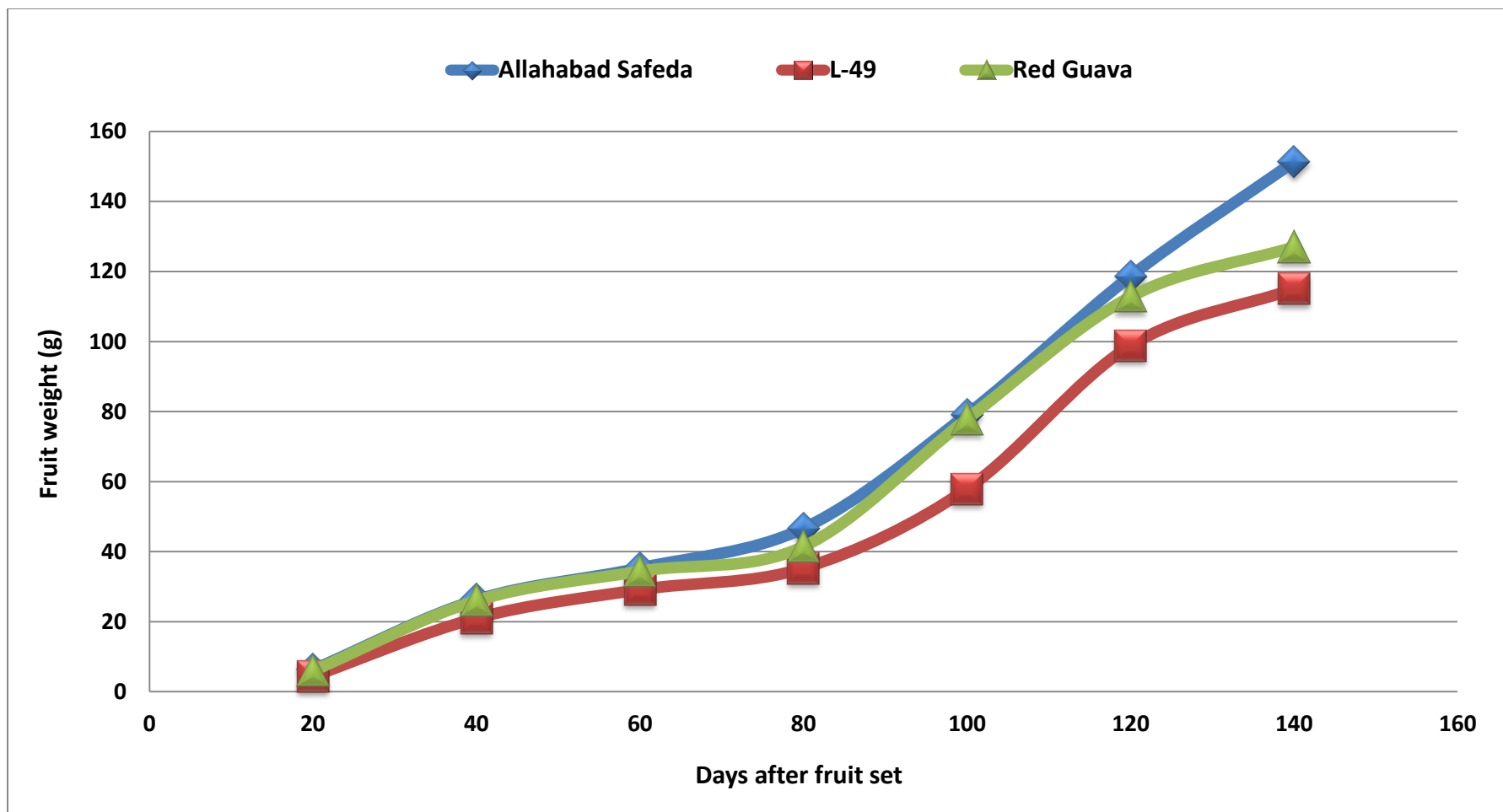
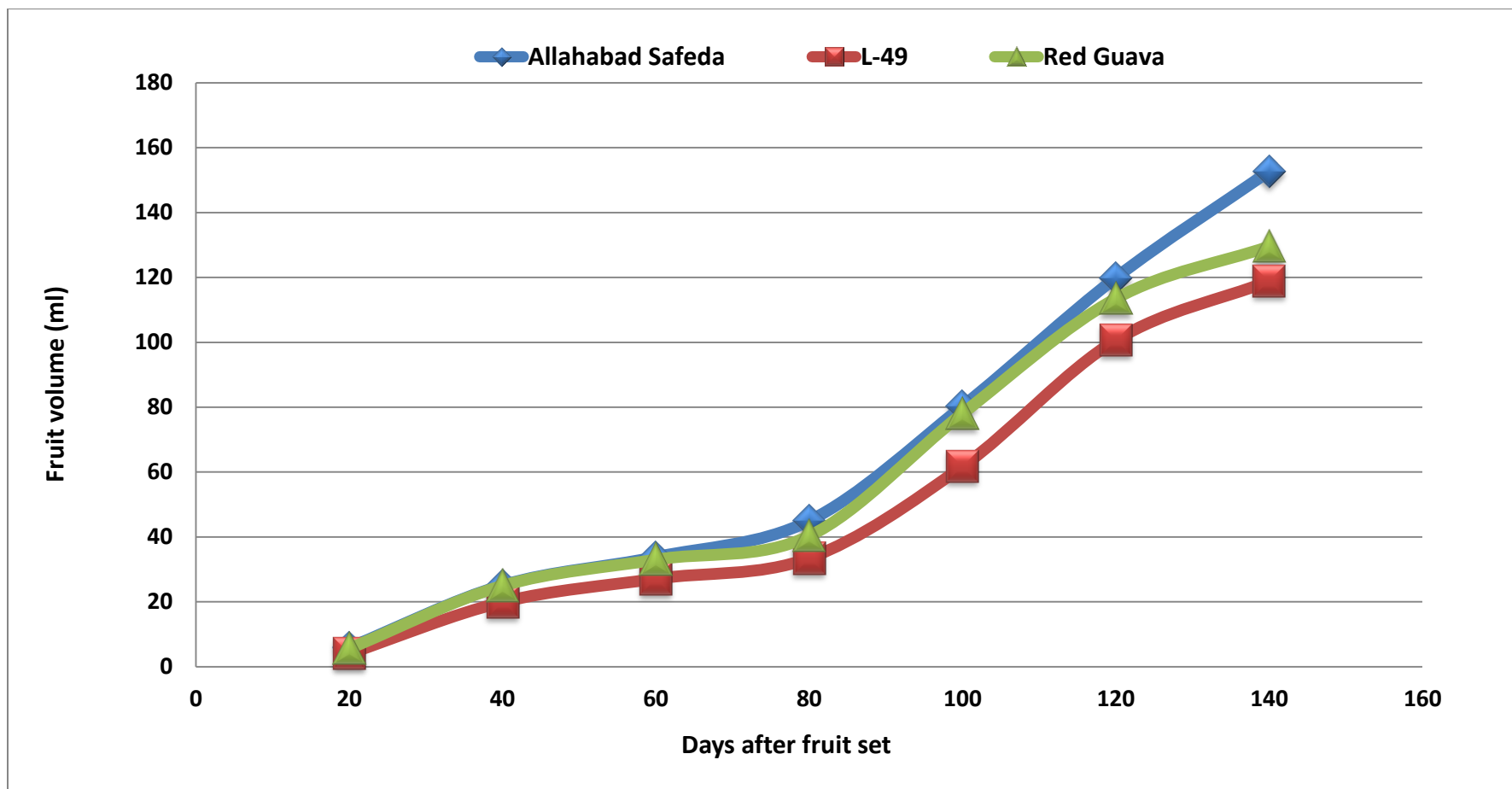


Fig. 4.2.1. The periodical weight (g) of guava fruit in different varieties during their growth and development stages



**Fig. 4.2.2. The periodical volume (ml) of guava fruit as influenced by different varieties during their growth and development stages**

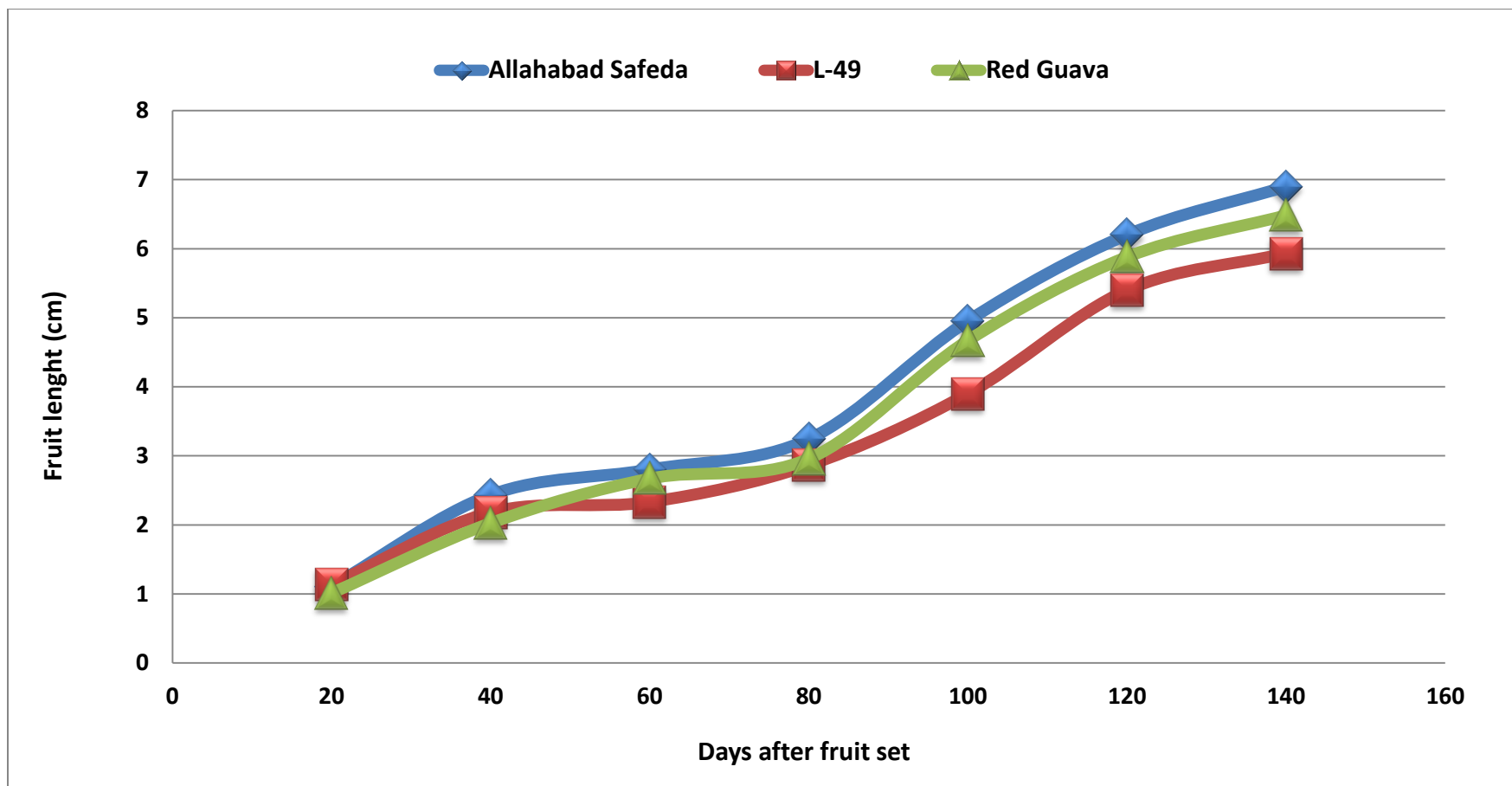
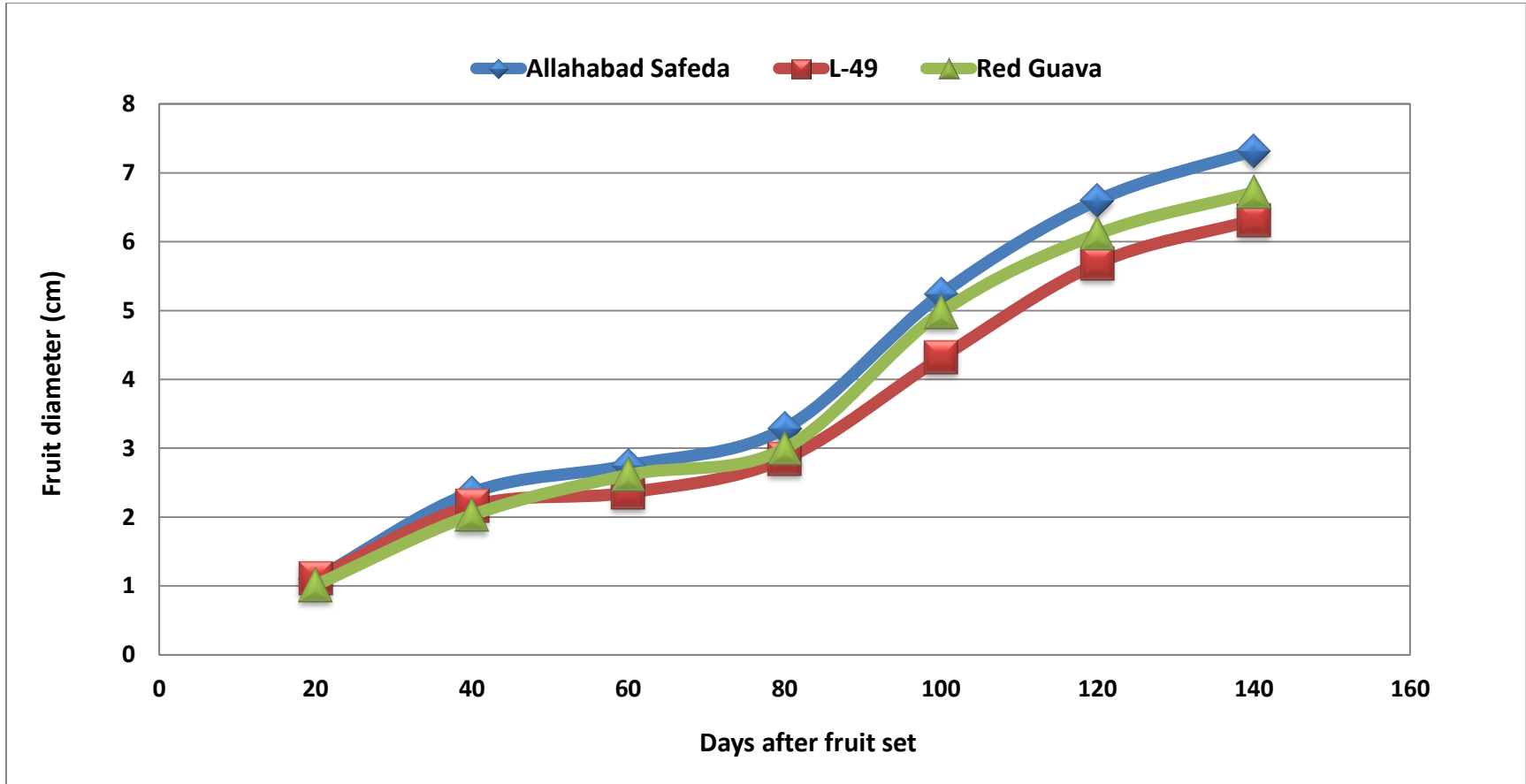


Fig 4.2.3. The periodical length (cm) of guava fruit as influenced by varieties during their growth and development stages



**Fig. 4.2.4.** The periodical diameter (cm) of guava fruit as influenced by varieties during their growth and development stages

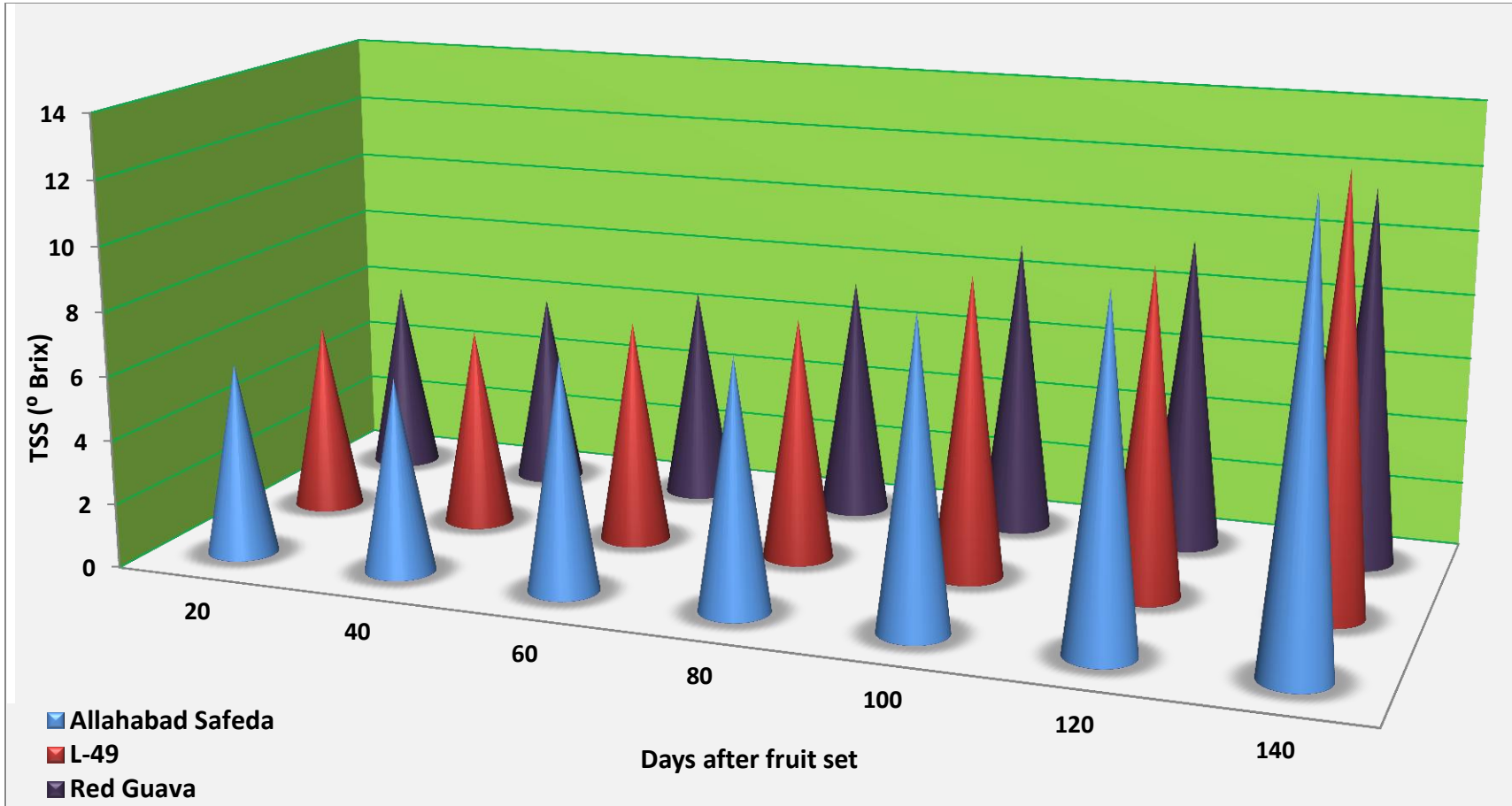


Fig . 4.3.2. The periodical total soluble solids (°Brix) of guava fruit as influenced different varieties during their growth and development stages

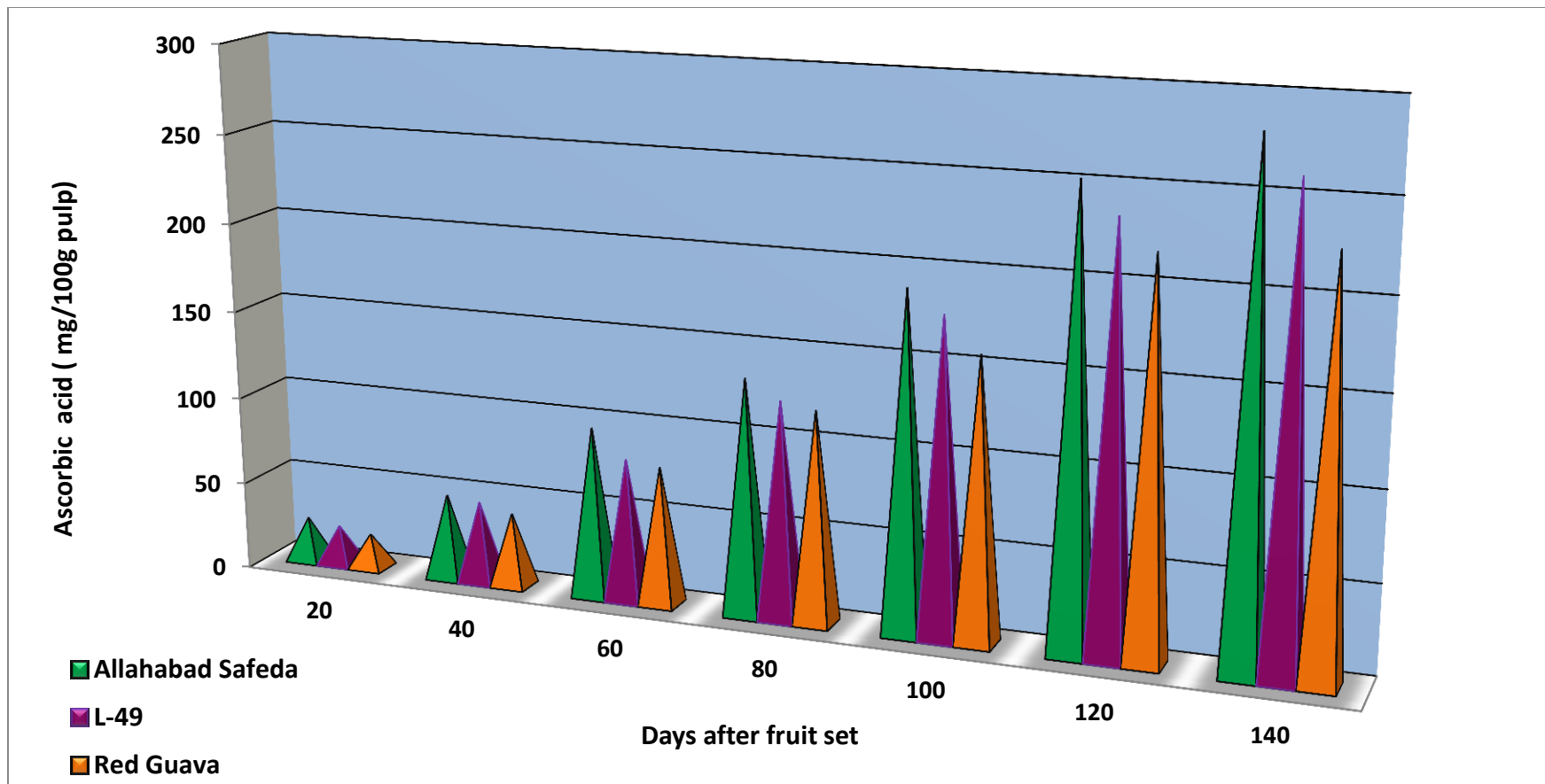
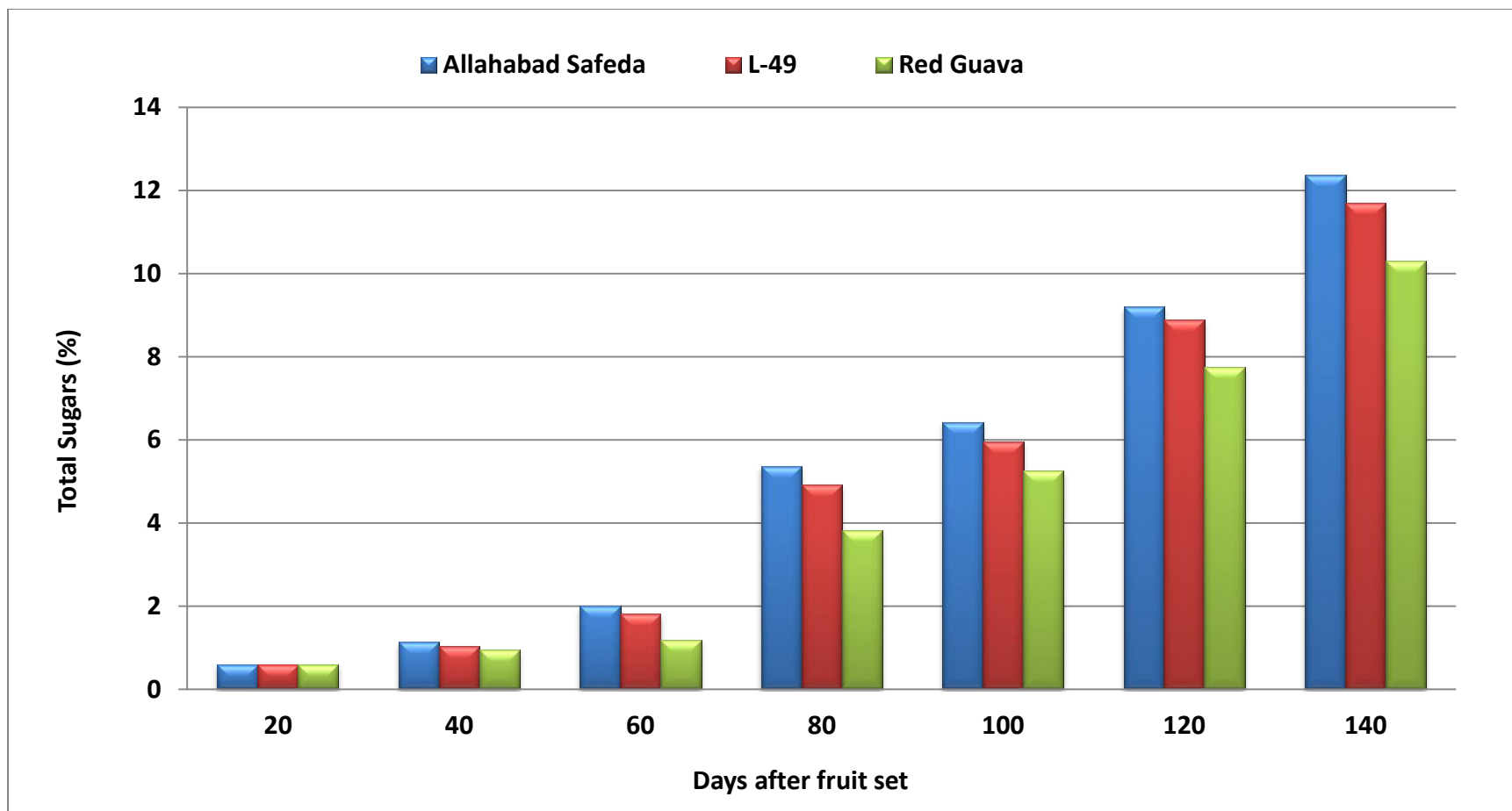
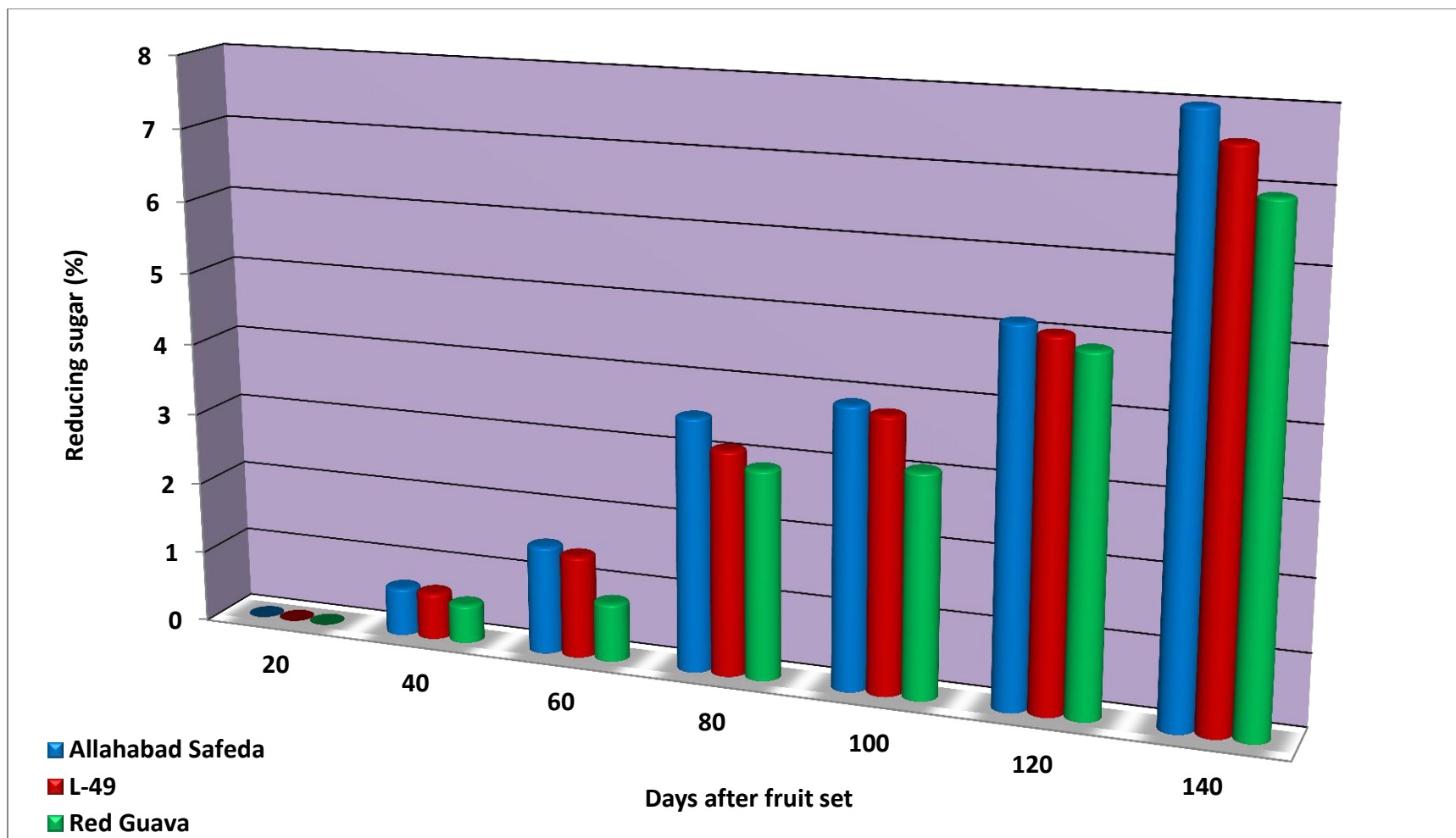


Fig. 4.3.7. The periodical ascorbic acid (mg/100 g pulp) of guava fruit as influenced by different varieties of guava during their growth and development stages



**Fig 4.3.3. The periodical total sugar (%) of guava as influenced by different varieties during their growth and development stages**



**Fig. 4.3.4.** The periodical reducing sugar (%) of guava fruit as influenced by different varieties during their growth and development stage

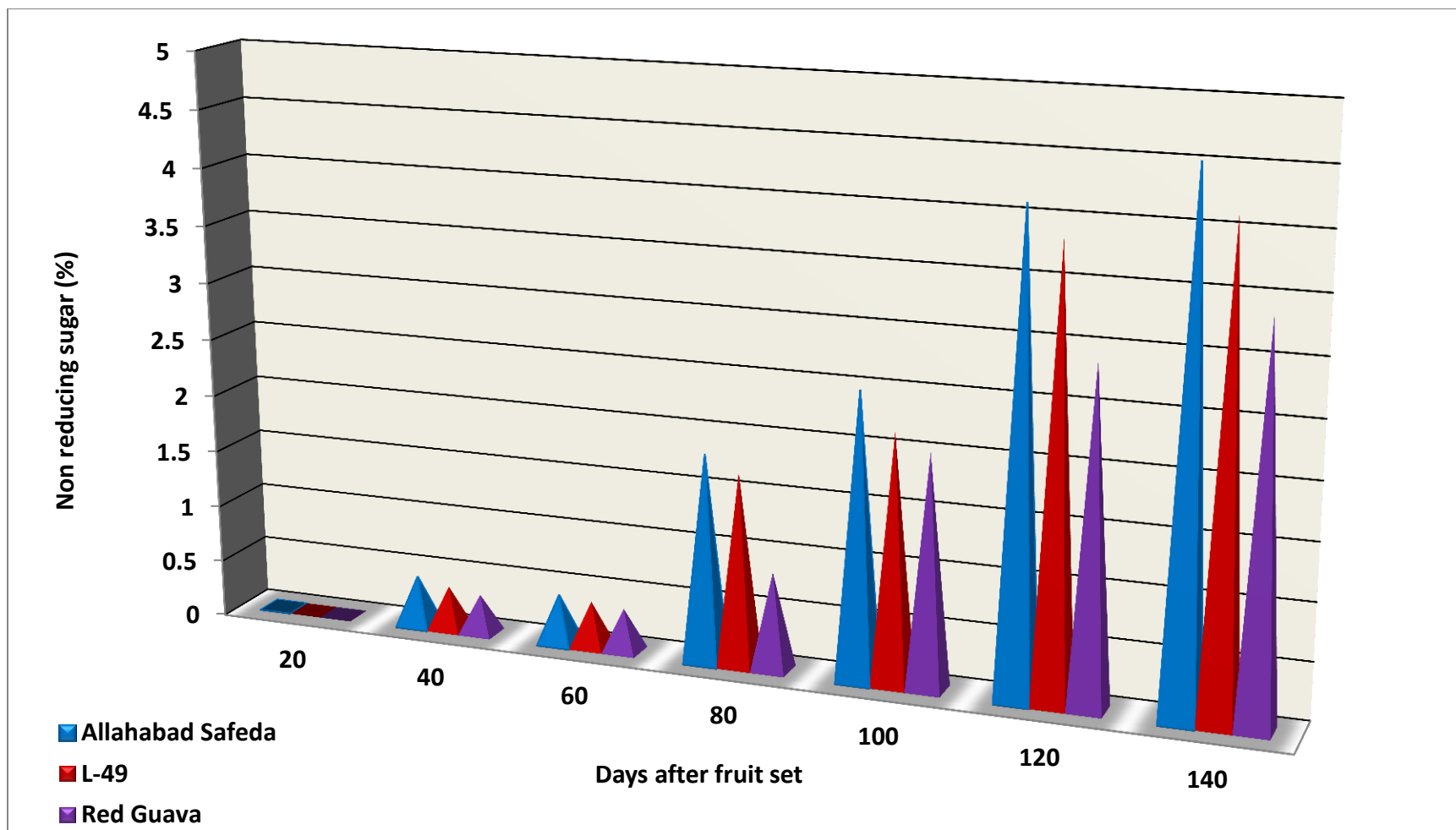
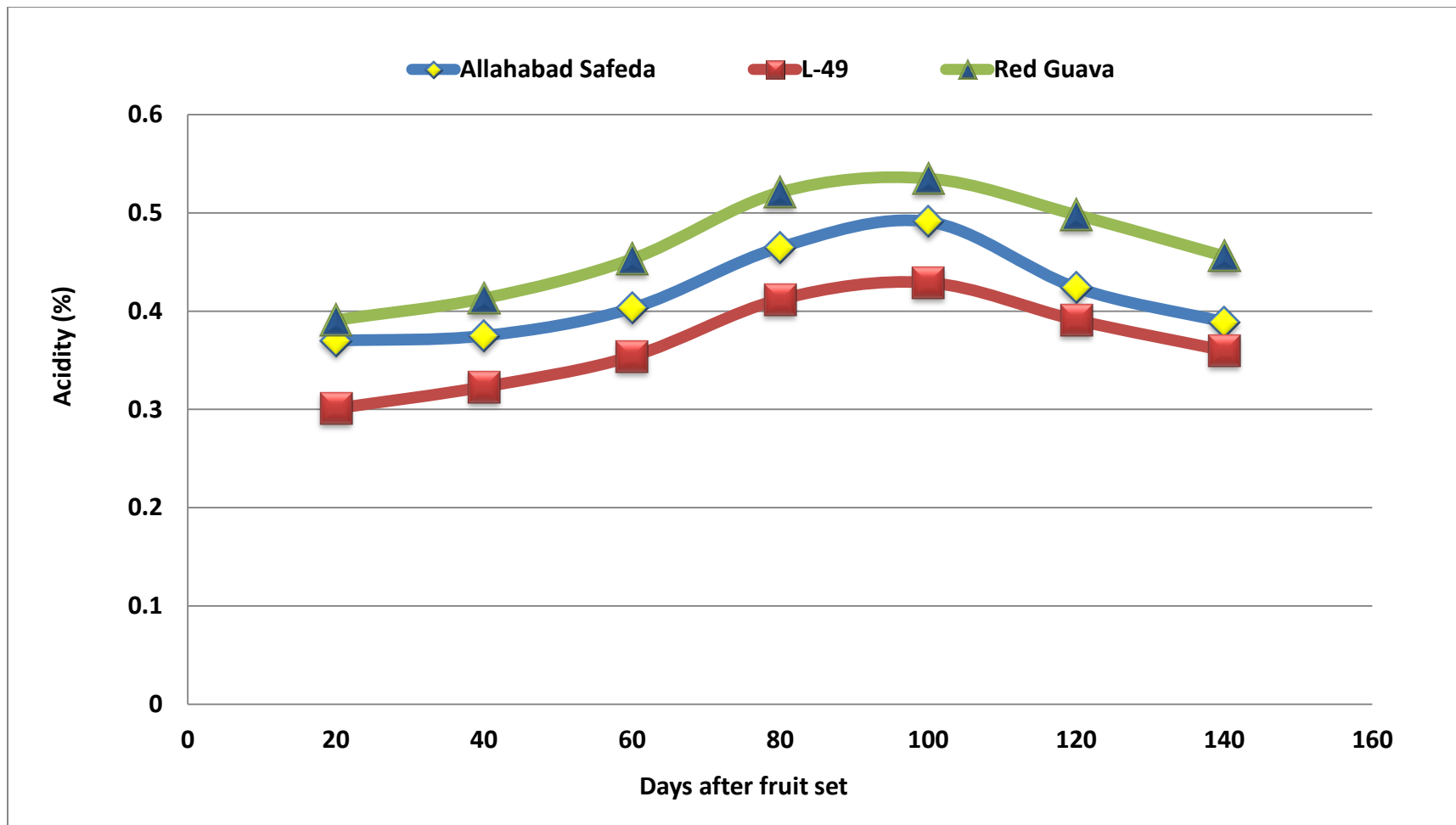
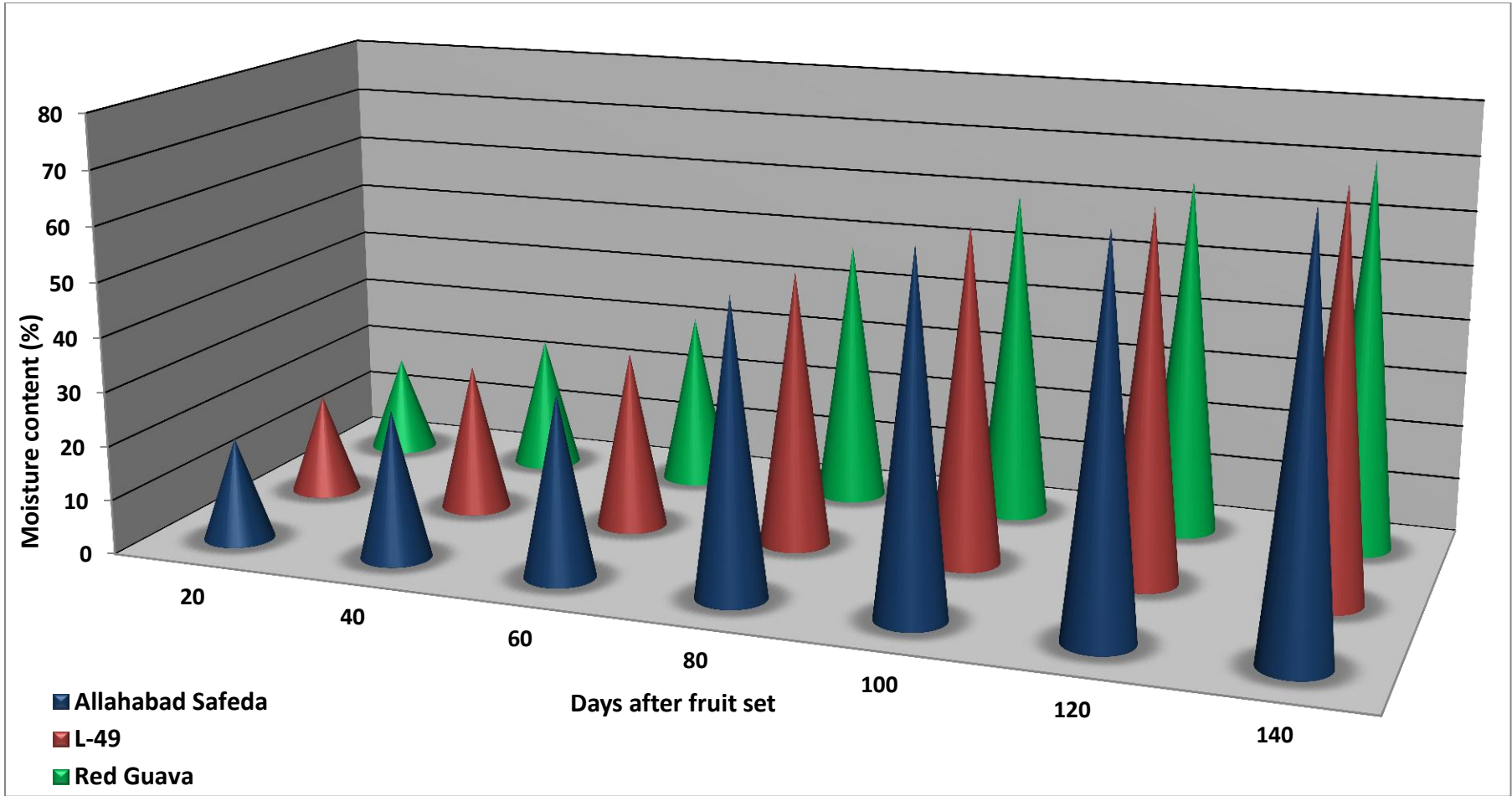


Fig. 4.3.5. The non-reducing (%) of guava fruit as influenced by different varieties during their growth and development stages



**Fig. 4.3.6.**The periodical acidity content (%) of guava fruit as influenced by different varieties during their growth and development stages



**Fig. 4.3.1. The periodical moisture content (%) of guava fruit as influenced by different varieties during their growth and development stages**



**Plate 1: General view of experimental plot**

**Allahabad Safeda**



**L - 49**

**Flowering**



**Red Guava**



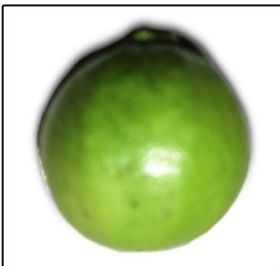
**Fruit setting**



**20 Days after Fruit setting**



**40 Days after Fruit setting**



**60 Days after Fruit setting**



**Plate 2a: Developmental stages of different varieties of guava**

Allahabad Safeda

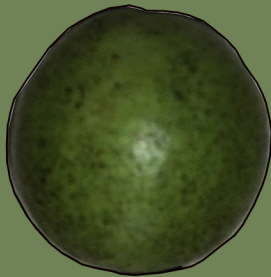
L - 49

Red Guava

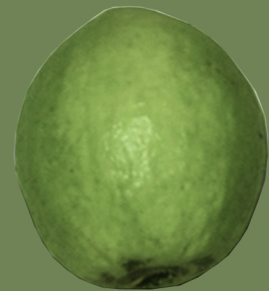
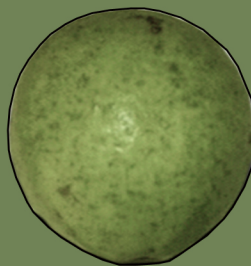
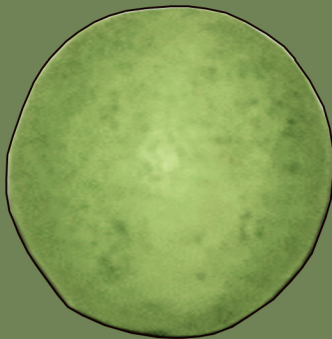
80 Days after Fruit setting



100 Days after Fruit setting



120 Days after Fruit setting



140 Days after Fruit setting



Plate 2b: Developmental stages of different varieties of guava