EFFECT OF PRE AND POST- HARVEST TREATMENTS ON RIPENING AND STORAGE LIFE OF WINTER SEASON GUAVA (*Psidium guajava* L.) cv. ALLAHABAD SAFEDA

A
Thesis
Submitted to

LOVELY PROFESSIONAL UNIVERSITY

Transforming Education Transforming India

For the award of

DOCTOR OF PHILOSOPHY (Ph.D.)

IN
(Horticulture)

By

Jatinder Singh
(41400189)

Supervised By
Dr. J. S. Bal

Co-Supervised by
Dr. Shailesh Kumar Singh

FACULTY OF SCIENCE AND TECHNOLOGY
LOVELY PROFESSIONAL UNIVERSITY
PUNJAB

2019

CERTIFICATE

I hereby declare that the thesis entitled**"Effect of pre and post-harvest treatments on ripening and storage life of winter season guava (*Psidium guajava* L.) cv. Allahabad Safeda"**is an authentic record of my work and carried out at Lovely Professional University as requirement for the degree of **Doctor of Philosophy (Ph.D.)** in the discipline of **Horticulture**, under the guidance of Dr. J. S. Bal, Former Professor of Horticulture and Head, Department of Fruit Science, Punjab Agricultural University, Ludhiana -141004 (India) and no part of this thesis has been submitted for any other degree or diploma.

Jatinder Singh

(Registration No. 40410189)

CERTIFICATE

This is to certify that thesis entitled**"Effect of pre and post-harvest treatments on ripening and storage life of winter season guava (*Psidium guajava* L.) cv. Allahabad Safeda"**submitted in partial fulfilment of the requirement for the award of degree of **Doctor of Philosophy (Ph.D.)** in the discipline of **Horticulture,** is a research work carried out by **Jatinder Singh (Registration No. 41400189)** under my supervision and that no part of this thesis has been submitted for any other degree or diploma.

(**Signature of Supervisor**)

Dr. J. S. Bal

Former Professor of Horticulture and Head

Department of Fruit Science

Punjab Agricultural University, Ludhiana- 141004

(Signature of Co- Supervisor)

Dr. Shailesh Kumar Singh

Associate Professor Horticulture and Head

Department of Horticulture

School of Agriculture

Lovely Professional University, Phagwara-144 411

DEDICATED

TO

MY REVERED PARENTS

AND

BELOVED SIBLINGS

ACKNOWLEDGEMENTS

First and foremost, I am thankful to almighty God for giving me strength, knowledge and opportunity to undertake this research study and complete it with satisfaction. It is my proud privilege to express my deep sense of gratitude and thankfulness to Dr. J. S. Bal, Former Professor of Horticulture and Head, Department of Fruit Science, Punjab Agricultural University, Ludhiana as my guide, for his encouraging attitude, constructive criticism, complete involvement and untiring efforts in the fruitful completion of this manuscript. Without his able guidance, this goal could not have been achieved. He has been generous in lending his intellectual ideas, inculcating me the spirit of an independent research worker and trained my mind to think systemically and logically. I am grateful to Dr. Anis Mirza, Associate Professor, Department of Horticulture, Lovely Professional University, Phagwara who helped me a lot for his sincere advice and constant encouragement required for successful completion of this manuscript.

I am greatly thankful to Dr. Shailesh Kumar Singh, Associate Professor and HOD (Co-guide), Department of Horticulture and Dr Ramesh Sadawarti (Professor and Dean), School of Agriculture for his constant help, valuable suggestions and kind co-operation throughout the course of investigation and preparation of this manuscript. My cordially thanks are due to Dr MPS Khurana (Professor, Soil Science), Dr V K Kaul (Professor, Plant Pathology), Dr Vikas Kumar (Food Technologist), Dr Gurpreet Singh (Associate Professor, Fruit Science), Dr Manish Bakshi, Dr Deepika Saxena (Assistant Professor, Fruit Science and Dr Joginder Singh Panwar (Bio-technologist) for inspiring attitude, timely help and constant encouragement for successful completion of research work.

My sincere thanks to Dr Malkit Singh (HDO) and Mr. Surjit Singh (Progressive Farmer) for providing research facilities (Orchard site) for successful conduct and completion of this research work.

I am highly indebted to all my family members especially my wife Mrs. Kulwinder Kaur, who inspired to complete my studies undeterred and in time. I would like to acknowledge my daughters- Simranjit Kaur (Mr Inderjit Singh Son-in-Law) and Vijay Pal Kaur and Sandy who supported me from time to time. I also owe my sincere thanks to Mr Kamaljit Singh (Farm Staff), Mr Davinder Singh, Mr. Parveen Kumar (Lab Staff) for their cooperation during the course of this study. Also, my special thanks are due to my student Ms. Manpreet Kaur for her selfless help during tenure of my research work.

Last but not the least I am thankful to all those who helped me in one way or another in completion of this document.

March , 2019

School of Agriculture,
Department of Horticulture,
Lovely Professional University,
Phagwara.

Title of thesis	**:**	**Effect of pre and post-harvest treatments on ripening and storage life of winter season guava (*Psidium guajava* L.) cv. Allahabad Safeda**
Name of the student	**:**	**Jatinder Singh**
Regd. Number	**:**	**41400189**
Name and Designation of Research guide	**:**	**Dr. J. S. BAL** **Former Professor of Horticulture and Head** **Department of Fruit Science** **Punjab Agricultural University, Ludhiana**
Name of the University	**:**	**Lovely Professional University, Phagwara, Punjab**

ABSTRACT

The investigations on "**Effect of pre and post-harvest treatments on ripening and storage life of winter season guava (*Psidium guajava*) cv. Allahabad Safeda**" were conducted at Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara during 2015-16 and 2016-17. Guava fruits were sprayed twice (first spray at the start of November at colour break stage and second at 15^{th} November) with NAA 100, 200 and 300 ppm; salicylic acid 100, 200 and 300 ppm and ascorbic acid 75, 150 and 300 ppm. The fruits were harvested after achieving desirable size and uniform colour. The fruits were packed in CFB boxes (4 kg capacity) and kept at ambient temperature and cold storage (Temp. 4-6°C and RH 85-90%). In ambient storage studies, the fruits treated with pre-harvest applications of chemicals were in acceptable condition up to 6 days of storage without deterioration in quality. NAA 100, 200 ppm and salicylic acid 200 ppm were found to be effective in retaining fruit size, colour, firmness, palatability rating, acidity, TSS, vitamin C and total sugars throughout the storage period in comparison to post-harvest applications of chemical. Less PLW and less spoilage were recorded in case of salicylic acid 200 ppm. In cold storage studies, shelf life of guava is maintained better up to 14 days in terms of fruit quality. Effect of pre-harvest spray of ethephon on guava fruit quality resulted in earliness of ripening process. Lower concentration of ethephon @ 250 ppm was the best in maintaining firmness, palatability rating and less PLW with less spoilage. Higher dose of ethephon @ 750 and 1000 ppm was effective in terms of advancement of TSS, vitamin C and total sugars throughout the storage period of guava fruit. It was concluded that NAA 200 ppm and salicylic acid 200 ppm were best in extending shelf-life of guava fruits for 6 days at ambient temperature and two weeks at low temperature. Ethephon @ 500 ppm at colour break stage enhance ripening and produce better quality fruits with uniform colour development.

Key words: Guava, Shelf life, Growth Regulators, Anti-oxidant, Quality, Ripening

CONTENTS

CHAPTER NO.	PARTICULARS		PAGE NO.
I	**INTRODUCTION**		**1-5**
II	**REVIEW OF LITERATURE**		**6-62**
	2.1	Pre-harvest application of Chemicals on Shelf Life of Winter Guava	7
	2.2	Post-harvest Application of Chemicals on Shelf Life of Winter Guava	33
	2.3	Ripening Studies in Winter Guava under Ambient Conditions	52
III	**MATERIALS AND METHODS**		**63-74**
	3.1	Pre-harvest applications of Chemicals on Shelf Life of Winter Guava	64
	3.2	Post-harvest Application of Chemicals on Shelf Life of Winter Guava	70
	3.3	Ripening Studies in Winter Guava under Ambient Conditions	73
IV	**RESULTS AND DISCUSSION**		**75-192**
	4.1	Effect of Pre-Harvest Treatments on Shelf Life of Guava cv. Allahabad Safeda under Ambient and Cold Storage Conditions	75
	4.2	Effect of Post-Harvest Treatments on Shelf Life of Guava cv. Allahabad Safeda under Ambient and Cold Storage Conditions	128
	4.3	Effect of Pre-harvest Spray of Ethephon on Ripening and Quality of Guava cv. Allahabad Safeda.	170
V	**SUMMARY AND CONCLUSION**		**193-199**
	5.1	Effect of Pre-harvest Treatments on Shelf life of Guava in Allahabad Safeda under Ambient and Cold Storage Conditions	193
	5.2	Effect of Post-harvest Treatments on Shelf life of Guava cv. Allahabad Safeda under Ambient and Cold Storage Conditions	196
	5.3	Effect of Pre-harvest sprays of Ethephon on Ripening and Quality of Guava cv. Allahabad Safeda	198
	LITERATURE CITED		**200-227**

LIST OF FIGURES

Fig. No.	Title	Page No.
1	Effect of pre-harvest application of chemicals on fruit firmness (lbs/cm^2) of guava under ambient storage (2015-16)	83
2	Effect of pre-harvest application of chemicals on fruit firmness (lbs/cm^2) of guava under ambient storage (2016-17)	88
3	Effect of pre-harvest application of chemicals on palatability rating (out of 20) guava under ambient storage (2015-16)	89
4	Effect of pre-harvest application of chemicals on palatability rating (out of 20) guava under ambient storage (2016-17)	89
5	Effect of pre-harvest application of chemicals on total soluble solids (%) of guava under ambient storage (2015-16)	96
6	Effect of pre-harvest application of chemicals on total soluble solids (%) of guava under ambient storage (2016-17)	96
7	Effect of pre-harvest application of chemicals on fruit firmness (lbs/cm^2) of guava under cold storage (2015-16)	97
8	Effect of pre-harvest application of chemicals on fruit firmness (lbs/cm^2) of guava under cold storage (2016-17)	97
9	Effect of pre-harvest application of chemicals on palatability rating (out of 20) of guava under cold storage (2015-16)	117
10	Effect of pre-harvest application of chemicals on palatability rating (out of 20) of guava under cold storage (2016-17)	117
11	Effect of pre-harvest application of chemicals on total soluble solids (%) of guava under cold storage (2015-16)	118
12	Effect of pre-harvest application of chemicals on total soluble solids (%) of guava under cold storage (2016-17)	118
13	Effect of post-harvest application of chemicals on fruit firmness (lbs/cm^2) of guava under ambient storage (2015-16)	132
14	Effect of post-harvest application of chemicals on fruit firmness (lbs/cm^2) of guava under ambient storage (2016-17)	132
15	Effect of post-harvest application of chemicals on palatability rating (out of 20) of guava under ambient storage (2015-16)	133
16	Effect of post-harvest application of chemicals on palatability rating (out of 20.0) of guava under ambient storage (2016-17)	133

17	Effect of post-harvest application of chemicals on physiological loss in weight (%) of guava under ambient storage (2015-16)	138
18	Effect of post-harvest application of chemicals on physiological loss in weight (%) of guava under ambient storage (2016-17)	138
19	Effect of post-harvest application of chemicals on spoilage (%) of guava under ambient storage (2015-16)	139
20	Effect of post-harvest application of chemicals on spoilage (%) of guava under ambient storage (2016-17)	139
21	Effect of post-harvest applications of chemicals on fruit firmness (lbs/cm^2) of guava under cold storage (2015-16)	153
22	Effect of post-harvest applications of chemicals on fruit firmness (lbs/cm^2) of guava under cold storage (2016-17)	153
23	Effect of post-harvest applications of chemicals on palatability rating (out of 20) of guava under cold storage (2015-16)	154
24	Effect of post-harvest applications of chemicals on palatability rating (out of 20) of guava under cold storage (2016-17)	154
25	Effect of post-harvest application of chemicals on physiological loss in weight (%) of guava under cold storage (2015-16)	159
26	Effect of post-harvest application of chemicals on physiological loss in weight (%) of guava under cold storage (2016-17)	159
27	Effect of post-harvest application of chemicals on spoilage (%) of guava under cold storage (2015-16)	160
28	Effect of post-harvest application of chemicals on spoilage (%) of guava under cold storage (2016-17)	160
29	Effect of ethephon on fruit firmness (lbs/cm^2) of guava (2015-16)	174
30	Effect of ethephon on fruit firmness (lbs/cm^2) of guava (2016-17)	174
31	Effect of ethephon on palatability rating (out of 20) of guava (2015-16)	175
32	Effect of ethephon on palatability rating (out of 20) of guava (2016-17)	175
33	Effect of ethephon on physiological loss in weight (%) of guava (2015-16)	183
34	Effect of ethephon on physiological loss in weight (%) of guava (2016-17)	183
35	Effect of ethephon on spoilage (%) of guava (2015-16)	184
36	Effect of ethephon on spoilage (%) of guava (2016-17)	184

LIST OF TABLES

Table No.	Title	Page No.
1	Effect of pre-harvest treatments of chemicals on fruit length (cm) of guava cv. Allahabad Safeda fruit under ambient storage conditions	76
2	Effect of pre-harvest treatments of chemicals on fruit breadth (cm) of guava cv. Allahabad Safeda under ambient storage conditions	78
3	Effect of pre-harvest treatments of chemicals on fruit weight (g) of guava cv. Allahabad Safeda under ambient storage conditions	82
4	Effect of pre-harvest treatments of chemicals on specific gravity of guava cv. Allahabad Safeda under ambient storage conditions	84
5	Effect of pre-harvest treatments of chemicals on fruit colour guava cv. Allahabad Safeda under ambient storage conditions	85
6	Effect of pre-harvest treatments of chemicals on fruit firmness (lbs/cm^2) guava cv. Allahabad Safeda under ambient storage conditions	87
7	Effect of pre-harvest treatments of chemicals on palatability rating (out of 20.0) of guava cv. Allahabad Safeda under ambient storage conditions	91
8	Effect of pre-harvest treatments of chemicals on seed weight (g) of guava cv. Allahabad Safeda under ambient storage conditions	93
9	Effect of pre-harvest treatments of chemicals on total soluble solids (%) of guava cv. Allahabad Safeda under ambient storage conditions	95
10	Effect of pre-harvest treatments of chemicals on acidity (%) of guava cv. Allahabad Safeda under ambient storage conditions	99
11	Effect of pre-harvest treatments of chemicals of vitamin C (mg/100g) of guava cv. Allahabad Safeda under ambient storage conditions	101
12	Effect of pre-harvest treatments of chemicals on total sugars (%) of guava cv. Allahabad Safeda under ambient storage conditions	103
13	Effect of pre-harvest treatments of chemicals on fruit length (cm) of guava cv. Allahabad Safeda under cold storage conditions	105
14	Effect of pre-harvest treatments of chemicals on fruit breadth (cm) of guava cv. Allahabad Safeda under cold storage conditions	107

15	Effect of pre-harvest treatments of chemicals on fruit weight (g) of guava cv. Allahabad Safeda under cold storage conditions	107
16	Effect of pre-harvest treatments of chemicals on specific gravity of guava cv. Allahabad Safeda under cold storage conditions	111
17	Effect of pre-harvest treatments of chemicals on fruit colour of guava cv. Allahabad Safeda under cold storage conditions	112
18	Effect of pre-harvest treatments of chemicals on fruit firmness (lbs/cm^2) of guava cv. Allahabad Safeda under cold storage conditions	114
19	Effect of pre-harvest treatments of chemicals on palatability rating (out of 20.0) of guava cv. Allahabad Safeda under cold storage conditions	116
20	Effect of pre-harvest treatments of chemicals on seed weight (g) of guava cv. Allahabad Safeda under cold storage conditions	120
21	Effect of pre-harvest treatments of chemicals on total soluble solids (%) of guava cv. Allahabad Safeda under cold storage conditions	122
22	Effect of pre-harvest treatments of chemicals on acidity (%) of guava cv. Allahabad Safeda under cold storage conditions	123
23	Effect of pre-harvest treatments of chemicals of vitamin C (mg/100g) of guava cv. Allahabad Safeda under cold storage conditions	125
24	Effect of pre-harvest treatments of chemicals on total sugars (%) of guava cv. Allahabad Safeda under cold storage conditions	127
25	Effect of post-harvest treatments of chemicals on fruit colour of guava cv. Allahabad Safeda under ambient storage conditions	129
26	Effect of post-harvest treatments of chemicals on fruit firmness (lbs/cm^2) of guava cv. Allahabad Safeda under ambient storage conditions	131
27	Effect of post-harvest treatments of chemicals on palatability rating (out of 20.0) of guava cv. Allahabad Safeda under ambient storage conditions	135
28	Effect of post-harvest treatments of chemicals on physiological loss in weight (%) of guava cv. Allahabad Safeda under ambient storage conditions	137

29	Effect of post-harvest treatments of chemicals on spoilage per centage of guava cv. Allahabad Safeda under ambient storage conditions	141
30	Effect of post-harvest treatments of chemicals on total soluble solids (%) of guava cv. Allahabad Safeda under ambient storage conditions	143
31	Effect of post-harvest treatments of chemicals on acidity (%) of guava cv. Allahabad Safeda under ambient storage conditions	145
32	Effect of post-harvest treatments of chemicals of vitamin C (mg/100g) of guava cv. Allahabad Safeda under ambient storage conditions	146
33	Effect of post-harvest treatments of chemicals on total sugars (%) of guava cv. Allahabad Safeda under ambient storage conditions	148
34	Effect of post-harvest treatments of chemicals on fruit colour of guava cv. Allahabad Safeda under cold storage conditions	150
35	Effect of post-harvest treatments of chemicals on fruit firmness (lbs/cm^2) of guava cv. Allahabad Safeda under cold storage conditions	152
36	Effect of post-harvest treatments of chemicals on palatability rating (out of 20.0) of guava cv. Allahabad Safeda under cold storage conditions	156
37	Effect of post-harvest treatments of chemicals on physiological loss in weight (%) of guava cv. Allahabad Safeda under cold storage conditions	158
38	Effect of post-harvest treatments of chemicals on spoilage (%) of guava cv. Allahabad Safeda under cold storage conditions	162
39	Effect of post-harvest treatments of chemicals on total soluble solids (%) of guava cv. Allahabad Safeda under cold storage conditions	164
40	Effect of post-harvest treatments of chemicals on acidity (%) of guava cv. Allahabad Safeda under cold storage conditions	166
41	Effect of post-harvest treatments of chemicals on vitamin C (mg/100g) of guava cv. Allahabad Safeda under cold storage conditions	168
42	Effect of post-harvest treatments of chemicals on total sugars (%) of guava cv. Allahabad Safeda under cold storage conditions	169

43	Effect of ethephon on fruit colour of guava fruits cv. Allahabad Safeda	171
44	Effect of ethephon on fruit firmness (lbs/cm^2) of guava fruits cv. Allahabad Safeda	173
45	Effect of ethephon on palatability rating (out of 20.00) of guava fruits cv. Allahabad Safeda	177
46	Effect of ethephon on PLW (%) of guava fruits cv. Allahabad Safeda under ambient storage	181
47	Effect of ethephon on fruit spoilage (%) of guava fruits cv. Allahabad Safeda	182
48	Effect of ethephon on total soluble solids (TSS%) of guava fruits cv. Allahabad Safeda	186
49	Effect of ethephon on acidity (%) of guava fruits cv. Allahabad Safeda	187
50	Effect of ethephon on vitamin C (mg/100 gm) of guava fruits cv. Allahabad Safeda under ambient storage	189
51	Effect of ethephon on total sugars (%) of guava fruits cv. Allahabad Safeda under ambient storage	191

Chapter I

INTRODUCTION

Guava (*Psidium guajava* L.) is a tropical fruit, belongs to the family- Myrtaceae. It is one of the most common and major fruit of India and is popularly known as "Apple of Tropics" due to its particular dessert and culinary usages. It contains a considerable amount of iron but 80 percent of which remains in the seed. The fruit is also an excellent source of vitamin C containing 2-5 times more than oranges. High amount of pectin in guava lowers the blood cholesterol. Besides this, it is a rational source of vitamin A and minerals like calcium and phosphorus. However, being a fruit of perishable nature, it is difficult to store for long periods (Sanjay 2000). The fruit is extensively used in the processing industry to prepare many delicious products like jam, jelly, juice, excellent salad and pudding.

Guava can withstand adverse climatic conditions and grows under a wide range of soil types from sandy loam to clay loam due to the hardy nature of the plant (Bal 1997). Globally India, Pakistan and Brazil are the principal producers of commercial guava cultivars. However, it is grown on a commercial scale in Indonesia, China, Mexico, Brazil, Philippines, Bangladesh, and Nigeria. The increase in its consumption, both as a table fruit and as a natural juice, has been a worldwide trend. Guava has well-established markets in more than 60 countries. Although, the area and production of guava increased in the last decade, but there is no significant increase in productivity. In production of guava, Madhya Pradesh is the largest producer of guava accounting for 23.8 per cent followed by Uttar Pradesh (21.2 %, Bihar (9.26 %) and Maharashtra (6.94 %). However, the best of guava is produced in Uttar Pradesh (Bal 2018). Guava is the fifth widely grown fruit crop in India. The area under guava is 2.54 lakh ha yielding 40.5 lakh metric tons accounted for 3.97 per cent of area and 4.42 per cent of production. The average productivity of guava is now 15.9 mt/ha (Bal 2018).

In Punjab, it ranks second in cultivation after citrus. Total area in the state is 8072 hectares with the annual production of 177570 tons. The district of Patiala, Ludhiana, Sangrur, SAS Nagar, Ferozepur, Jalandhar, Muktsar, Bathinda, Ropar, and Amritsar are known for guava cultivation (Bal 2014). Under Punjab conditions, guava flowers two times in a year. The first bloom occurs in April-May for the rainy season crop and the second in August-September for the winter season crop. Rainy season crops are poor in quality while the winter crop is superior in quality, free from fruit fly infestation and fetches higher price as compared to rainy season crop (Lal and Dass 2017). However, the fruits of the winter season crop remain hard and do not develop properly on the tree due to low temperature.

Being highly perishable, guava fruits have to be marketed immediately after harvest. A large portion of fresh fruits is lost worldwide after harvest. The post-harvest losses range from 10-15 percent. The main causes are physiological (wilting, shriveling and chilling injury etc.), pathological (decay due to fungi and bacteria) and physical (mechanical injury factors) which are interrelated and show co-influence like the mechanical injury is also associated to post-harvest decay in many cases (Madrid 2011).

Post-harvest losses are estimated at 20 to 40 percent in developing countries and 10 to 15 percent in developed countries, depending on the crop and the season (Madrid 2011). The high degree of post-harvest losses in developing countries are associated with poor storage and food-handling technologies (Salami *et al* 2010) due to poor infrastructure for storage of fresh fruits in comparison to advanced countries (Parfitt *et al* 2010).

The per capita accessibility of fruits is far below the suggested level (230 g) and is further reduced due to the high level of post-harvest losses during post-harvest handling, storage, and ripening. The decrease of post-harvest losses by lengthening the shelf life of guava can help to improve the situation. Many efforts are, thus needed to regulate the supply of fruits in the markets. Further, the share of the guava fruits, export from India is not enough (0.65%), which can be improved up with the increasing storage life of fruits. It has been established that the pre/post-harvest treatments of various growth regulators like auxins and gibberellins on various fruit crops enhance their shelf life and improve the fruit quality by delaying the onset of senescence during storage (Singh 1980).

Calcium compounds extend the shelf life of fruits by maintaining the fruit firmness, minimizing the rate of respiration, disease incidence and protein breakdown (Gupta *et al* 1987). Pre-harvest sprays of potassium and growth regulators are one of the most important practices of the new strategies applied in the integrated fruit production systems, improving fruit quality (El-hilali *et al* (2003). Artificial methods such as temperature alteration and use of chemicals or growth regulators may enhance the ripening as well as the storage life of the guava fruits. A substantial quantity of guava fruits goes waste in our country due to lack of proper storage facilities. The primary purpose of storage is to control the rate of transpiration, respiration, ripening and delay any undesirable biochemical changes and also to check the disease infection in the guava fruits and consequently extends the period of availability in the market.

The various measures for reduction of post-harvest losses like low-temperature storage use of growth regulators/chemicals, irradiation, and processing of fully ripened guava fruits, are adopted so that the surplus horticultural produce may be available. Hence, the use of good post-harvest handling practices from field to market also become more significant. Thus, the storage of fruits with the use of growth regulators /chemicals and different packing materials combined with suitable temperatures need special attention. Since, the response of fruits to these treatments varies with different kinds and varieties of fruits and the local ambient conditions, it may be necessary to find out a suitable expertise for extending the shelf-life of guava fruits.

After harvest, a number of factors influence the shelf life and quality of guava fruit. Among them, cultivar, fruiting season, maturity stage, kinds of materials used for wrapping purposes during storage, temperature and humidity prevailing over the storage environment are very important. During the storage period, deterioration of guava is attributed to adverse physico-chemical changes, namely loss of weight due to respiration and transpiration, softening of the flesh, loss due to microbial attack and change in sugar and acid content.

Dutta *et al* (1991) found prolonged shelf life of guava with ethylene absorbent in a sealed polythene bag. Little work has so far been reported on storage, stage of ripening and wrapping materials on the shelf life of guava. Prolonged shelf life could facilitate the export of guava and earn foreign currency. Various kinds of experiments have been tried to identify the proper stage of ripening of guava, low cost and proper wrapping materials as well as ideal storage temperature to prolong the shelf life and quality to encourage the farmer to grow more guavas and to minimize the shortage of fruit (guava) in the country.

Till now storage with low temperature conditions has been considered the most effective method to maintain the superiority of most fruits due to its effects on reducing respiration rate, transpiration, and ethylene production, maturing, senescence and rotten process.

Plant bio-regulators are organic combinations, either natural or synthetic that transforms or control one or more precise physiological procedure within a plant. They can hasten or delay the growth or maturation rate or otherwise alter the behavior of plants or their products (Olaiya and Osonubi 2009). They can be used to advance or delay fruit harvest by manipulating fruit maturation and ripening. An increase in the storage life and enhancement of fruit quality is indeed desirable and the initial step required for safeguarding positive marketing is to harvest the crop at the optimal stage of maturity (Looney 1998). Plant growth regulators are very useful in improving physico-chemical aspects of fruits (Karole and Tiwari 2016).

Naphthalene acetic acid (NAA) is a man-made plant hormone in the auxin family. It has various physiological roles, such as encouraging cell division and enlargement. NAA can penetrate into plant by various means like leaves, branches and tender skin etc. and can affect plant and fruit properties. NAA increases the growth rate of the fruit which results in a bigger fruit size at harvest without any undesirable reduction in yield. It does not occur naturally and like all auxins, is toxic to plants at high concentrations. Increased amounts of NAA has undesirable effects and cause growth embarrassment. High concentrations check the rate of protoplasmic flowing.

Salicylic acid (SA) is a plant growth regulator, classified as a phenyl propanoid compound. It has been recently established that salicylic acid is a safe chemical, used to control the post-harvest quantity or quality losses of consumable crops. SA as a natural and safe phenolic compound exhibits a high probability in controlling post-harvest losses of fruit crops. It was established that various intrinsic biosynthetic pathways and effects of exogenous SA on decay and disease resistance, oxidative stress, ethylene biosynthesis and action, fruit firmness, fruit ripening, respiration, antioxidant systems and nutritional quality have also been influenced (Asghari and Aghdam 2010).

Ascorbic acid is present in plant tissues undergoing active growth and development, and its amount varies among different species and cultivars of plants. It is very high in horticultural crops like fruit of Barbados cherry or West Indian cherry, which contains over 1% of its fresh weight in ascorbic acid (Loewus and Loewus 1987). Climatic conditions including light and temperature have a strong influence on the chemical composition of fruits (Klein and Perry 1982). Vitamin C is very sensitive to destruction when subjected to adverse handling and storage environment. Losses are much worst by prolonged storage, low relative humidity, higher temperatures, and chilling injury. It is easily oxidized, especially in aqueous solutions (Parviainen and Nyyssonen 1992). Pre-harvest factors include climatic conditions and cultural practices (Weston and Barth 1997). All these factors are accountable for variation in vitamin C content of fruits at harvest. Other factors include fruit maturity at harvest, harvesting technique, and postharvest handling surroundings also affect the vitamin C content of fruits (Kader 1992).

Ethephon is a general plant growth regulator, which belongs to phosphonate family. It is voluntarily absorbed by plants and results in ethylene which is a natural plant hormone. It affects physiological processes (ripening, maturation) and encourages the production of ethylene. Ethephon is mainly expressed as a soluble concentrate (SL) and retailed under numerous trade names resultant to specific practices. Ethephon is used in fruits to boost fruit maturity (early and constant ripening and coloring of mature fruits).

Keeping in view the above-identified conditions, the current studies were planned with different treatments as pre- and post-harvest application involving growth regulators and chemicals on the shelf life of guava cv. Allahabad Safeda fruits at ambient and cold storage with the following objectives:

1. To study the pre-harvest application of chemicals on the shelf life of guava under ambient and cold storage temperature.
2. To study the post-harvest dipping of chemicals on shelf life of guava under ambient and cold temperature.
3. To study the impact of ethephon on the ripening of winter guava under ambient conditions.

Chapter II

REVIEW OF LITERATURE

Being living entities, fruits and vegetables in their post-harvest life are dependent on their own stored foods for meeting the energy demands to carry out several physiological and biochemical process such as transpiration, respiration, ripening and others with no significant photosynthetic activity. Fruits and vegetables are the perishable commodities and guava is no exception. Chemical modification of ripening and senescence with a view to increasing the shelf life of fruits has of late, engaged the attention of the researchers. The scientific method of post-harvest handling of fruits not only facilitate proper care of agricultural produce but also help in enhancing the shelf life of produce. High level of post-harvest losses of horticultural produce in the country points towards the need for proper handling of produce in a scientific manner. Under Indian conditions, there is an urgent need to develop suitable techniques for guava fruits intended for fresh fruit markets.

Guava is a highly perishable fruit and the physiological changes in fruits after harvest are continuous until the fruits become unfit for consumption. If the rate of such changes can be reduced to some extent then the shelf life of guava fruits can be effectively increased, and spoilage could be reduced.

In guava, little information on the influence of growth regulators on the shelf life of guava under ambient and cool storage temperature is available. Although some work on this aspect has been reported by some workers in different locations. However, detailed information on this important aspect (storage behavior) is not available, particularly on guava variety Allahabad Safeda, which is commonly grown in Punjab.

Some researchers recommended 5°C as the optimum storage temperature for guava. The weight loss from the fruit was dependent on both the temperature and duration of storage. Storage at 20°C extended the post-harvest life by a few days as suggested by Augustin and Azizah (1988).

Gaspar *et al* (1997**)** recommended that a storage temperature of 8°C for 'Kumagai' guava for 2 or 3 weeks at which fruits remained in good condition while temperature was 25°C. Guava fruits become overripe and mealy within a week under ambient conditions, whereas, in cold storage, the shelf life could be manipulated up to two weeks at 6-8 °C and 90-95% R.H. (Mahajan *et al* 2009).

As research work done in this aspect on guava is not abundant. Therefore, the literature on other important tropical and sub-tropical fruits has also been reviewed. A brief review on the influence of growth regulators on the shelf life of guava under ambient and cool storage temperature including the impact of ethephon on the aging of winter guava is given under different headings.

2.1 Pre-harvest application of Chemicals on Shelf Life of Winter Guava

2.1.1 Ambient Storage

2.1.1.1 Effect of Naphthalene Acetic Acid

2.1.1.1.1 Physical Characters of Fruits

2.1.1.1.1.1 Fruit size

Gaur (1996) observed that decrease in rainy season guava crop and capable improved winter season production was obtained by spraying with 600 ppm Naphthalene acetic acid. All these treatments also improved fruit size and net income per tree. Kundu and Mitra (1997) carried research work on 11-year-old guava cv. L- 49 and revealed that NAA @100 ppm markedly increased the average size of the fruit. Highest fruit volume, fruit length, diameter of fruit at harvest was observed with foliar spray of NAA @100 ppm in guava cv. Allahabad Safeda at Mandsaur, Gwalior (Sharma 2013). Kumar and Kumawat (2013) conducted studies at Madhya Pradesh on six years old guava tree cv. Chittidar and revealed that foliar spray of $ZnSO_4$ 0.8% + borax 0.4% + NAA 50 ppm + GA_3 100 ppm was most suitable to increase volume of fruit and pulp thickness. Hiteshkumar (2014) recorded maximum fruit diameter at Anand Agricultural University by application of NAA@ 400 mg/l. Kaur and Kaur (2017) reported while working on guava cv. Allahabad Safeda under Punjab conditions that foliar spray of NAA (50, 75,100 ppm) resulted in maximum fruit length and fruit weight.

Better fruit size was observed with application of NAA in cv. Sanaur-2 (Bal *et al* 1982). Sandhu *et al* (1990) reported that maximum size and volume of fruits of ber cv. Umran were obtained when sprayed with NAA @ 20 ppm. Amoros *et al* (2004) worked in loquat fruit cv. Algerie and applied naphthalene acetic acid @ 25ppm, 50 and 100 ppm to fruit when they were at 50 and 30% of their ultimate size. Total production was significantly increased by NAA@ 25, 50-ppm applications due to an increase in fruit size. Pandey *et al* (2012) concluded that the application of NAA @ 20 ppm was most effective application for increasing fruit length, width, acidity and ascorbic acid content in ber cv. Banarsi Karaka. Gill and Bal (2013) conducted experiment by spraying Umran ber trees with NAA and GA_3 each @10, 20, 30, 40, 50 ppm one time in the 2^{nd} fortnight of October and again these sprays were applied in the 2^{nd} fortnight of November. They recorded higher fruit size and weight with NAA @ 30 ppm. It was concluded that significant increase in fruit size was happened in ber cv. Umran with application of NAA @ 30 ppm. For the stone related characteristics, the highest reduction in stone breadth was recorded with NAA @ 30 ppm. No significant variation was recorded in stone length and weight of ber with application of growth regulators.

2.1.1.1.1.2 Fruit weight

Singh *et al* (1992) accessed the effectiveness of chemicals for deblossoming the rainy season guava fruit crop cv. 'Allahabad Safeda' and reported that all treatments of NAA @ 400, 600, 800 or 1000 ppm at full bloom stage resulted in complete deblossoming and highest yield for winter crop and highest fruit weight. Farag and Kassem (2000) found while working in Manshiya' clone guava that NAA resulted into good increase in fruit weight as compared with the control. Yadav *et al* (2001) observed that spray treatment of NAA@ 60 ppm on 15 years old guava tree cv. Sardar resulted in the highest fruit weight in the winter season crop. Kher *et al* (2005) reported that NAA (20, 40, 60 and 80 ppm) treatment given 15 days prior to harvest increased weight of the fruit in guava due to accumulation of sugars and high pulp percentage in treated winter season guava cv. L-49 fruits. Highest fruit pulp weight and pulp per cent in guava cv. Allahabad Safeda under conditions of Gwalior (M.P) was reported with foliar application of NAA @100 ppm (Sharma 2013). Kumar *et al* (2010) reported that maximum fruit weight was attained with foliar spray of $ZnSO_4$ 0.8% + borax 0.4% + NAA 50 ppm + GA_3 100 ppm. Enhancement in fruit weight might be accredited to the strengthening of middle lamella and as a result cell wall, which later might had increased the free passage of solutes to the fruits. Hiteshkumar (2014) reported at Anand Agricultural University, Gujarat that maximum fruit weight of red guava was recorded with treatment of NAA@ 400 mg/l and it was minimum in absolute control. These findings are in conformity with the results reported in guava by Kumar *et al* (1994) and Katiyar *et al* (2009). Rajput *et al* (2015) recorded maximum weight of fruits with 0.2 per cent boron + NAA @ 150 ppm, which was at par with 0.2 % boron + NAA @ 200 ppm at Junagadh during kharif season on guava cv. Lucknow-49.

It was concluded in loquat that when inflorescence stalks were treated with NAA at various concentrations, no significant effect was recorded on fruit weight (Chang 1989). Kale *et al* (1999) found that NAA (10 and 20 ppm) application in ber trees cv. Umran, 30 days 60 days after full bloom resulted in improvement of quality of fruit in terms of weight and size with higher concentration of NAA. They reported that combination of GA_3 and NAA were not much effective. Pandey (1999) reported in ber cv. Banarasi Karaka, trees that application of NAA @ 20 ppm increased the weight and volume of fruits. Singh and Randhawa (2001) obtained the maximum sized fruit with NAA @ 60 ppm treatment in Umran ber, while, NAA @20 ppm was most effective in reducing fruit drop. Maximum fruit weight, fruit size (length and breadth), pulp per cent and pulp: stone were found with NAA @10 ppm treatment which was statistically at par with NAA 20 ppm (Singh *et al* 2001). Rattan and Bal (2008) found that fruit size was improved with NAA @20 and 30 ppm in cvs. Kaithli and Wallaiti ber. The average fruit weight was improved with different NAA applications and it was recorded maximum with NAA @20-30 ppm in both cultivars. The fruit yield per tree was significantly increased with various applications of NAA. The average yield was recorded maximum with NAA @ 20 ppm in cv. Kaithli and @20-30 ppm in cv. Walliaiti. Ber fruits of cv. Gola were subjected to various treatments of naphthalene acetic acid and ferrous sulphate, alone as well as in combination during fruit development stage and results revealed that NAA @ 100 ppm was most effective in improving the fruit weight (Meena *et al* 2013).

2.1.1.1.1.3 Specific gravity

Yadav *et al* (2001) observed the effect of foliar application of NAA @ 20, 40 and 60 ppm on 15 years-old guava trees cv. L-49. They concluded that application of NAA @ 60 ppm improved the fruit length, volume, specific gravity, weight and yield. Katiyar *et al* (2008) conducted an experiment on plants of guava cv. Sardar which were treated with NAA @20, 40, 60, 80 ppm at Kanpur (U.P). During studies fruits were kept in perforated poly bags and stored under room temperature conditions. They found that the fruit size and specific gravity were reduced with storage. Response of pre-harvest foliar spray of NAA on guava plant cv. Dharidar was studied and it was concluded that this application did not bring any impact on specific gravity (Mohabe 2015).

Tripathi *et al* (2009) found that NAA @15, 20 and 25 ppm treatment could affect specific gravity of ber fruits. Singh and Singh (2015) worked on Indian gooseberry at Narendra Deva University of Agriculture and Technology, Faizabad and applied PGRs like, naphthalene acetic acid, gibberellic acid, 2, 4-dichloro phenoxy acetic acid and thio-urea either alone or in combination. They concluded that there were non-significant differences in specific gravity of aonla fruits under different treatments which might be due to proportionate enhancement in the volume and weight of fruits in trees sprayed with different PGRs.

2.1.1.1.1.4 Fruit colour

Singh *et al* (1996) reported that NAA @600 ppm resulted in the higher yellowness index and better appearance in the winter season crop of guava. Baraya (1997) reported in guava fruits that application of NAA @ 50 and 100 ppm at pre-harvest stage maintained attractive yellow colour till 9^{th} day of storage as compared to control. Phani *et al* (2015) found that naphthalene acetic acid increased skin colour (Hunter 'L', 'a' and 'b') gradually and pectin content in guava diminished constantly with the advancement of storage period. Mature green stage fruits of guava showed promising results in suspending the physiological and biochemical changes related to colour turning stage. Lal and Das (2017) observed while working in guava orchard of Assam Agricultural University, Jorhat that fruit colour ranged from light green to light yellow with allocation of various growth regulators including GA_3.

Chahal and Bal (2004) showed the colour modification in ber fruits cv. Umran treated with NAA but at the slower rate. Fruit physical characteristics were greatly enhanced by application of NAA. The influence of plant growth regulators on fruit size and quality in ber cv. Sanuar-2 was studied. It was revealed that NAA (@30 ppm was better for fruit quality in terms of fruit colour (Gill and Bal 2016).

2.1.1.1.1.5 Fruit firmness

Singh (1988) studied the effect of pre-harvest spray of NAA and concluded that higher concentration of NAA @100 ppm was effectual in sustaining the edible fruit quality and marketability of guava fruits for more than 6 days by postponing the onset of senescence during storage of guava fruit. It was found in guava cv. 'Allahabad Safeda' that pre-harvest treatment with NAA @ 200 ppm and calcium nitrate (1.5%) maintained higher scores of firmness throughout the storage (Reddy 1992). Farag and Kassem (2000) concluded in Manshiya' clone guava that NAA alone was not able to influence fruit firmness at harvest. They reported that the combination of NAA with $CaC1_2$ caused a significant retardation in the loss of firmness. Kher *et al* (2005) observed significant improvement in fruit firmness of guava fruit cv. Sardar after NAA treatment. Katiyar *et al* (2008) reported guava cv. Sardar by applying NAA @ 20, 40, 60, 80 ppm and concluded that foliar application of plant growth regulators had a positive effect on the post-harvest life of guava fruits under Uttar Pradesh conditions.

Amoros *et al* (2004) treated loquat fruit with NAA at 30 per cent and submitted that NAA application had no influence on firmness. Kaur (2008) revealed in plum cv. Sutlej Purple that when NAA @ 10, 25 and 50 ppm sprayed twice i.e. during March and April resulted in increased fruit weight, size and fruit firmness.

2.1.1.1.1.6 Palatability rating

Teaotia *et al* (1972) submitted that guava (var. Allahabad Safeda) sprayed with naphthalene acetic @50, 100 or 200 ppm resulted in enhancement in acidity but did not influence palatability of the fruit. The effect of NAA on storage life of 'Allahabad Safeda' guava was found that lower concentration of calcium nitrate (1%) in combination with higher concentration of NAA (100 ppm) was beneficial for extending the shelf-life of fruits with high acceptability (Singh 1988). Similarly, Reddy (1992) found in guava cv. Allahabad Safeda fruits that application of NAA @ 200 ppm at pre-harvest stage caused higher organoleptic rating during the storage. It was established that NAA @600 ppm resulted in higher organoleptic quality and better firmness in guava (Singh *et al* 1996).

Gill and Bal (2016) worked in ber fruit and reported that the palatability rating of fruits was increased by various PGR sprays as compared to control. They recorded that palatability rating was considerably higher with NAA @40 ppm. The minimum palatable rating was observed in control. Arora and Singh (2014) proved that use of plant growth regulators was good option to improve market suitability of ber. They revealed that NAA treatment @30 ppm resulted in maximum palatability rating of fruits in terms of taste.

2.1.1.1.1.7 Seed weight

Different concentrations of NAA were sprayed on guava (cv. Red Flesh) and it was reported that NAA application at higher concentrations lowered fruit quality. Fruit drop exhibited negative correlation with all other characteristics except acidity whereas pulp: seed ratio had encouraging correlation with TSS and negative relationship with acidity (Iqbal *et al* 2009). Bindhyachal (2011) reported at Ranchi (Jharkhand) in guava cv. Arka Amulya that seed content (kg/plant) was significantly higher in NAA @20 ppm. Kumar and Kumawat (2013) conducted experiment on guava tree cv. Chittidar and established that spray of $ZnSO_4$ 0.8% + borax 0.4% + NAA 50 ppm + GA_3 100 ppm was most suitable regarding reduction of the seed per cent and seed pulp ratio which ultimately improved the yield per tree in guava. Under Gujarat conditions NAA @ 300 mg/l and NAA 400 mg/l resulted in high seed weight in red guava (Hiteshkumar 2014). Lal and Das (2017) recorded highest seed weight under GA_3 @50 ppm application and lowest in 100 ppm NAA treatment in guava at Jorhat conditions. They explained the possible cause for increasing in seed weight might be due to bigger size and more fruit weight. Larger seed size was found in GA_3@50 ppm treatment while it was the lowest in NAA @100 ppm; which might be due to smaller dimension of seed.

Rajput and Singh (1982) concluded that fruit weight was increased when ber cv. Banarasi Karaka was treated with NAA @ 40 ppm. Katyal (1987) reported that fruit stone weight and pulp/stone ratio were improved with the increasing concentrations of NAA in ber cv. Kaithli. Stone weight was decreased when 10 ppm NAA was applied at full bloom in ber cv. Umran. During these studies fruits were treated with NAA @10 and 20 ppm at full bloom stage and 15 days after flowering. Maximum decrease was noted in stone weight of fruit with application of NAA @10 ppm (Bal *et al* 1988). Singh *et al* (2001) concluded that stone weight and size were not significantly affected by applying growth regulators in ber. Application of NAA @20 ppm at CCS HAU, Hisar resulted in improvement in pulp/stone ratio in ber cv. Umran. It was submitted that stone weight was not significantly affected by various chemical treatments (Jeet 2004). Bhati and Yadav (2003) reported that NAA application @ 20 ppm in ber cv. Gola, improved pulp-stone ratio. Maximum reduction in stone related traits, breadth and percentage was recorded with NAA 30 ppm treatment. But it was not significant variation regarding stone length resulted from growth regulators in ber tree (Arora and Singh 2014).

2.1.1.1.2 Bio-chemical Characters of Fruits

2.1.1.1.2.1 Total soluble solids

Singh *et al* (1992) accessed the effectiveness of chemicals for deblossoming the rainy season guava fruit crop cv. 'Allahabad Safeda' and reported that all treatments of NAA@400, 600, 800 or 1000 ppm at full bloom stage resulted in complete deblossoming and high TSS with 800 ppm NAA. It was established in guava crop regulation that NAA application had no effect on fruit TSS (Singh *et al* 1996). Kher *et al* (2005) observed that there was significant increase in TSS of fruit when treated with NAA in guava cv. Sardar. Katiyar *et al* (2008) conducted an experiment on guava cv. Sardar which were treated with NAA @ 20, 40, 60, 80 ppm at room temperature and found that NAA application resulted in maximum TSS content. It was concluded at Gomal University, Pakistan that spray of naphthalene acetic acid on summer guava cv. Red Fleshed and resultant fruit drop exhibited negative correlation with all other characters except acidity whereas pulp seed ratio had positive association with TSS and total sugars. NAA treatments improved all these ingredients (Iqbal *et al* 2009). Bindhyachal (2011) found in guava cv. Arka Amulya that NAA @10-20ppm showed appreciable higher TSS content in fruit. Kumar and Kumawat (2013) conducted research on guava cv. Chittidar and found that spray of $ZnSO_4$ 0.8% + borax 0.4% + NAA 50 ppm + GA_3 100 ppm was most helpful in maximizing TSS/acid ratio in guava fruit. Garasiya *et al* (2013) carried out research studies at Gujarat and concluded that TSS content of guava fruit cv. L–49 was considerably increased by the various treatments of plant growth regulators. NAA @40 ppm registered the highest TSS and it remained at par with NAA@20 ppm. Under control fruits registered lowest TSS. Hiteshkumar (2014) reported in red guava that NAA @ 400 mg/l exhibited considerably higher total soluble solids. Maximum TSS and ascorbic acid were recorded with foliar spray of NAA 200 ppm + ZnSO4 0.4% + K_2SO_4 2% in guava cv. Dharidar (Mohabe 2015).

Improved TSS, TSS/acid ratio and ascorbic acid content have been recorded in ber by Bal *et al* (1982, 1988), Sandhu and Thind (1988) and Singh *et al* (1989) with NAA @10 to 25 ppm. Kale *et al* (1999) reported that NAA application in ber cv. Umran, at 30 days 60 days after full bloom resulted in improvement of fruit quality of fruit in terms of TSS, acidity and pulp percentage. Various combinations of GA_3 and NAA were not much effective. Singh *et al* (2001) studied that the effects of various chemicals on fruit drop, yield, and quality of ber fruit cv. Umran. NAA treatments were best in improving the yield and quality of Umran fruits. They recorded higher yield and total soluble solid content with NAA @60 ppm. Bal and Randhawa (2007) found that TSS was slightly improved with NAA treatments in Kaithli and Wallaiti cultivars of ber. Katiyar *et al* (2009) obtained fruits with maximum TSS by NAA treatment in ber cv. Banarsi Karaka. Yadav *et al* (2011) verified that foliar treatment of NAA (30 ppm) increased TSS in aonla cv. Banarasi. Pandey *et al* (2012) reported that the application of NAA was most effective treatment for increasing fruit TSS in ber cv. Banarsi Karaka. It was concluded that naphthalene acetic acid (NAA) was responsible for maximizing TSS of the ber fruits of cv. Gola (Meena *et al*2013).Gill and Bal (2016) reported in ber cv. Umran fruit that spray of NAA @ 50 ppm, one time in the 2^{nd} fortnight of October and again in the 2^{nd} fortnight of November resulted in higher content of total soluble solids.

2.1.1.1.2.2 Acidity

According to Reddy (1992) pre-harvest treatment with NAA did not influence the acidity of guava fruits cv. 'Allahabad Safeda' during storage. It was concluded that NAA @ 600 ppm was very useful in rainy season guava and winter season crop regarding acidity content and sugars of guava fruit along with net income (Gaur 1996). Brahmachari *et al* (1997) in guava found minimum acidity with NAA treatment. Acidity was also declined by NAA treatment because it might help in preventing excessive polymerization and accumulation of more sugar in the cells of guava plant. Baraya (1997) observed that pre-harvest application of NAA @ 50 ppm in guava cv. Lucknow- 49 maintained higher acidity during storage as compared to control. Kher *et al* (2005) reported minimum acidity content in guava fruit cv. Sardar when treated with NAA. Maximum reduction was recorded with foliar spray of NAA @ 100 ppm in guava cv. Allahabad Safeda followed by NAA @ 50 ppm. Iqbal *et al* (2009) worked on NAA @ 0, 15, 30, 45, 60, 75 and 90 ppm concentration in summer guava cv. Red Flesh and reported that NAA @45 ppm application decreased acidity. The effect of NAA and GA_3 was studied on winter season guava cv. L–49 in Gujarat and it was concluded that foliar application of NAA @40 ppm gave the lowest acidity (Garasiya *et al* 2013). Kumar *et al* (2013) reported maximum reduction in acidity of guava fruits with foliar spray of $ZnSO_4$ 0.8% + borax 0.4% + NAA 50 ppm + GA_3 100 ppm. It seems that acid under the influence of advanced concentration of growth regulators might has either immediately been converted into sugar and their derivatives by reactions connecting overturn glycolytic pathways or might have been used in respiration. These results are in accordance with the results obtained in guava by Yadav *et al* (2011) and Brar *et al* (2012).

Gill and Bal (2016) observed lesser acidity when trees were sprayed with NAA @30-50 ppm in ber cv. Umran. They sprayed ber cv. Umran two times with NAA @ each at 10, 20, 30, and 40, 50 ppm in October and again in November and recoded higher content of total soluble solids with lower acidity content with NAA @50 ppm treatment.

Chang (1989) treated inflorescence stalks of loquat with NAA at various concentrations. In most cases there were no effects on fruit weight and shape and acid levels were highest with NAA @ 10 ppm. Kale *et al* (1999) reported in ber cv. Umran that treatment of NAA @10 and 20 ppm after full bloom resulted in development in acidity and TSS. Bal and Randhawa (2007) found that acidity was decreased under all the NAA treatments in case of ber varieties viz. Kaithli and Wallaiti. The fruits treated with higher concentration of NAA retained higher acidity during storage possibly due to postponement of ripening process. The decrease in titrable acids during the storage may be attributed to marked rise in malic enzyme and pyruvate decarboxylation response during the climacteric period, corresponding with increase in the rate of respiration. Rattan and Bal (2008) reported that the spray at growth phase was always better than at fruit set stage in ber. The highest yield was obtained with the application of NAA @ 60 ppm. The total acidity was declined under all the NAA applications, but more decrease was noted with NAA@ 20 ppm in Kaithli ber and NAA @20-30 ppm in Wallaiti ber. Gill and Bal (2013) reported in ber cv. Umran fruit that spray of NAA @ 50 ppm (one time in the 2^{nd} fortnight of October and again in the 2^{nd} fortnight of November) resulted in lower acidity. It was concluded that NAA@ 30 ppm can be successfully used to prevent physiological fruit drop as well as to improve physio chemical traits of Umran ber.

2.1.1.1.2.3 Vitamin C

Dhanani (1984) stated that double sprays of NAA, one before and after fruit set followed by two times spray of GA improved the quality of fruits regarding ascorbic acid content of guava fruit cv. Allahabad Safeda. Pre-harvest application of NAA @ 200ppm resulted in higher ascorbic acid content throughout the storage (Reddy 1992). Yadav *et al* (2001) deliberated in guava cv. L-49 guava tree that spraying with NAA resulted into maximum contents of ascorbic acid. Dubey *et al* (2002) conducted research work in winter season guava cv. Allahabad Safeda and discovered that out of various concentrations of NAA @125, 250 and 750 ppm, NAA @250 ppm considerably resulted in highest vitamin C and total sugars contents of quality of guava. Jayachandran *et al* (2005) studied the effects of NAA (100 and 200 ppm), GA_3 (50 and 100ppm) with Teepol (0.1%) as surfactant. All growth regulators were uniformly sprayed on Lucknow-49 trees of uniform vigour 15 days before harvest and packed in 300-gauge bags of polythene with 0.1 % ventilation and stored at room temperature (30±2°C) and R.H. (70-75%). They revealed that ascorbic acid was improved up to 3rd day with NAA treatment and then declined up to the 9^{th} day. Singh *et al* (2009) experimented with pre-harvest application of NAA and found that this treatment resulted in enhanced ascorbic acid in guava fruits. Bindhyachal (2011) reported that in winter season guava cv. Arka Amulya that vitamin C was the highest in case of NAA @20 ppm over other treatments like GA_3, boron and ethephon. Garasiya *et al* (2013) reported under Gujarat conditions that plant growth regulators like NAA, 2, 4-D and CCC had significant effect on various contents of guava fruit cv. L–49. Treatment of NAA 40 @ ppm gave the maximum ascorbic acid which was at par with NAA@ 20 ppm. The least amount of ascorbic acid was recorded in control. Hiteshkumar (2014) reported that vitamin C content in red guava was observed the highest vitamin C with NAA@ 400 mg/lit. in Anand Agricultural University Anand, Gujarat. Parkhe *et al* (2015) sprayed NAA one month prior to harvesting and observed its action in improving yield and quality of guava fruit. Rajput *et al* (2015) determined that quality of guava cv. Lucknow-49 was the best with NAA@ 150 ppm.

Singh and Randhawa (2001) stated that treatment with NAA resulted in highest ascorbic acid content in ber fruit cv. Umran. Sawale *et al* (2001) reported in 'Nagpur' mandarin under Akola conditions that treatment with NAA resulted in richness of vitamin C in the fruit. Similar results were also reported by Singh *et al* (2002) in ber. Sharma *et al* (2005) submitted that ascorbic acid (vitamin C) of litchi fruit could be enhanced by NAA treatment. Gill and Bal (2016) worked in ber fruit and found that NAA @ 30 ppm treatment resulted in enhancement higher vitamin C content as compared to control. Pandey *et al* (2012) reported that the application of NAA was most effective treatment for increasing fruit ascorbic acid in ber cv. Banarsi Karaka. Ahmed *et al* (2012) reported that ascorbic acid content was advanced after application of NAA in case of Dushehri mango.

2.1.1.1.2.4 Total sugars

The beneficial effect of NAA treatments on TSS content of guava cv. 'Allahabad Safeda' fruits has also been observed by Reddy (1992). Gaur (1996) recorded that decrease in rainy season guava crop and better winter season production was achieved by spray with NAA @ 600 ppm. All these treatments also improved the fruit quality aspects like sugars, acidity along with TSS etc. and net income per tree. Singh *et al* (1996) deliberated in guava crop regulation by using NAA that its application had no noteworthy impact on fruit quality but influenced percentage total sugar content. This finding is in conformity with the result of Kumar *et al* (1998) in guava fruit. Yadav *et al* (2001) specified that improvement in TSS with NAA in winter season guava cv. L-49 exhibited good increase in total sugar content. Jayachandran *et al* (2005) found an increasing trend of total sugar content up to 6^{th} day and declining trend on 9^{th} day in guava stored at room temperature (30±2°C) and R.H. (70-75%) with NAA. During studies, spray was done 15 days before harvest and fruits were packed in

300-gauge bags of polythene with 0.1 % ventilation. Samples were dried in an oven at 65-70°C to a constant weight and variation in weight was used to obtain the moisture content. Garasiya *et al* (2013) observed in guava cv. L-49 that the application of NAA @ 20 and 40 ppm significantly enhanced the quality parameters *viz.*, total soluble solids, reducing sugars, non-reducing sugars and total sugars. Maximum total sugars, reducing sugars and non-reducing sugars were observed by foliar spray of GA_3 followed by and NAA @ 100 ppm. It was reported that diversion of more solids towards developing fruits and might also improve the conversion of complex polysaccharide into sugars in guava cv. Allahabad Safeda (Sharma 2013). Kumar and Kumawat (2013) carried out research studies on guava cv. Chittidar and reported that foliar spray of $ZnSO_4$ 0.8% + borax 0.4% + NAA 50 ppm + GA_3 100 ppm was successful regarding improvement of sugars, reducing sugars and non-reducing sugars in the fruit. Hiteshkumar (2014) recorded maximum reducing sugars with NAA@ 400 mg/l. While, minimum reducing sugar was observed in the control treatment. Mohabe (2015) observed in guava cv. Dharidar that highest value of reducing sugars, total sugars and non-reducing sugars could be found in case of foliar spray of NAA 200 ppm + $ZnSO_4$ 0.4% + $K2SO_4$ 2% treatment. Lal and Das (2017) found the highest total sugar content in GA_3 @50 ppm in guava while lowest was reported under control. The probable reason for increased sugar in GA_3 application might be due the improved activity of the hydrolytic enzyme which changed the complex polysaccharides into simple sugar content. Growth regulators also raised translocation of photosynthetic metabolites from other parts of the plant towards to developing fruits of guava.

Sandhu and Thind (1988) observed that NAA @ 20 ppm significantly improved reducing and total sugars (%) in ber cv. Umran. Chaudhary *et al* (1992) reported that application of NAA significantly improved reducing and non-reducing sugars in loquat. Kale *et al* (1999) reported in ber trees cv. Umran that spray application of NAA @10 and 20 ppm after full bloom resulted in improvement in total sugars and reducing sugars. Mixture of GA_3 and NAA were not much successful. Pandey *et al* (2012) reported that the application of NAA was most effective treatment for increasing total sugars of ber cv. Banarsi Karaka.

2.1.1.2 Effect of Salicylic Acid

2.1.1.2.1 Physical Characters of Fruits

2.1.1.2.1.1 Fruit size

Bindhyachal (2011) concluded in guava cv. Arka Amulya during winter season that GA_3 @ 50 ppm gave the maximum of fruit length which was closely followed by salicylic acid @100 ppm whereas maximum fruit breadth was recorded in ethephon @100 ppm which was statistically at par with salicylic acid @100 ppm. Minimum size of fruit was registered in control. It was further observed in guava cv. Arka Amulya that salicylic acid @100 ppm gave maximum increase in shoot length, number of leaves and leaf area over control but fruit breadth was best in case of ethephon @100 ppm which was statistically at par with salicylic acid 100 ppm.

Champa *et al* (2014) observed a considerable enhancement in cluster length and breadth of Flame Seedless grapes when sprayed with 1.5- or 2.0-mM salicylic acid compared to control and 1.0 mM salicylic acid. Ngullie (2014) while working on mango cv. Kesar reported that various chemical treatments (like salicylic acid and humic acid) significantly improved fruit length as compared to control. Various concentrations of salicylic acid on mango cv. Kesar failed to exert noteworthy effect on fruit breadth.

2.1.1.2.1.2 Fruit weight

Amanullah *et al* (2017) observed lowest weight loss in guava fruits with salicylic acid @ 600 μM followed by fruits treated with 700 μmol. The highest weight loss was recorded with control at 5th day. Salicylic acid has also been reported to efficiently decrease the respiration rate in peach fruits (Han *et al* 2003). Zheng and Zhang (2004) reported that salicylic acid treatment maintained Ponkan mandarin fruit weight during storage. Abbasi *et al* (2010) established that after 6-week storage of peach at 1°C, the average weight loss was least in salicylic acid @1mM treated fruits as compared to control. Champa *et al* (2014) recorded a significant increase in cluster weight and yield of Flame Seedless grapes in both seasons when vines were sprayed with 1.5- or 2.0-mM salicylic acid, compared to control and 1.0 mM salicylic acid. Similar results are reported by Brar *et al* (2014) in peach fruits that salicylic acid @ 200 ppm significantly reduce the physiological loss as compared to control ones.

2.1.1.2.1.3 Specific gravity

Specific gravity of berries was unaltered when treated with salicylic acid. Specific gravity is the guiding index to judge the physiological maturity of the fruits and is recognized as a trustworthy key for fruits such as mango (Pantastico 1975). Dastjerdi *et al* (2014) concluded that salicylic acid treatment had no substantial effects on gravity and ascorbic acid in the case of mango. Champa *et al* (2014) reported in table grapes cv. Flame Seedless at Punjab Agricultural University, Ludhiana, Punjab that salicylic acid applications did not affect berry specific gravity considerably in two crop seasons studied. Adel *et al* (2017) studied different physical parameters (weight, volume and specific gravity) in pear at Zanjan University, Qazvin-Iran and revealed that maximum weight, volume and specific gravity in fruits were allocated to the treatment of salicylic acid with concentration of 0.1 gram in a liter.

2.1.1.2.1.4 Fruit colour

While working on guava cv. 'Baladi' it was concluded that immersion in salicylic acid at high level 500 µM had advanced fruit color (ho) compared with other concentrations of salicylic acid and water-control (Lo'ay and Khateeb 2011). Salicylic acid @ 300 ppm improved value of brightness of guava fruits under ambient storage conditions. In the untreated fruits rapid loss of green colour was experienced than the treated fruits during storage. The untreated fruits lost their green colour after 7^{th} day in storage. However salicylic acid @ 300 ppm treated fruits retained green under ambient condition up to 7^{th} day of storage (Kaur 2016).

Zainuri and Terry (2001) conducted experiment on mango fruits cv. Kensington Pride and treated them with 1000mg/l of salicylic acid. They observed that mango fruit skin colour became sluggish considerably with salicylic acid treatment. Zeng *et al* (2008) observed that there was a slightly slowdown in peel de greening and repressed respiration rate in fruits of mango treated with salicylic acid. Lolaei *et al* (2012) accessed the effect of salicylic acid as pre-treatment on fruit quality of strawberry cv. Camarosa and concluded that salicylic acid delayed the ripening of strawberry fruits as evident by lessening of redness than in control fruit.

2.1.1.2.1.5 Fruit firmness

Asgharia and Aghdam (2010) found that salicylic acid applications helped in sustaining the marketability of guava fruits up to 3 weeks, while it was just 2 weeks in the untreated fruits. This all happened due to role of salicylic acid in delaying respiration rate of fruits. Lo'ay and Khateeb (2011) reported in guava cv. 'Baladi' that when fruit were immersed in salicylic acid at high level 500 µM had advanced fruit firmness compared with other concentrations of salicylic acid and water-control. Gill *et al* (2014) observed that fruits treated with n-propyl gallate sustained significantly higher average firmness in guava during storage, followed by salicylic acid @450 ppm application. They reported that salicylic acid @ 450 ppm resulted in the second highest firmness. Control fruits experienced a quick loss of firmness during storage that resulted in excessive softening and shriveling of fruits.

Obeed (2011) reported in grape cv. Flame Seedless that pre-harvest foliar application of salicylic acid @100 ppm at pea stage and verasion stage considerably resulted in higher berry firmness. Sultan *et al* (2015) showed that salicylic acid maintained higher levels of flesh firmness in loquat.

2.1.1.2.1.6 Palatability rating

Salicylic acid is a vital metabolite in grape berries and plays an indispensable role in determining berry quality such as astringency and bitterness (Chamkha *et al* 2003). Gill *et al* (2014) observed that irrespective of chemical treatment the organoleptic rating of all the treated guava fruits improved up to 14^{th} days of storage, and afterwards a regular decline in sensory score was recorded. In control treatment, maximum acceptability rating was recorded after 7^{th} days of storage and rated as 'highly acceptable' up to 15^{th} days, trailed by a speedy decline, and were acknowledged unfit for consumption after 21 days of storage. Fruits treated with salicylic acid @ 450 ppm exhibited considerably higher palatability rating of 7 day and rated as 'highly desirable' for 21 days of storage. The advancement of palatability rating in fruits during storage might be due to the build-up of sugars and acids as a result of hydrolysis of starch and other complex molecules leading to the development of flavour in guava fruits. Hindrance in the rate of catabolic processes in treated fruits may also influence the overall sensory qualities, thus extending higher organoleptic rating during comprehensive periods of storage. Kaur (2016) recorded mean value of organoleptic rating 7.94 in guava fruits under Punjab conditions with salicylic acid @ 200 ppm which was significantly advanced than salicylic acid @ 300 ppm treatment. Control fruits had exhibited considerably reduction in palatability rating from 7^{th} day to 14^{th} day of storage. On the 21^{st} day fruits in all the treatments (including control) got blemished.

2.1.1.2.1.7 Seed weight

Bindhyachal (2011) reported in guava cv. Arka Amulya that seed content (kg/plant) was significantly higher in fruit with salicylic acid @100ppm and it was followed by naphthalene acetic acid @ 20 ppm.

Kassem *et al* (2011) observed that pre-harvest foliar sprays of salicylic acid on pu-yun jujube trees cultivar resulted in increased seed weight.

2.1.1.2.2 Bio-chemical Characters of Fruits

2.1.1.2.2.1 Total soluble solids

The spray of salicylic acid regulated the carbohydrate metabolism in source and sink tissue of the plants. The hydrolysis of sucrose by invertase controls the levels of plant hormones like salicylic acid and jasmonic acid (LeClere *et al* 2003). Ngullie (2014) in mango cv. Kesar observed that total soluble solids were significantly affected by foliar spray of unlike concentrations of salicylic acid in mango cv. Kesar. However, salicylic acid @ 2000 ppm was found to be the most effectual and resulted in considerably highest total soluble solids. On the other hand, control fruits recorded an increase in TSS up to 14 days (10.90%) followed by a sharp decline during storage of guava fruit (Gill *et al* 2014).

2.1.1.2.2.2 Acidity

Studies carried out on guava cv. Allahabad Safeda at Regional Fruit Research Station, Patiala conditions showed that acid content in the guava fruits followed a declining trend throughout the storage period. Salicylic acid treated fruits maintained markedly higher acidity than the untreated fruits, which recorded a minimum mean acidity. Decline in the acidity was faster in the untreated fruits, whereas the treated fruits showed a steady fall in acidity (Gill *et al* 2014).

Kumar and Reddy (2008) reported that foliar spray of salicylic acid @100 ppm considerably reduced titratable acidity in mango cv. Baneshan. Ngullie (2014) reported that titrable acidity (%) was significantly influenced by foliar spray of unlike concentrations of salicylic acid in mango cv. Kesar. However, salicylic acid @2000 ppm was found to be the most effective and resulted in significantly minimum titrable acidity.

2.1.1.2.2.3 Vitamin C

Lo'ay and Khateeb (2011) found that the fruits of guava cv. 'Baladi' when immersed in salicylic acid at high level 500 µM, had less IL per cent degradation in total phenol, fruit browning and sustained the vitamin C. Gill *et al* (2016) concluded that ascorbic acid content in guava cv. Allahabad Safeda had decreased irrespective of chemical treatments during storage period. Salicylic acid treatments helped in maintenance of ascorbic acid at considerably higher levels as compared to control fruit. Ascorbic acid level was significantly lower in untreated fruits.

While working on mango cv. Kesar at Navsari, Ngullie (2014) reported that ascorbic acid (mg/100g pulp) content of mango was affected by foliar spray of different concentrations of salicylic acid. It was reported that the application of different concentrations of salicylic acid had no significant effect on ascorbic acid content of mango fruits. However, maximum ascorbic was noticed when the mango trees were sprayed with salicylic acid @ 2000 ppm and minimum was in control. Lolaei *et al* (2012) concluded that of salicylic acid caused less weight loss and higher vitamin C and redness than the control in strawberry fruit. They added that salicylic acid treatment postponed the onset of the climacteric peak of respiration and ethylene production and improved its storekeeping quality. Tareen *et al* (2012) reported that salicylic acid treatment in peach maintained the higher level of ascorbic acid. In these studies, they found that salicylic acid @ 2.0 mmol L-1 concentration could be used commercially to protect peach fruits for up to five weeks without any spoilage.

2.1.1.2.2.4 Total sugars

Manoj and Upendra (2000) reported in banana fruit that salicylic acid treated fruits recorded enhancement in reducing sugar level in concentration mode but considerably higher as compared to controlled fruits. Enhancement in non-reducing sugars was due to dehydration and hydrolysis of the polysaccharides of the banana fruits. Srivastava and Dwivedi (2000) also concluded the increasing tendency of non-reducing sugars in banana fruit treated with 500- and 1000-mM salicylic acid, respectively. Gaidi and Bohra (2003) reported in ber that growth regulator salicylic acid @ 100 and 500 mg/liter resulted in decrease of total sugar content. Mohamed *et al* (2012) reported that there was enhancement in total sugars content in salicylic acid treated navel orange fruits as compared to controlled fruits. In peach cv. Flordaprince a declining trend was observed in total soluble contents with rising concentration of salicylic acid and these treatments maintained a notably lower reducing and total sugars, anthocyanin and enzyme activity than control (Awad 2013). Ngullie (2014) reported that reducing sugar significantly influenced by foliar spray of different concentrations of salicylic acid in mango cv. Kesri. However, salicylic acid @2000 ppm was found to be the most effective and resulted in improvement of reducing sugars. The accumulation of reducing sugars might be due to improved translocation of more photosynthetic assimilates to the fruits and crashing of starch during ripening. Similar findings were also reported by Singh *et al* (2001) and Kumar and Reddy (2008) in mango.

2.1.1.3 Effect of Ascorbic Acid

2.1.1.3.1 Physical Characters of Fruits

2.1.1.3.1.1 Fruit size

Ibrahim *et al* (2013) reported that spraying ascorbic acid, citric acid or amino acids each at 500 to 2000 ppm on Zaghloul date considerably effective in improving fruit traits like increasing fruit proportions as compared to control treatment. Al-Khawaga (2014) observed in grapevines that spraying with vitamins C resulted in improved berry dimensions (length & width) and yield over control treatment.

2.1.1.3.1.2 Fruit weight

Loss in physiological weight is basically due to respiration and transpiration (Shanta Krishnamoorthy and Subramanyam 1970). The materials were being used up in the de gradative reactions and for the procedure that make the fruit to attain edibility. As a result of this reaction, fruit loses a part of its original weight during the course of ripening (Haard and Salunkhe 1975). Gill *et al* (2014) found in winter guava cv. 'Allahabad Safeda' that ascorbic acid treatments resulted in minimum weight loss, lower decay frequency, higher TSS and acidity. It was established that ascorbic acid proved important treatment in enhancing the storage life span of guava fruits. Reddy *et al* (2014) reported that physiological loss in weight was significantly least in guava fruits treated with ascorbic acid @ 500 ppm and closely it was followed by ascorbic acid @1000ppm.

Ibrahim *et al* (2013) reported that foliar application of ascorbic acid and citric acid each at 500 to 2000 ppm on Zaghloul date palms considerably accompanied improved weight of bunch in comparison with the control treatment.

2.1.1.3.1.3 Specific gravity

Pawar *et al* (2011) reported increase in specific gravity in sapota fruits from 1.04 (mature stage) to 1.07 (ripe stage) during ripening and specified that, the decrease in weight of fruit was less than the equivalent decrease in its volume. Similar observations have been reported in karonda fruit by Joshi *et al* (1986).

2.1.1.3.1.4 Fruit colour

It was specified that high acceptable organoleptic rating resulted in ascorbic acid treated guava fruit (Gill *et al* 2014). Ravikiran (2007) observed that the lowest PLW was observed in benzyl adenine (BA) 100 ppm followed by ascorbic acid 1000 ppm and was highest in control in papaya cv. Red Lady under Hyderabad conditions.

2.1.1.3.1.5 Fruit firmness

In winter guava cv. 'Allahabad Safeda' that ascorbic acid treatments resulted in minimum firmness loss and higher TSS (Gill *et al* 2014). Reddy *et al* (2014) reported that fruit firmness in guava was 2.13 (kg/cm^2) with ascorbic acid @ 500 ppm and 2.33(kg/cm^2) with ascorbic acid @ 1000 ppm while in control treatment it was just 13.2 (kg/cm^2).

Kaur (2009) reported in ber cv. Umran and noted the highest mean fruit firmness in ascorbic acid 3 per cent treatment whereas the decrease was most pronounced in the controlled fruits kept without pedicel. The reduction in fruit firmness was also less marked in the controlled fruits kept with pedicel compared to controlled kept without pedicels. The fruit firmness in ber fruits decreased with the increase during the period of storage irrespective of the chemical treatments.

2.1.1.3.1.6 Palatability rating

Gill *et al* (2014) reported that guava fruits treated with ascorbic acid (100 ppm) expressed higher palatability rating of 7 and rated as 'highly desirable' after 21 days. The enhancement of palatability rating in fruits during storage might be due to development of sugars and acids as a consequence of hydrolysis of starch and other complex molecules leading to the advancement of flavor in fruits. Postponement in the rate of catabolic processes in ascorbic acid treated fruits may influence the sensory assets thus extending a higher organoleptic rating.

Kaur and Bal (2014) recorded that palatability rating of ber fruits was higher in different treatments of ascorbic acid. High palatability rating was noted in ber fruit through dipping treatment with ascorbic acid. Application of ascorbic acid resulted in enhancing storability, consumer acceptability and reducing post-harvest losses in mango (Ahmed 1998).

2.1.1.3.1.7 Seed weight

Kaur (2009) observed decreasing trend in pulp/stone ratio of ber fruits with duration of storage under all treatments. Ascorbic acid 3 per cent was most suitable for retaining highest pulp/stone ratio compared to other treatments whereas the minimum pulp/stone ratio was noted in the fruits treated with sodium carbonate 1 per cent.

Ibrahim *et al* (2013) discovered at Egypt on Zaghloul date that spraying ascorbic acid and citric acid each at 500 to 2000 ppm considerably was effectual in improving fruit qualities like increasing fruit pulp per cent; pulp/ seeds as compared to control treatment. Al-Atroushy and Qader (2015) carried out research studies in olive orchard at Kurdistan region, Iraq and observed that fruit weight and fruit flesh weight for trees sprayed with ascorbic acid were higher. Maximum values were obtained in trees sprayed with ascorbic acid at 400 mgL-1 respectively at untreated trees, whereas ascorbic acid had no effect on seed weight of olive fruit at different concentrations**.**

2.1.1.3.2 Bio-chemical Characters of Fruits

2.1.1.3.2.1 Total soluble solids

While working at Hyderabad Reddy *et al* (2014) observed that ascorbic acid @ 500 ppm resulted in TSS 12.11 percent and @ 1000 ppm resulted in 12.08 per cent while in control it was 11.33 per cent in case of guava fruit. Kaur (2016) concluded in guava cv. Shewta that TSS content of the fruit is not much affected by the application of ascorbic acid @1 per cent, 1.5 per cent or 2 per cent under ambient storage conditions. Almost equal values were obtained by applying different concentration of ascorbic acid**.**

2.1.1.3.2.2 Acidity

Gill *et al* (2014) found that acid content of guava fruits showed a declining tendency throughout the storage. Ascorbic acid application maintained higher acidity content than control. Studies have been detailed that fruits treated with ascorbic acid retained a higher acidity value during the storage most likely due to postponed ripening. These results are conformity with Jayachandran *et al* (2007) in guava, Siddiqui, and Gupta (1995) in ber.

2.1.1.3.2.3 Vitamin C

The loss in ascorbic acid on prolonged storage might be due to rapid conversion of L-ascorbic acid into dehydroascorbic acid in the presence of enzyme ascorbinase (Mapson 1970). Reddy *et al* (2014) reported that ascorbic acid content of the guava fruit increased with ascorbic acid 500 ppm and @1000 ppm. During experiment ascorbic acid content was declined from 3rd day (222.53 mg/100g) to 12th day (109.32 mg/100g). Gill *et al* (2014) recorded a decrease in ascorbic acid during the storage. They noted highest ascorbic acid (200.85 mg/100 g pulp).

It was established that the ascorbic acid content of the ber cv. Umran fruits during room storage was not influenced by various ascorbic acid treatments (Siddiqui and Gupta1995).

2.1.1.3.2.4 Total sugars

Jayachandran *et al* (2007) discovered that ascorbic acid applications decreased the post-harvest losses, improved quality and extended shelf-life of the guava fruits as compared to control fruits. Bindhyachal (2011) reported in guava cv. Arka Amulya, total sugars were improved with salicylic acid @ 100 and 200 ppm. Minimum ascorbic acid content was observed recorded in control. Reddy *et al* (2014) stated that total sugars were improved with ascorbic acid @ 500 ppm, 1000 ppm as compared to control treatment in guava.

2.1.2 Cool Storage

2.1.2.1 Effect of Naphthalene Acetic Acid

2.1.2.1.1 Physical Characters of Fruits

2.1.2.1.1.1 Fruit size

Singh *et al* (2017) also proved that average fruit weight and size of guava reflected a steady reduction during different days of cold storage which might be due to loss of moisture but at slow rate. Ghazzawy (2013) stated that naphthalene acetic acid improved fruit size and postponed ripening in Barhee date palm cultivar.

2.1.2.1.1.2 Fruit weight

Bal *et al* (1988) reported in ber that fruit weight was increased with different concentrations of naphthalene acetic acid. The increase in fruit weight was recorded in case of 10 ppm concentration followed by 25 ppm treatment of naphthalene acetic acid.Singh and Singh (2015) revealed under Uttar Pradesh conditions that maximum increase in fruit weight of Indian Gooseberry (*Emblica officinalis* Gaertn.) was noted when trees were sprayed with NAA (15 ppm) + Thiourea (0.1%). Useful role of NAA and 2, 4-D in improving fruit weight was also described by Ghosh *et al* (2009) in sweet orange, Pandey (1999) in ber and Pawar *et al* (2005) in pomegranate. Encouraging role of NAA and GA_3 application on fruit weight may be described from the fact that these are related with cell division and cell enlargement (Leopold 1964).

2.1.2.1.1.3 Specific gravity

Bal *et al* (1982) accomplished that there was no decrease in specific gravity with the application of naphthalene acetic acid and 2, 4, 5-T in ber cv. Sanaur-2. Kishan and Godara (1992) dipped mature fruits of ber cv. Gola in solutions of GA_3 100 ppm, potassium permanganate 1000 ppm and kinetin 25 ppm. It was concluded that after long storage, specific gravity was not notably affected by treatments. Yadav and Rathore (2004) discovered that combination of thiourea + ferrous sulphate application considerably decreased specific gravity in ber.

2.1.2.1.1.4 Fruit colour

Chahal and Bal (2004) treated the fruits harvested from ber cv. Umran at the peak maturity period with GA_3 25, 50, 100 ppm, naphthalene acetic acid 50, 100 and 200 ppm and wax MP 1:2, 1:4 and 1:6, then packed in Netlon, CFB cartons and wooden boxes. The fruits were kept at cold storage at 0 - 3.3.0 °C and 85-90 per cent RH, removed after 10, 20 and 30 days, kept for three days at ambient temperature and then analyzed. Colour changes in fruits treated with GA_3 and packed in CFB cartons were slower than those in other treatments. Fruits treated with naphthalene acetic acid and wax under Netlon and wooden boxes could not maintain the colour up to acceptance limits and turned dark brown after 30 days of cold storage and three days of ambient temperature. In Netlon and wooden boxes, 25 ppm GA_3 recorded fewer changes in colour development. Browning percentage was lowest (5%) in fruits treated with GA_3 and kept in CFB cartons after 10 days of cold storage and 3 days at ambient temperature. In CFB cartons, 200 ppm naphthalene acetic acid and wax treatments accounted for maximum colour change (dark brown).

Under Hyderbad conditions in papaya cv. Red Lady, it was concluded that among the antioxidants, benzyl adenine 100 ppm followed by ascorbic acid 1000 ppm displayed lower colour index of the fruits (Ravikiran 2007).

Bal *et al* (2010) concluded that ber fruits cv. Umran maintained their original colour up to 20 days under cold storage conditions and no browning was noted in fruits treated with naphthalene acetic acid application in CFB boxes. After 20 days of storage fruits turned to deep yellow in all treatments except in control where browning were noted.

2.1.2.1.1.5 Fruit firmness

Gill *et al* (2014) reported that firmness in guava fruits cv. Allahabad Safeda had improved up to 14 days in storage and after this period a decreasing trend was noted. Kaur (2009) sprayed ascorbic acid in ber cv. Umran and recorded maximum fruit firmness was with ascorbic acid 3 per cent after 28 days of storage. The results of this experiment revealed that mean maximum fruit firmness during storage was maintained by ascorbic acid 3 percent.

2.1.2.1.1.6 Palatability rating

Significant higher palatability was recorded in guava fruits by ascorbic acid (100 ppm) treatment and rated them as 'highly desirable' after storage of 21 days (Gill *et al* 2014).

Bal *et al* (2010) observed highest palatability rating in fruits of cv. Umran ber was with GA_3 @ 25 and 50 ppm packed in CFB cartons and ber fruits remained in 'Excellent' state for 20 days under cold storage conditions. After 25 days of storage the rating of fruits was recorded as 'good' merely in naphthalene acetic acid @ 50 and @100 ppm treatments in CFB boxes. After 30 days of storage ber fruits were rated 'fair' but not suitable for marketing.

2.1.2.1.1.7 Seed weight

Kaur (2009) treated ber cv. Umran with ascorbic acid and recorded that the cumulative pulp/stone ratio was maximum in the fruits treated with sodium carbonate 3 per cent, followed by ascorbic acid 3 per cent. During this experiment minimum pulp/ stone ratio was recorded in the fruits treated with sodium carbonate 1 percent.

2.1.2.1.2 Bio-chemical Characters of Fruits

2.1.2.1.2.1 Total soluble solids

Singh *et al* (1989) observed that total soluble solids in ber fruits were significantly affected by NAA, Zn and B sprays. NAA (50 ppm) recorded maximum increase in TSS. Boron +Zinc +NAA induced maximum TSS followed by Zinc+ NAA. Foliar sprays of urea (0, 1.0, and 2.0 %) and NAA (0, 10, 20 and 30 ppm) was done on ber trees cv. Gola at fruit setting stage. The spray of 2.0 per cent urea recorded maximum TSS followed by 20 ppm NAA (Bhati and Yadav 2003). Bal *et al* (2010) reported that Umran ber fruits treated with different NAA concentrations showed higher total soluble solids when packed in Netlon.

2.1.2.1.2.2 Acidity

Bal *et al* (1982) found a significant difference in TSS/ acid ratio of ber fruit cv. Sanaur-2 with 10-50 ppm NAA and 50ppm 2, 4, 5-T treatments applied during October and November. It was observed that there was little variation in TSS /acid ratio of Sanaur-5 ber sprayed with NAA and 2, 4, 5 –T @ 10-50 ppm (Bal *et al* 1984). Bal *et al* (1988) reported that in ber cv. Umran there was marked difference in TSS/acid ratio with the use of NAA. The highest TSS /acid ratio was registered with 25 ppm NAA.

2.1.2.1.2.3 Vitamin C

Mandal *et al* (2012) experimented with winter guava and revealed that pre-harvest spray of NAA @ 50, 75 and 100 ppm resulted in increased ascorbic acid (mg/100g) during storage. This study was conducted under the cold storage (6-8°C and 90-95% RH) conditions and the fruits were taken out from the cold storage at interval of 10, 20, 30 and 40 days.

2.1.2.1.2.4 Total sugars

Ghazzawy (2013) studied the application of naphthalene acetic acid in Barhee date palm cultivar and recorded that it resulted in decrease of total sugars and the strands were kept at 0°C and 85- 90 % relative humidity for 45 days.

2.1.2.2 Effect of Salicylic Acid

2.1.2.2.1 Physical Characters of Fruits

2.1.2.2.1.1 Fruit size

Marzouk and Kassem (2011) established that pre-harvest foliar application of salicylic acid at 100 ppm on grape cv. Thompson Seedless improved berry length, width, and berry shape and cluster shape index compared to the control.

2.1.2.2.1.2 Fruit weight

Wang *et al* (2006); Sayyari *et al* (2009) studied in peach and pomegranates that the higher concentration of salicylic acid was more effectual than lower ones regarding weight loss and fruit decay under cold storage as compared to control treatment. Abbasi *et al* (2010) discovered that after 6-week storage of peach at 1°C, weight loss was least in 1mM salicylic acid treated fruits as compared to control. Marzouk and Kassem (2011) reported that salicylic acid can improve physical properties of fruits such as size in Thompson Seedless grapevine.

Pre-harvest spray of salicylic acid @100 ppm in grape cv. Thompson Seedless increased cluster weight, length and berry shape index compared to the control. Moreover, increase in berry weight, length, width berry shape index, and the juice content were also reported**.**

2.1.2.2.1.3 Specific gravity

Katiyar *et al* (2008) stated that the specific gravity of guava fruits after 6 days of storage was maximum under 90 ppm of GA_3 application and 1.013 on the day of storage. GA_3 at 30 and 90 ppm remained at par in this regard established statistically superior to rest of the treatments barring 120 ppm GA_3 and 600 ppm CCC. Champa *et al* (2014) reported that salicylic acid treatment could affect specific gravity of grape berries significantly.

2.1.2.2.1.4 Fruit colour

Kaur (2016) showed that salicylic acid @ 300 ppm exhibited good values of brightness of guava fruits under cold storage conditions. In untreated guava fruits rapid loss of green colour was recorded than the treated fruits. The untreated fruits lost their green colour after 7^{th} day in cold storage. However salicylic acid @ 300 ppm treated fruits maintained green colour till 14^{th} day. Madhav *et al* (2016) conducted study on guava fruits of cv. Allahabad Safeda and treated with salicylic acid at 1 mM and 2 mM concentration and stored at 10°C for 12 days. It was discovered that fruits treated with salicylic acid at 2 mM concentration exhibited minimum colour change.

Cao *et al* (2013) opined that ber trees sprayed with salicylic acid four times (30, 60, 90, and 110 DAFB) considerably deferred the change of index in ber fruit skin colour from green-to-red by 34.2 %, after 60 days during cold storage. Champa *et al* (2014)reported in Flame Seedless grapes that when vines were sprayed with 1.5 or 2.0 mM, and 1.0 mM salicylic acid and during subsequent cold storage (3–4 °C, 90–95 % RH), salicylic acid demonstrated higher efficacy on maintaining peel colour, reducing the rate of berry softening, alongside effectively suppressing other ripening associated changes.

2.1.2.2.1.5 Fruit firmness

Kaur (2016) predicted that there was loss of guava fruit firmness with storage time, but all the chemical applications appreciably maintained the firmness of guava fruit as compared to the untreated fruits under both types of storage conditions. It was reported that fruits treated with salicylic acid @ 300 ppm recorded maximum value of firmness followed by salicylic acid @ 200 ppm which was statistically at par with salicylic acid @100 ppm. The fruits under control exhibited minimum fruit firmness under cold storage which was considerably lower than all other applications. Madhav *et al* (2016) in guava fruits cv.

Allahabad Safeda studied the effect of salicylic acid at 1 mM and 2 mM concentration and stored at 10°C for 12 days. It was concluded that fruits treated with salicylic acid at 2 mM concentration exhibited maximum firmness.

Salicylic acid avoids fruit softening by influencing activities of major cell wall degrading enzyme such as cellulase, polygalactouronase and xylanase (Srivastava and Dwivedi 2000 and Zhang *et al* 2003). Continuation of higher fruit firmness when treated with salicylic acid has been detailed in other fruits such as kiwi (Fattahi *et al* 2010), strawberry (Shafiee *et al* 2010) in Chinese jujube (Kaseem *et al* 2011) and in peach (Tareen *et al* 2012). Champa *et al* (2014) reported in Flame Seedless grapes that when vines were sprayed with 1.5- or 2.0-mM salicylic acid and 1.0 mM salicylic acid and stored at cold storage (3–4 °C, 90–95 % RH). Salicylic acid demonstrated higher efficacy on reducing the rate of berry softening and suppressing other ripening associated changes.

2.1.2.2.1.6 Palatability rating

Maximum palatable guava fruits cv. Shweta were recorded with salicylic acid @300 ppm application with mean (7.93) organoleptic rating and it was closely followed by 7.65 with salicylic acid @ 200 ppm under cold storage conditions which was statistically at par with salicylic acid @ 100 ppm. It was reported that organoleptic rating of fruits improved significantly up to 14th day of storage with salicylic acid treatments under cold storage (Kaur 2016). Guava fruits treated with n-PG (300 ppm) exhibited minimum decay incidence, enhanced firmness and also maintained highly acceptable organoleptic rating up to 3 weeks of storage (Gill *et al* 2016).

Champa *et al* (2014) reported in Flame Seedless grapes that when treated with 1.5- and 2.0-mM salicylic acid had advanced overall acceptability rating in the taste panel, at different storage interval.

2.1.2.2.1.7 Seed weight

Baninaiem *et al* (2016) reported while working in the greenhouse at University of Hormozgan (Iran) in tomato that salicylic acid application had no noteworthy influence on weight loss (storing at 10°C for 40 days). Tomato fruit weight loss did not demonstrate any changes in response to different salicylic acid treatments.

2.1.2.2.2 Bio-chemical Characters of Fruits

2.1.2.2.2.1 Total soluble solids

Yeganeh *et al* (2013) observed that pre-harvest application of salicylic acid treatment considerably enhanced the post-harvest performance of berries qualities including: dry matter, sugar: acid ratio and fruit quality in grapes during cold storage. Awad (2013) observed a decreasing trend in fruit total soluble solids with rising salicylic acid concentrations and all the three salicylic acid treatments sustained a considerably lower reducing and total sugars than control, when immersed peach fruits in 0, 0.5, 1.0, and 1.5 mM salicylic acid solution for 10 min., stored at 0°C for 28 days, then moved to 20 °C for 3 days. In grapevine cv. Flame Seedless trained on bower (overhead) system in the vineyard at PAU, Ludhiana, it was found that during cold storage (3–4 °C, 90–95 % RH), clusters treated with 1.5- and 2.0-mM salicylic acid efficiently impeded the degradation of TSS on the contrary to control in which impressive reduction of TSS was noticed after 45 DAS (Champa *et al* 2014).

2.1.2.2.2.2 Acidity

Gill *et al* (2016) reported in winter guava fruit cv. Allahabad Safeda that n-PG @300 ppm affected fruits by exhibiting enhanced total soluble solids, acidity, pectin and phenol contents while storage conditions were 6-8°C and 90-95% R.H.

Champa *et al* (2014) reported in grapevine cv. Flame Seedless trained on bower (overhead) system that berry acidity content was not affected by spraying of salicylic acid.

2.1.2.2.2.3 Vitamin C

Awad (2013) conducted studies on Flordaprince fruits at commercial maturity by immersing in 0, 0.5, 1.0- and 1.5-mM salicylic acid solution for 10 min., stored at 0 °C for 28 days, then moved to 20°C for 3 days to simulate shelf life. He concluded that ascorbic acid content in fruits enhanced in vitamin C with increasing salicylic acid concentration, but prolonging storage periods generally declined vitamin C content.

2.1.2.2.2.4 Total sugars

Salicylic acid treatments sustained a significantly lower reducing and total sugars than control, when fruits of peach were immersed in 0, 0.5, 1.0, and 1.5 mM salicylic acid solution for 10 min., stored at 0°C for 28 days (Awad 2013). Yeganeh *et al* (2013) established that in pre-harvest salicylic acid treatment the post-harvest performance of berries in all traits including- sugar: acid ratio, acidity and overall fruit quality was improved in grapes during cold storage.

2.1.2.3 Effect of Ascorbic Acid

2.1.2.3.1 Physical Characters of Fruits

2.1.2.3.1.1 Fruit size

The fruit size in mango was affected by sword (K_2O 25%, Mg 0.5%, salicylic acid 25% and L- ascorbic acid 0.01%) (El-Razek *et al* 2013). However, the maximum significant value of mango weight was noted when sword was used at 2% twice followed by the same concentration sprayed. Nabil *et al* (2013) studied under Egypt conditions that gibberellic acid alone or in combination with citric and ascorbic acid affected fruit volume (cm^3) and fruit dimensions (length and diameter) as compared with the control (untreated trees) in case of "Hollywood" and "Golden Japanese" plum cultivars.

2.1.2.3.1.2 Fruit weight

GA_3 improved fruit firmness and fruit weight in sweet cherry (Basak *et al* 1998). Cruz *et al* (1999) reported that the weight of 'Hayward' fruit increased when the synthetic cytokinin CPPU was applied along with GA_3. El-Razek *et al* (2013) reported at Egypt that fruit weight in mango was affected by sword (a commercial product which contains salicylic acid 25% and L- ascorbic acid 0.01%). However, the highest significant value of fruit weight was observed when sword chemical was sprayed at 2% twice. Nabil *et al* (2013) studied under Egypt conditions and revealed that gibberellic acid alone or along with citric and ascorbic acid influenced fruit weight of "Hollywood" and "Golden Japanese" plum cultivars.

2.1.2.3.1.3 Specific gravity

Bhat (2000) revealed in Jammu region that lowest specific gravity in guava could be recorded with urea 15 per cent naphthalene acetic acid 800 ppm and 1000 ppm. It was concluded that highest specific gravity could be obtained with hand deblossoming followed by 2, 4-D 150 ppm and 200 ppm as compared to control.

2.1.2.3.1.4 Fruit colour

Kaur (2016) while working on guava cv. Shweta found that ascorbic acid resulted in postponement of the colour degradation. It was concluded that untreated fruits exhibited rapid colour changes in cold storage.

Jain *et al* (1981) in ber reported the change colour of the fruit from yellowish green to yellow and then light brown and finally change into dark brown at 13ºC. Similar observation was given by Bal (1982) regarding change in fruit colour of ber in 20 days of storage at cool temperature. Amarante *et al* (2005) studied the effects of pre-harvest spraying of gibberellic acid (GA_3) and aminoethoxyvinylglycine (AVG) in peach cv. Rubiduox and found that application of GA_3 (100 mg/l) and AVG (75 and 150 mg/l) gave better retention of skin background colour in cold storage. Kaur (2009) recorded the highest value of 'a' in untreated fruits of ber cv. Umran kept without pedicel after 28 days of storage while highest 'b' value was recorded in the fruits treated with ascorbic acid 3 % after 21 days of storage (Hunter Lab values).

2.1.2.3.1.5 Fruit firmness

Highest mean fruit firmness was recorded in case of ber cv. Umran fruits treated with ascorbic acid and whereas the decrease was most prominent in the untreated fruits kept devoid of pedicel. The fruit firmness in Umran ber fruits decreased with the enhancement in duration of storage irrespective of the chemical applications (Kaur 2009). Firmness of all the ascorbic acid treated fruits was improved up to 14 days of storage, and thereafter, a slow decline was observed in guava (Gill *et al* 2014). Analogous outcomes have been described in guava (Jayachandran *et al* 2007) and ber (Siddiqui and Gupta 1995).

2.1.2.3.1.6 Palatability rating

Kaur (2009) recorded highest palatability rating after 7 days of storage in ascorbic acid 2 per cent treated fruits. After 21 days of storage duration, maximum palatability rating (7.0 out of 10) was observed in fruits treated with ascorbic acid @ 1 and 3 per cent, boric acid 3 per cent and untreated fruits of ber cv. Umran with both with and without pedicel.

2.1.2.3.1.7 Seed weight

El-Razek *et al* (2013) reported that seed weight in mango was increased by sword (K_2O 25%, Mg 0.5%, salicylic acid 25% and L- ascorbic acid 0.01%) concentration than the control**.**

2.1.2.3.2 Bio-chemical Characters of Fruits

2.1.2.3.2.1 Total soluble solids

TSS content of the guava fruits is not much affected by the application of ascorbic acid @1 per cent, 1.5 per cent or 2 per cent under cold storage conditions (Kaur 2016).

Bal (1982) reported that in ‘Sanaur-2’ ber fruits, stored at cool temperature of 0-4ºC, TSS increased quickly after 10 days of storage and then started declining after 20 days of storage. Similar fluctuations in TSS was also observed by Jain *et al* (1981), Banik *et al* (1988) and Baviskar *et al* (1995) during storage studies were carried out in ber fruit. It was concluded that total soluble solids/ acid ratio increased slowly with the increased duration of storage. The highest average TSS/acid ratio was recorded in ber cv. Umran fruits, treated with sodium carbonate 1 per cent and the lowest was found in the fruits treated with ascorbic acid (Kaur 2009).

2.1.2.3.2.2 Acidity

Such a decline in acidity has been accredited to transformation of acids to sugars and its consumption in respiration process (Pool *et al* 1972). Jawanda *et al* (1980) recorded that acidity of ber fruit decreased as the storage period increased in various treatments. The acidity of fruits was maximum during storage and its content decreased considerably after the storage. The maximum acidity (0.164%) was recorded in ber fruits treated with ascorbic acid 1 per cent. The reduction in acidity of ber fruits was quite slow under cool conditions (Bal 1982).

2.1.2.3.2.3 Vitamin C

Reddy (2009) in guava cv. Allahabad Safeda observed that ascorbic acid content was found to be higher in the benzyl adenine @100 ppm applied fruits in combination with 0.20 KGy & 0.40 KGy irradiation dose during cold storage conditions. It was reported that vitamin C content in ber cv. Umran decreased considerably with the increase in cold storage duration. Ascorbic acid 2 per cent and 3 per cent treatments resulted in appreciably higher retention of average vitamin C content as compared to all other applications while untreated fruits kept without pedicel maintained lowest vitamin C content (Kaur 2009).

2.1.2.3.2.4 Total sugars

Total sugars in Umran ber were improved significantly at the initial stage up to 14 days of storage followed by a reduction at the later stage. Highest content of total sugars (9.62%) was found in case of ascorbic acid 3percent followed by boric acid treatments. Lowest average total sugars content was projected in the untreated fruits. The total sugars were estimated appreciably higher in the fruits treated with ascorbic acid 3 percent after 14 days of storage (Kaur 2009).

2.2 Post-harvest Application of Chemicals on Shelf Life of Winter Guava

2.2.1 Ambient Storage

2.2.1.1 Effect of Naphthalene Acetic Acid

2.2.1.1.1 Physical Characters of Fruits

2.2.1.1.1.4 Fruit colour

Selvan and Bal (2005) while working on Sardar guava revealed that lower concentration of naphthalene acetic acid retained the creamish yellow colour of the fruits in the storage. It was concluded that naphthalene acetic acid @ 50 ppm and 75 ppm resulted in the conversion of fruit colour to creamish yellow after a period of 9^{th} day of storage.

According to Valero *et al* (1998) vacuum penetration of GA_3 (100 ppm) was effective in decreasing the colour change in lemon fruits during storage. Chahal and Bal (2004) discovered that colour changes were slower in ber fruits cv. Umran treated with naphthalene acetic acid when packed in CFB boxes.

2.2.1.1.1.5 Fruit firmness

Dhoot *et al* (1984) observed that naphthalene acetic acid @ 150 ppm was very effectual in retaining the firmness of guava fruits during storage period. Padmavathamma (1990) conducted post-harvest studies on storage of guava fruits (Allahabad Safeda and Lucknow-49) at Rajendranagar, Hyderabad. It was established that naphthalene acetic acid treatment was the most effective treatment regarding fruit firmness. Maximum firmness was evidenced in the fruits wrapped in polythene bags followed by the fruits treated with naphthalene acetic acid during storage. Reddy (1992) recorded that post-harvest treatment with naphthalene acetic acid 200 ppm, maintained higher scores of firmness of guava cv. 'Allahabad Safeda' in storage.

2.2.1.1.1.6 Palatability rating

Dhoot *et al* (1984) revealed the effect of naphthalene acetic acid on shelf life of guava and explained that after 6 days of storage, fruits treated with naphthalene acetic acid @150 ppm scored better organoleptic rating than those untreated ones. Tandon *et al* (1984) studied that the organoleptic quality of 'Allahabad Safeda' guava was improved by the application of naphthalene acetic acid and it was the highest after 9 days storage of guava fruit. Singh (1988) studied the effect of naphthalene acetic acid on the storage life of Allahabad Safeda guava and found that higher concentration of naphthalene acetic acid @100 ppm was effective in maintaining the edible quality and marketability of guava fruits for more than 6 days by delaying the onset of senescence during storage. Bhalerao *et al* (1994) established that naphthalene acetic acid @ 150 ppm resulted in the highest organoleptic rating after 9 days storage of guava cv. 'Sardar'. Singh *et al* (2017) conducted experiment on the effect of naphthalene acetic acid on guava fruit and reported that highest mean palatability rating was noted in the fruit treated with naphthalene acetic acid @ 200, 300 ppm. Fruits from these treatments were categorized as 'excellent' while other fruits were having 'good' palatability rating. After 6 days of storage all the fruits were rated with 'very good' palatability rating while after 9 days of storage the fruits under all treatment fruits have just good palatability rating. After long storage the guava fruits treated with naphthalene acetic acid had 'fair' rating regarding palatability. They concluded that the rapid decrease in palatability rating during storage was because of the fruit spoilage.

Baviskar *et al* (1995) reported higher organoleptic rating of ber fruits in CFB and polythene packaging, kept open or packed in Netlon covering. Marketable ber fruits enhanced after 3, 6, 9, and 12 days of storage when dipped in naphthalene acetic acid @ 50, 100 or 200 ppm and stored at room temperature (22°C and 80-85% RH). Summy and Jawandha (2015) noted that putrescine @ 3 mmol L-1 treatment was effective in maintaining the high palatability and total sugars at the end storage period in peaches.

2.2.1.1.1.8 Physiological loss in weight

Singh (1988) studied the effect of naphthalene acetic acid on the storage life of Allahabad Safeda guava. It was concluded that higher concentration of naphthalene acetic acid (100 ppm) was effective in minimizing the loss of weight in storage. The increased physiological weight loss in guava crop during storage had also been established by Bhalerao *et al* (1994). They found that dipping of guava fruits cv. 'Sardar' in naphthalene acetic acid and wrapping in plastic film resulted in the least reduction in weight loss of fruits. Jagadeesh and Rokhade (1998) dipped guava fruits cv. Sardar-1 in naphthalene acetic acid @ 150 ppm and stored at room temperature. They revealed that physiological loss in weight increased as the storage period had increased. It was explained that higher vapour pressure of moisture inside the fruit than the surrounding atmosphere and unrestricted respiration due to abundance of oxygen accessible in the surrounding area of fruits, could be held responsible for strengthening this activity. Rana *et al* (2015) stated that decline in physiological weight loss and fruit decay due to treatment with naphthalene acetic acid might be associated with reduction in transpiration and respiration rate in guava plant tissues. These results are supported by Blankenship and Dole (2003); Singh *et al* (2004); Martinez *et al* (2009) in fruit crops. While working on guava crop under Punjab conditions, Singh *et al* (2017) found that the weight loss was not considerably affected in storage. At 12 days of storage, the maximum weight loss was observed in control and minimum weight loss was in naphthalene acetic acid @ 400 ppm treated guava fruits. All treatments have been reported significant reduction in weight loss over control whereas naphthalene acetic acid @ 300 and 400 ppm had been reported to be important over all other treatments in this respect.

2.2.1.1.1.9 Fruit spoilage

Singh (1988) studied the effect of naphthalene acetic acid on the storage life of Allahabad Safeda guava. It was found that higher concentration of naphthalene acetic acid (100 ppm) was beneficial in minimizing the rotting percentage. Singh *et al* (2017) reported in guava fruit that fruit decay was augmented with increasing number of days of storage at normal temperature. Very less fruit decay was observed in case of naphthalene acetic acid @200, 300 and 400 ppm while highest fruit decay was reported in control. The fruit decay in guava storage was due to water loss and collapse of pulp at ambient storage temperature.

Ber fruits cv. Gola' treated with naphthalene acetic acid @ 50, 100 and 200 ppm resulted in lessening of rotting in storage (Bandhopadhyay and Sen 1995).

2.1.1.1.2 Bio-chemical Characters of Fruits

2.1.1.1.2.1 Total soluble solids

Tandon *et al* (1984) and Jagadeesh and Rokhade (1998) carried out their studies at Karnataka by applying naphthalene acetic acid in guava fruits cv. Sardar-1 and found that percentage of TSS had improved by naphthalene acetic acid treatment. Yadav *et al* (2001) accomplished that traits like fruit weight, organoleptic rating, TSS, ascorbic acid and total sugars content were improved considerably over control by naphthalene acetic acid treatment @ 20 to 60 ppm and decreased pressure (kg/cm2) of fruit appreciably to make it more acceptable. Selvan and Bal (2005) studied that TSS content in the fruit of Sardar guava was significantly higher with naphthalene acetic acid @ 25 ppm after 3rd day of storage. It was followed by other treatments like GA_3, Ca $(NO_3)_2$ and Benlate etc. Singh *et al* (2017) reported TSS improved with different treatments (naphthalene acetic acid and Boric acid) during storage at room temperature (25°±1°C) and 75% RH under Punjab condition. Higher TSS was noticed in fruits treated with naphthalene acetic acid @ 300 ppm, 400 ppm after 12 days of storage. The high range of total soluble solid might be due to the efficient translocation of photosynthesis to the fruit by regulation of naphthalene acetic acid.

Bandyopadhay and Sen (1995) concluded that an increase in TSS of ber fruits cv. Gola during storage. In this experiment ber fruits were dipped in naphthalene acetic acid @ 50,100 or 200 ppm before storage. Bal *et al* (2010) found that ber fruits cv. Umran treated with naphthalene acetic acid treatments showed higher TSS when packed in Netlon.

2.1.1.1.2.2 Acidity

Dhoot *et al* (1984) observed higher acidity in fruits of guava treated with naphthalene acetic acid on 6th day while on 3rd day the acidity content was more in control. Similar results in guava were recorded by several research workers (Garg *et al* 1978 and Sharma and Dashora 1999).

Higher acidity content was observed in naphthalene acetic acid treated ber fruits on 3rd day but this trend was reversed on 6th day of storage (Banik *et al* 1988). The lessening in acidity of ber fruits was slow down by GA_3 application, was noted by kishan and Godara (1992). According to Bandyopadhay and Sen (1995) the acid content in ber fruit cv. Gola was decreased during storage, when dipped in naphthalene acetic acid @ 50, 100 or 200 ppm solutions before ambient storage.

2.1.1.1.2.3 Vitamin C

Brahmachari *et al* (1996) proved that application of naphthalene acetic acid at 25 to 50 ppm in ‘Sardar’ guava improved quality of fruit over control.

Bal *et al* (1984) and (1988) observed a significant increase in fruit T.S.S. / acid ratio, vitamin C content and reduced the acidity of the ber fruit. Banik *et al* (1988) found that there was no adverse effect on ascorbic acid content of the fruits in ber cv. Gola under all treatments like naphthalene acetic acid, wax and with advancement in the storage period. Singh *et al* (1989) stated that spray of naphthalene acetic acid 50 ppm with some micronutrients resulted in improvement of total sugar, T.S.S., acidity, T.S.S. / acid ratio and ascorbic acid content in ber cv. Pewandi. Bandyopadhay and Sen (1995) reported that ascorbic acid of ber fruits cv. Gola was declined during storage when dipped in naphthalene acetic acid @ 50, 100 and 200 ppm during ambient storage.

2.1.1.1.2.4 Total sugars

Jagadeesh and Rokhade (1998) conducted study on guava fruits cv. Sardar-1 by dipping in naphthalene acetic acid @ 150 ppm (stored at room temperature) and found that the percentage of total soluble solids was improved during initial stages but later on it was declined.

An increase was recorded in total sugars and reducing sugars with the progression of storage period in ber. Furthermore, sharp decline was recorded in total sugars and improvement in reducing sugars. They explained that this increase happened due to naphthalene acetic acid treatment during storage (Banik *et al* 1988).

2.2.1.2 Effect of Salicylic Acid

2.2.1.2.1 Physical Characters of Fruits

2.2.1.2.1.4 Fruit colour

Kaur (2016) reported that salicylic acid @ 300 ppm treated guava fruits retained green colour in storage under ambient condition fruits up to 7th day of storage. It was proved that all the post-harvest treatments (including salicylic acid) delayed the ripening. Amanullah *et al* (2017) showed that post-harvest application of salicylic acid on guava at ambient temperature resulted in lowest color score. Highest color score were recorded at 10th day of storage.

Zeng *et al* (2008) observed slightly slowdown in peel degreening and inhibited respiration rate in mango fruits treated with salicylic acid. Lolaei *et al* (2012) investigated the effect of salicylic acid as post-harvest applications on the strawberry cv. Camarosa fruit quality and established that treatment of SA postponed the ripening of strawberry fruits as obvious by lessening of redness than control.

2.2.1.2.1.5 Fruit firmness

Lo'ay and Khateeb (2011) conducted their studies on guava fruit in region of Demyatta province. During experiment harvested fruits were immersed in salicylic acid solutions for 20 min. and kept at room temperature. It was revealed that fruit firmness was augmented as the concentration of salicylic acid was increased. Further it was explained that increasing fruit firmness with advanced salicylic acid concentration might be related with the consequence of salicylic acid on cell wall degradation enzymes such as pectin degradation and cellulose. Kaur (2016) outlined that salicylic acid treatment effectively retain the fruit firmness under ambient storage conditions. Higher fruit firmness was recorded in salicylic acid @ 300 ppm under ambient condition of storage. The untreated (without salicylic acid application) fruits showed fast loss in firmness. Salicylic acid efficiently maintained the firmness of the fruits in all concentrations. It was reported that salicylic acid @ 300 ppm was found more effective in retaining the firmness of the fruits.

Treatment with salicylic acid at nontoxic concentration of fruits has been shown to be effective in retarding the ripening and firmness of banana fruit (Srivastava and Dwivedi 2000) and kiwifruit (Zhang *et al* 2003). Sultan *et al* (2015) dipped loquat fruits in solution with 5 mM salicylic acid, for 5 minutes and stored under room conditions (18±2°C and 55% R.H.). They showed that SA sustained higher levels of flesh firmness in loquat.

2.2.1.2.1.6 Palatability rating

Palatability rating in guava fruit was significantly increased up to 7th day under room temperature conditions. Then it reduced progressively. It was recorded highest in fruits treated with salicylic acid @ 200 ppm under ambient condition. The untreated fruits showed an initial increase in palatability rating up to 7th day of storage, thereafter it decreased throughout the storage period and least organoleptic score was recorded under storage condition, Kaur (2016).

Jawandha *et al* (2012) treated ber fruits with gibberellic acid and after 10 days of storage, the maximum palatability rating was noted in GA_3 60 ppm treatment. The lowest palatability rating was recorded in control. It was proved that palatability rating decreased as the storage period progressed.

2.2.1.2.1.8 Physiological loss in weight

Kaur (2016) reported that lowest cumulative mean of physiological loss in weight (PLW) was observed in guava fruits treated with salicylic acid @ 300 ppm under ambient storage conditions. PLW was highest in untreated fruits. It was established that with the enhancement of storage period there was progressive loss in weight of guava fruits.

Amanullah *et al* (2017) discovered by treating guava fruit with different concentration of salicylic acid (0, 400, 500, 600 and 700 µmol) and stored at room temperature. They found that treated fruits with salicylic acid @ 600 µmol had lower values for weight loss as compared to other salicylic acid concentrations. They concluded that the 600 µmol salicylic acid concentration was an advantageous post-harvest treatment to boost the shelf life of guava fruit in short term storage.

Salicylic acid has been reported to reduce the respiration rate in peach fruits (Han *et al* 2003). The role of SA in reducing physiological weight loss percentage had been established in strawberry (Shafiee *et al* 2010) and peach (Tareen *et al* 2012). Brar *et al* (2014) reported in peach fruits that salicylic acid 200 ppm considerably reduced the physiological loss in weight as compare to control. Sultan *et al* (2015)conducted an experiment in which loquat fruit were treated with 5 mM salicylic acid, dipped for 5 min., air dried and stored under room conditions (18±2°C and 55% RH). These results showed that post-harvest treatments with salicylic acid slowed down weight loss of loquat fruits.

2.2.1.2.1.9 Fruit spoilage

Kaur (2016) revealed that 5 to 13 per cent fruit got deteriorated under different treatments of SA and 25 % in control under ambient condition up to 7^{th} day of storage. Minimum spoilage was observed in the fruits treated with salicylic acid @ 300 ppm. The spoilage was further augmented up to 21 days. It was recorded that fruit spoilage was 100% on 21st day of storage. Amanullah *et al* (2017) observed lowest fruit decay in guava fruits, when treated with 600 µM salicylic acid followed by fruits those were treated with 700 µmol SA. They recognized highest decay in control. Significant differences in decay per centage of fruit were recorded by them. Highest values of fruit decay were noted at 10^{th} day and lowest fruit decay at 600 µmol at 5^{th} day, followed by 700 µmol at 5^{th} day.

Zhulong and Shiping (2006) in sweet cherry fruits studied that dipping treatment in salicylic acid at 0.5 mM for 10 min. resulted in reduction of frequency of decay. Limin and Fenfen (2011) reported that post-harvest treatments with salicylic acid (0.5 g/L for 10 min.) resulted in lessening of spoilage percentage in chestnut fruit. Abbasi *et al* (2012) discovered that salicylic acid proved to be the most effective in keeping quality of peach fruit along with deferment of fruit decay during storage.

2.2.1.2.2 Bio-chemical Characters of Fruits

2.2.1.2.2.1 Total soluble solids

Kaur (2016) reported that total soluble solids (TSS) were increased in winter crop of guava cv. Shweta throughout the storage period. Under ambient condition it (TSS) was improved up to 7th day of storage and reduced afterward. All the salicylic acid concentrations were resulted in higher mean TSS. It was verified that salicylic acid proved better in sustaining higher total soluble solids throughout the storage period up to 7th day under ambient conditions. Amanullah *et al* (2017) recorded advanced TSS/acid ratio in guava at ambient temperature and fruits were treated with salicylic acid @ 600 µmol followed TSS/acid ratio of fruits those were treated with @ 700 µmol. Lowest TSS/acid ratio was recorded in control. They showed that differences in TSS/acid ratio of fruit were significant. It was explained that TSS was better during storage period as a result of insoluble starch conversion into soluble solid content. This change in soluble solids concentration may be correlated with hydrolytic regulation of starch concentration during post-harvest storage which ultimately results in starch conversion (breakdown) to sugars which is key fruit ripening indicator process.

Lougheed *et al* (1979) opined that increase in TSS and sugars during storage might be due to hydrolysis of starch into sugars as on entire hydrolysis of starch no further increase happens and consequently a decline in TSS is expected as they along with other organic acids are first and foremost substrate for respiration. Kays (1991) stated that enhancement in TSS of fruits might be due to decline behavior of different enzymes and by postponing the senescence, disorganization of cellular structure and inhibiting of microbial activities. Karlidag *et al* (2009) reported while working on strawberry fruits that soluble solids concentration increased when plants were sprayed with salicylic acid than control. This alteration in soluble solids concentration may be connected with hydrolytic regulation of starch concentration during post-harvest storage which ultimately resulted in starch translation (breakdown) to sugars which is key fruit ripening pointer process.

2.2.1.2.2.2 Acidity

Dhoot *et al* (1984) reported higher acidity in guava fruits with application of naphthalene acetic acid on sixth day of storage while on third day the acidity was more in control. Same results were recorded by several researchers (Garg *et at* 1978 and Sharma and Dashora 1999) in guava with CCC, 2, 4-0, 2, 4, 5-7 and BA treatments. Amanullah *et al* (2017) reported that acidity in guava fruits showed significant differences among all salicylic acid treatments. They recorded lowest acidity in guava fruits those were treated with salicylic acid @ 600 µmol. They recorded minimum values of acidity at 10th day. It was concluded that lowest total titrable acidity with salicylic acid @ 600 µmol, followed by salicylic acid @ 700 µmol.

Pre-harvest treatment of winter pineapple fruit with salicylic acid resulted in an improvement of titrable acidity of the fruit (Lu *et al* 2011). Lolaei *et al* (2012) studied the effect of salicylic acid as pre-harvest treatments on fruit quality of the strawberry cv. Camarosa. They reported that pre-harvest treatment of SA had advanced titratable acidity values than the control. Reddy *et al* (2016) reported that pre-harvest application of salicylic acid at 200 ppm on mango cv. 'Amrapali' fruits and storage at ambient conditions (30 ± 5°C and 50 ± 5% RH) showed delaying the ripening cum senescence processes through suppression of respiration rate and retention of high firmness, TSS and titratable acidity compared to untreated fruits.

2.2.1.2.2.3 Vitamin C

Maximum ascorbic acid was reported in guava fruits; those treated with salicylic acid @ 600 μmol, followed by salicylic acid @ 700 μmol. The lowest ascorbic acid was observed in control. It was concluded that fruit ascorbic acid was higher at 5^{th} day than 0 day. Highest ascorbic acid was noted at 10^{th} day (Amanullah *et al* 2017).

Jahromi and Ramazani (2015) reported that salicylic acid @ 250 mgL-1 led to enhancement of fruit qualitative characters and post-harvest life of ber fruits cv. Seb in comparison to control and other treatments.

2.2.1.2.2.4 Total sugars

It was reported under Punjab conditions that salicylic acid @300 ppm retained higher level of total sugars in winter crop of guava fruit cv. Shweta under ambient environment (Kaur 2016). Amanullah *et al* (2017) reported maximum total sugar in fruits those were treated with salicylic acid @ 600 μmol followed by salicylic acid @ 700 μmol. Lowest total sugar contents were observed in control. Total sugar contents were recorded at 5^{th} day of storage that was higher than 0 day. The highest values of total sugar contents were observed at 10^{th} day.

Ghazzawy (2013) studied the storage ability of Barhee date palm cultivar and found that total sugars were decreased by spraying naphthalene acetic acid and BA in both seasons more than other treatments as followed by salicylic acid and GA_3. Ali *et al* (2013) reported while working on Apricot cv. Habi that dipping treatment with salicylic acid at (0.5, 1, 1.5 and 2mM) resulted in increased total sugars throughout storage.

2.2.1.3 Effect of Ascorbic Acid

2.2.1.3.1 Physical Characters of Fruits

2.2.1.3.1.4 Fruit colour

Kaur (2016) recorded the colour of winter crop of guava cv. Shweta fruits under ambient conditions after ascorbic acid treatment. It was noted that fruit colour changed slowly as the storage period advanced. Fruits colour was of green at the time of harvest. All the concentration of ascorbic acid effectively maintained the colour of the fruit and showed light yellow green colour till the end of storage. Untreated fruits showed quick colour changes in ambient storage condition.

2.2.1.3.1.5 Fruit firmness

Kaur (2016) recorded that ascorbic acid had affected the fruit firmness in winter guava cv. Shweta under ambient storage conditions as compared to control.

2.2.1.3.1.6 Palatability rating

It was observed that under ambient condition the guava fruit remained palatable up to 7^{th} day and afterwards it lessened considerably in control fruits (Kaur 2016). Fruits treated with salicylic acid exhibited highest organolepting rating followed by ascorbic acid @ 2.0 percent application up to 7^{th} day of storage.

2.2.1.3.1.8 Physiological loss in weight

Ascorbic acid @ 1.0 percent showed less PLW per cent than the untreated fruits of winter guava cv. Shewta (Kaur 2016).

Application of ascorbic acid 1000 ppm in grapes resulted into lower cumulative physiological loss in weight (Ramprasad *et al* 2004).

2.2.1.3.1.9 Fruit spoilage

Highest mean fruit spoilage was recorded in guava in control and it was followed by ascorbic acid treatment (Kaur 2016). It was established that ascorbic acid applications had non-significant effect on spoilage in winter guava cv. Shewta under ambient storage conditions.

Apelbaum *et al* (1981) concluded that ascorbic acid might reduce the ethylene production and respiration activities by hindering the probable free radical interceded ACC to ethylene pathway of ethylene.

2.2.1.3.2 Bio-chemical Characters of Fruits

2.2.1.3.2.1Total soluble solids

Rajput *et al* (2015) found that TSS of guava fruits was minimum (20.10%) with ascorbic acid @ 1000 ppm stored at ambient conditions.

2.2.1.3.2.2 Acidity

Kaur (2016) studied that ascorbic acid @2.0 per cent exhibited advanced level of acidity in winter crop of guava fruits cv. Shweta under ambient condition (room temperature). Minimum acid content observed in untreated fruits kept under ambient condition.

2.2.1.3.2.3 Vitamin C

Kaur (2016) reported highest vitamin C content in winter crop of guava cv. Shweta fruits treated with ascorbic acid @ 2.0 per cent under ambient conditions. It was established that untreated fruits exhibited minimum level of vitamin C.

Siddiqui and Gupta (1995) proved that the ascorbic acid of the ber cv. Umran fruits during room storage was not affected by ascorbic acid @300 ppm. Zhao *et al* (2009) studied that various citric acid treatments kept the ascorbic acid at higher levels. But they obtained best results by application of citric acid @ 1.5 per cent.

2.2.1.3.2.4 Total sugars

Banik *et al* (1988) recorded minimum total sugars in the ber fruits treated with ascorbic acid @100 ppm. It was concluded that maximum total sugars were observed in the fruits treated with ascorbic acid @ 3 per cent and minimum total sugars were recorded in the untreated fruits placed without pedicel in storage. They found that total sugars were significantly higher in the fruits treated with ascorbic acid 3 per cent in contrast to other applications after 14 days of storage. Zhao *et al* (2009) recorded maximum total sugars in fruits treated with ascorbic acid 2 per cent closely followed by ascorbic acid 3 percent after 7th days of storage. After 14 days of ambient storage, maximum total sugars were recorded in *Zizyphus jujube* fruits.

2.2.2 Cool Storage

2.2.2.1 Effect of Naphthalene Acetic Acid

2.2.2.1.1 Physical Characters of Fruits

2.2.2.1.1.4 Fruit colour

Selvan and Bal (2005b) revealed that naphthalene acetic acid @ 25 and 50 ppm retained light yellow green colour (YGG 145B) of guava fruits in cold storage. Higher concentration of naphthalene acetic acid @75 ppm resulted as best treatment in postponement of senescence whereas guava fruits were observed light green coloured (YGG 142A) after a storage of 21st and 28th days. Deepthi and Sekhar (2015) carried out experiment in guava (cv. Lucknow-49) at Hyderabad. After treatment with naphthalene acetic acid (100 and 200 ppm) fruits were placed in cold storage (10±1ºC and 90±5% RH). It was concluded that skin colour of fruits turned slightly yellow from light green.

Chahal and Bal (2004) showed the colour modification rate in ber fruits cv. Umran treated with naphthalene acetic acid. But this rate was slower after storing them in cold storage for different durations. Bal *et al* (2010) found that ber fruits cv. Umran maintained their colour up to 20 days in cold storage and no browning was noted in fruits treated with naphthalene acetic acid application in CFB boxes. After, 20 days of storage fruits exhibited deep yellow colour.

2.2.2.1.1.5 Fruit firmness

Selvan and Bal (2005) observed that guava fruit firmness was decreased quickly in storage. It was recorded highest in fruits which were treated with naphthalene acetic acid @ 25ppm, after 28 days of storage. Deepthi and Sekhar (2015) carried out experiment on guava crop at Hyderabad and fruit firmness was recorded during cold storage (10±1°C and 90±5% RH) after naphthalene acetic acid treatment of guavas cv.Lucknow-49. They observed that fruit firmness decreased consistently with the advancement of storage period. Activity of cell wall degrading enzyme declined slowly, till the fruits became ripe, but augmented in the over-ripe stage.

2.2.2.1.1.6 Palatability rating

Bal *et al* (2010) concluded highest palatability rating in ber fruits cv. Umran with naphthalene acetic acid 50 and 100 ppm and fruits remained in ‘Excellent’ condition for 20 days in cold storage. After 30 days of storage ber fruits were rated fair but they were not fit for marketing. Fruits treated with AVG, and 1-MCP kept alike response regarding the continuation of quality, however when these applications were combined, an enhancement in quality maintenance occurred after long-term storage of ‘Brookfield’ apples at Santa Maria (RS), Brasil (Brackman *et al* 2015).

2.2.2.1.1.8 Physiological loss in weight

Dhoot *et al* (1984) showed that lower concentration of naphthalene acetic acid considerably declined the physiological loss in weight (PLW) in Sardar guava fruits. Selvan and Bal (2005) recorded lowest mean physiological loss in weight in benlate (a fungicide) treated fruits but naphthalene acetic acid @ 50 ppm also showed less value regarding PLW and resulted similar trend.

Banik *et al* (1988) reported that wax coated fruits of ber cv. Gola, kept in cold storage (10-20°C) exhibited least physiological loss in weight after naphthalene acetic acid treatment. Bal *et al* (2010) carried out their studies in ber fruits cv. Umran treated with naphthalene acetic acid @ 50 ppm and kept in CFB boxes, showed slightest reduction in PLW stored at 0-3.3°C and 85-90 per cent RH.

2.2.2.1.1.9 Fruit spoilage

Lowest mean spoilage in guava fruits was recorded with application of naphthalene acetic acid @ 50 ppm but it remained high in control (Selvan and Bal 2005).

Bal *et al* (2010) recorded very lesser amount of spoilage in ber fruits *cv.* Umran up to 10 days under cold storage conditions. Least spoilage was recorded in fruits treated with naphthalene acetic acid @ 100 ppm packed in corrugated fiber boxes (CFB).

2.2.2.1.2 Bio-chemical Characters of Fruits

2.2.2.1.2.1 Total soluble solids

Dashora (2001) reported that naphthalene acetic acid @ 200 ppm treatment resulted in lower total sugar content in winter guava. Al-Saif (2011) conducted studies on *Syzygium samarangense* (water apple/wax apple) at University of Malaya Kuala lumpur and revealed that total soluble solids content was influenced significantly by the application of various treatments of naphthalene acetic acid.

2.2.2.1.2.2 Acidity

It was found that acidity was at its highest in naphthalene acetic acid@ 25 ppm in grapes cv. Thompson Seedless. A decrease had been noted in acidity after 14 days in storage. This decease had been accredited due to alteration of acids to sugars and their utilization in respiration activity (Pool *et al* 1972). Selvan and Bal (2005) recorded that in harvested guava fruits the acidity was nearly 0.58 per cent and increased with application of naphthalene acetic acid @ 25 ppm (0.76%). The highest acid content was recorded with naphthalene acetic acid treated fruits.

Bal and Singh (1978) found that Umran ber acidity decreased as storage duration progressed. Nkansah *et al* (2012) reported that mean values of plant growth regulators on acidity, TSS/TA and pulp colour followed alike trend of no implication in the hormone applications (25 ppm GA_3+25 ppm NAA and 50 ppm GA_3+50 ppm NAA) but important differences were recorded between the plant growth regulators and the control in both seasons and locations in quality of Keitt Mangoes in Coastal Savanna Ecological Zone of Ghana.

2.2.2.1.2.3 Vitamin C

Selvan and Bal (2005) observed higher vitamin C in Sardar guava fruits with naphthalene acetic acid treatment (from 25-75 ppm) and followed a decreasing trend with progress in storage days.

Ghosh *et al* (2009) revealed that fruit weight was maximum in case of aonla cv. NA-10 with 0.5% $ZnSO_4$ spray, followed by naphthalene acetic acid 10 ppm at Mohanpur. Fruit quality with regard to total sugars and ascorbic acid was enhanced in all treated fruits compared to control.

2.2.2.1.2.4 Total sugars

Total sugars increased in storage when guava fruits were treated with naphthalene acetic acid @ 150-250 ppm (Dhoot *et al* 1984). Selvan and Bal (2005) proved that total sugars in Sardar guava, were not much influenced by naphthalene acetic acid treatment.

Harhash and Al-Obeed (2007) reported that total and reducing sugars in Barhee and Shahl dates were declined significantly by naphthalene acetic acid application as compared with the control.

2.2.2.2 Effect of Salicylic Acid

2.2.2.2.1 Physical Characters of Fruits

2.2.2.2.1.4 Fruit colour

Madhav *et al* (2016) found fruit colour slightly improved in guava cv. Allahabad Safeda after treatment with salicylic acid @1 mM and 2 mM concentration and storage at 10°C for 12 days. They concluded that such fruits exhibited minimum colour change. Kaur (2016) also concluded that colour of guava fruits changed gradually as the storage period progressed. Fruit colour was nearly green at the time of harvest. All the concentration of salicylic acid efficiently retained fruit colour and showed light yellow green colour till the storage period under cold storage. Untreated fruits exhibited immediate colour changes.

2.2.2.2.1.5 Fruit firmness

Salicylic acid application @1 mM and 2 mM concentration in guava cv. Allahabad Safeda and storage at 10°C for 12 days maintained maximum fruit firmness (Madhav *et al* 2016). Kaur (2016) found that in winter crop of guava cv. Shweta, fruit firmness was higher with salicylic acid @ 300 ppm treatment in cold storage. It was reported that untreated fruits displayed quick loss in firmness under cold storage conditions. All the concentrations of salicylic acid effectively maintained the firmness of the guava fruit under Punjab conditions.

Salicylic acid and its derivatives are commonly used to enhance post-harvest life of fruits by controlling their firmness. Salicylic acid has been used to enhance flesh firmness of harvested peaches during storage (Wang *et al* 2006) and banana fruits during ripening (Srivastava and Dwivedi 2000). Thus, salicylic acid has incredible ability to sustain the fruits quality during storage. Tareen *et al* (2012) carried out research studies in peach fruits cv. 'Flordaking' at Rawalpindi and reported that maximum fruit flesh firmness was recorded in 2.0 mmol L-1 salicylic acid followed by 1.5 mmol L-1 salicylic acid as compared to control. Advanced firmness in treated fruits might be accredited to the reduced hydrolysis of soluble starch.

2.2.2.2.1.6 Palatability rating

Palatability rating of winter crop of guava fruit cv. Shweta noticeably increased up to 14^{th} day under cold storage. Then it decreased gradually throughout the storage period. It was highest in fruits treated with salicylic acid @ 300 ppm under cold storage. The untreated fruits exhibited initial increase in palatability rating up to 7^{th} day of storage and then decreased considerably throughout the storage period. It was reported that palatability rating decreased stridently as the progression of storage period (Kaur 2016).

Bal *et al* (2010) recorded the highest palatability rating in ber fruits cv. Umran with GA_3 at 25 and 50 ppm packed in CFB boxes and ber fruits retained in 'excellent' condition for 20 days in cold storage.

2.2.2.2.1.8 Physiological loss in weight

Madhav *et al* (2016) studied the effect of salicylic acid @ 1 mM and 2 mM in guava cv. Allahabad Safeda and stored fruits at 10°C for 12 days. They found that fruits treated with SA @ 2 mM concentration exhibited minimum weight loss. Kaur (2016) noticed lowest cumulative mean of physiological loss in weight in winter crop of guava cv. Shweta treated with salicylic acid @ 300 ppm under cold conditions. It was observed that the rate of PLW was reduced in other treatments. Higher concentration of salicylic acid was found to be more effective in reduction of PLW till the storage period.

Hajilou and Fakhimrezaei (2013) applied salicylic acid treatments on apricot 'Asgar-Abad' fruit and stored at 1ºC. They concluded that fresh weight loss and TSS contents were improved by various treatments of salicylic acid.

2.2.2.2.1.9 Fruit spoilage

Guava cv. Allahabad Safeda, dipped in salicylic acid @ 1 mM and 2 mM and stored fruits at 10°C for 12 days, had showed suppressed / postponed the respiration activity and ethylene production (Madhav *et al* 2016). Kaur (2016) reported that winter crop of guava cv. Shweta did not exhibit any signs of spoilage till 7th day of storage in all the treatments including control under cold condition. Least spoilage was reported in salicylic acid treated fruits @ 300 ppm under cold storage. The spoilage was further increased up to 21 days and fruits gave pitiable appearance in almost all the treatments of salicylic acid.

2.2.2.2.2 Bio-chemical Characters of Fruits

2.2.2.2.2.1 Total soluble solids

The delicate nature of peach fruits led to decrease in value and quality of the fruit and it was connected along with rapid loss in soluble solid contents. Salicylic acid treatment considerably maintained higher SSC in a concentration dependent approach. Peach fruits were found to be superior with soluble solid contents (sweet) consumer satisfactoriness (Crisosto *et al* 2003). Mirdehghan and Ghotbi (2014) conducted experiment in pomegranate fruits of cvs. Malas Yazdi and Malas Ashkezar. Fruits were dipped in salicylic acid (1 and 2 mM from source of acytyl salicylic acid) for five minutes. Then, the fruits were kept in cold storage at 1.5 ± 0.5ºC and 85±5% RH for 2 months. They applied SA at 1 mM and found that it increased the TSS compared to untreated fruits. Similar results are reported by Srivastava and Dwivedi (2000) in banana fruits.

2.2.2.2.2.2 Acidity

Kaur (2016) found higher acid content in winter crop of guava cv. Shweta fruits with application of salicylic acid @ 200 ppm under cold storage conditions. The minimum acid content was recorded in untreated fruits.

Mirdehghan and Ghotbi (2014) dipped pomegranate fruits in salicylic acid (1 and 2 mM from source of acytyl salicylic acid) for five minutes and kept in cold storage at 1.5±0.5ºC and 85±5% RH for 2 months. The result showed that total acidity was not influenced by salicylic acid treatment. Similar results have been reported by Ding *et al* (2007) in mango, Ranjbar *et al* (2007) in pomegranate and Biten Court De Souza *et al* (1999) in strawberry fruits, who described that total acids were not affected by SA or MeJA.

2.2.2.2.2.3 Vitamin C

Madhav *et al* (2016) reported in guava cv. Allahabad Safeda that salicylic acid treatment @ 1 mM and 2 mM concentrations, maintained vitamin C content of fruits.

Baninaiem *et al* (2016) reported that vitamin C content in tomato fruits was decreased during storage (10°C for) and it was maintained with post-harvest treatments of salicylic acid. Tomato fruits treated with salicylic acid showed comparatively higher levels of vitamin C than control.

2.2.2.2.2.4 Total sugars

Highest total sugars guava cv. 'Allahabad Safeda' in Punjaband revealed that fruits with in salicylic acid @ 200 ppm which was statistically at par with salicylic acid @ 200 and 100 ppm, respectively. In all the applications, total sugars were highest in salicylic acid @300 ppm treatment on 21st day of cold storage. While, it was lowest on the 21st day of storage in control fruits of winter crop of guava cv. Shweta (Kaur 2016).

Ascorbic acid is very susceptible to degradation in comparison to other nutrients during processing and storage (Akhtar *et al* 2010). Tareen *et al* (2012) carried out research studies in peach fruits and concluded that various treatments affected a gradual change in ascorbic acid level during the entire five weeks storage period. However, 2.0 mmol L-1 salicylic acid treated peach fruits sustained higher ascorbic acid content as compared to control while, rest of the salicylic acid treatments and control continued to be non-significant.

2.2.2.3 Effect of Ascorbic Acid

2.2.2.3.1 Physical Characters of Fruits

2.2.2.3.1.4 Fruit colour

The fruit colour of winter crop of guava cv. Shweta changed slowly as the storage period progressed. Green colour fruits were harvested. All the concentrations of ascorbic acid resulted in delaying the colour degradation. The untreated fruits exhibited fast colour changes in cold storage Kaur (2016).

2.2.2.3.1.5 Fruit firmness

Gill *et al* (2014) studied the effects of post-harvest treatment of ascorbic acid on storage life and quality attributes of winter guava cv. 'Allahabad Safeda' in Punjab. They dipped fruits in ascorbic acid (25, 50, 100 ppm) for 5 minutes and stored in walk-in-cold room and maintained at 6-8 °C and 90-95 per cent RH. It was revealed that fruits treated with the ascorbic acid @100 ppm showed minimum firmness loss after 21 days of cold storage.

Kaur (2016) showed highest mean fruit firmness and total sugars in ber fruits treated with ascorbic acid @ 3 percent. The pedicels were appropriately kept with fruits up to 21 days of storage in cold chamber at 7ºC temperature and 90-95 percent RH.

2.2.2.3.1.6 Palatability rating

Bal (1982) described that the advancement of palatability rating in ber fruits during storage might be due to the development of sugars and acids as a consequence of hydrolysis of starch and other molecules leading to the improvement of flavour in fruits. The increase in organoleptic rating score under cold and ambient condition may be due to slow tempo of biochemical activities resulting from declined transpiration and respiration rate under storage conditions. Gill *et al* (2014) studied the effects of post-harvest treatment of ascorbic acid in winter guava cv. 'Allahabad Safeda' in Punjab and revealed that fruits with application of ascorbic acid @100 ppm retained acceptable organoleptic rating up to 21 days in cold storage.

The palatability rating of ber decreased with progression of storage period when kept in cold chamber at 7ºC temperature and 90-95 per cent RH (Kaur, 2016).

2.2.2.3.1.8 Physiological loss in weight

Weight loss of 5 per cent during storage is the highest permissible limit in case of fruits, above which the fruits exhibit shriveling and happen to unmarketable (Mahajan *et al* 2009). Gill *et al* (2014) concluded that PLW, generally increased during the storage period regardless treatment of ascorbic acid. They observed that ascorbic acid treated fruits of Allahabad Safeda registered the lowest mean PLW. It was the maximum in control fruits. They observed that the average PLW declined significantly by boosting the concentration of ascorbic acid.

Banik *et al* (1988) reported in ber fruits that application of ascorbic acid @ 100 ppm at low temperature storage of 10-12°C and 85-90 per cent RH reduced the physiological loss as compared to control fruits. Kaur (2016) reported in ber fruits that treatment with ascorbic acid @ 2 per cent resulted in least physiological loss in weight. Lowest physiological weight loss was noted after 7 days and highest after 28 days of storage at 7ºC and 90-95 per cent R.H. The PLW was significantly increased with continuation of storage period.

2.2.2.3.1.9 Fruit spoilage

Ascorbic acid guarded the fruits against oxidative damages and biotic stresses (pathogen attack etc.) due to improved antioxidants level that might prevent too much softening and rotting of fruits (Paliyath and Subramanian, 2008). Gill *et al* (2014) reported that ascorbic acid @100 ppm treated guava fruits showed least decay incidence score whereas in control fruits the decay was highest. However, the lesser concentration of ascorbic acid was found at par, yet significantly in lowering decay incidence was recorded by them.

Banik *et al* (1988) and Siddiqui and Gupta (1995) reported least spoilage in ber fruits when ascorbic acid treatment applied along with low temperature storage. Kaur (2016) observed at PAU, Ludhiana that ber fruit spoilage was less in ascorbic acid @ 2 per cent treatment when kept in cold chamber at 7ºC temperature and 90-95 percent RH.

2.2.2.3.2 Bio-chemical Characters of Fruits

2.2.2.3.2.1 Total soluble solids

Gill *et al* (2014) studied the effects of post-harvest treatment of ascorbic acid by dipping treatment for 5 minutes in winter guava cv. 'Allahabad Safeda'. They discovered that fruits treated with ascorbic acid @100 ppm displayed higher TSS after 21 days of cold storage.

Siddiqui and Gupta (1989) revealed that post-harvest dipping in ascorbic acid solution @ 150 and 300 ppm reduced over ripening and increased TSS in ber. Kaur (2016) showed that when ber fruits were dipped in ascorbic acid showed an increase in TSS to 14 days of storage but followed a decrease at later period of storage (kept in cold chamber at 7ºC temperature and 90-95 percent RH). They concluded that Umran ber kept with pedicel could be stored adequately for 21 days in cold chamber (7ºC) without any important effect on their quality. Strawberry (Red Dream and Camarosa varieties) and Raspberry (Nova and Killarney varieties) fruits were harvested in Georgia and dipped into 0 per cent, 1 per cent or 2 per cent ascorbic acid solution at 20 ± 1 °C temperature for 2.5 min. and stored at −40 °C. They concluded that after 3 months storage period that TSS of strawberry and raspberry fruits was decreased by 10–14 per cent in both treated and untreated samples (Turmanidze *et al* 2017).

2.2.2.3.2.2 Acidity

Echeverria and Valich (1989) described that the reduction in acid content of guava fruits with the increase in storage period could be accredited to the use of organic acids in respiratory activities by the cells of the fruit and alteration of acids into total sugars. Guava fruits treated with ascorbic acid retained higher acidity during the storage possibly due to postponed ripening. Similar results also have been reported in guava by Jayachandran *et al* (2005). Gill *et al* (2014) reported that the acid content in the guava fruits followed a decreasing trend throughout the storage (6-8°C and 90-95% RH) period. Treated fruits maintained significantly higher acidity content when ascorbic acid was applied. Untreated fruits showed minimum mean acidity. The decrease in the acid content of the fruit was more rapid in the untreated guava fruits whereas treated fruits registered a regular fall in acidity level.

Siddiqui and Gupta (1989) concluded that post-harvest dipping in ascorbic acid solution @ 150 and 300 ppm had no effect on acidity of ber fruits. Further, Siddiqui and Gupta (1995) reported that the acid content of ber fruits stored at room temperature (25±5°C) was not affected by ascorbic acid (300 ppm).

2.2.2.3.2.3 Vitamin C

The decline in ascorbic acid during storage might be due to conversion of ascorbic acid to dehydroascorbic acid or due to action of ascorbic acid oxidase (Mapson 1970). Gill *et al* (2014) found that ascorbic acid content was declined during the storage in fruits of winter guava cv. 'Allahabad Safeda'. They observed that ascorbic acid @100 ppm treated fruits exhibited maximum ascorbic acid content. It was recorded that vitamin C content of guava fruits declined significantly in all the treatments of ascorbic acid with the advancement of the cold storage period condition. Highest vitamin C content was observed in fruits treated with ascorbic acid @ 2.0 percent under cold storage conditions. Untreated fruits revealed least level of vitamin C under such conditions (Kaur 2016).

It was reported that post-harvest dipping in ascorbic acid solution @ 150 and 300 ppm had no effect on ascorbic acid during storage of ber (Siddiqui and Gupta 1989). Kaur (2016) reported that when ber fruits were dipped in ascorbic acid, showed an increase in total sugars up to 14 days of storage (7ºC temperature and 90-95 percent R.H.) but followed a decrease at later period of storage. It was concluded that Umran ber kept with pedicel could be stored adequately for 21 days in cold chamber (7ºC) without any important effect on their quality. Higher retention of vitamin C was observed in fruits of ber with ascorbic acid treatment. Mirdehghan and Ghotbi (2014) reported that treatment of pomegranate fruits with 2 mM salicylic acid had the lowest ascorbic acid although difference between other treatments and the untreated fruits was not important.

2.2.2.3.2.4 Total sugars

When ber fruits were dipped in ascorbic acid, an increase was recorded in total sugars up to 14 days of storage but followed a decrease at later period of storage (kept in cold chamber at 7ºC temperature and 90-95 per cent R.H.). It was concluded that Umran ber kept with pedicel could be stored adequately for 21 days in cold chamber (7ºC) without any important effect on fruit quality (Kaur 2016).

2.3 Ripening Studies in Winter Guava under Ambient Conditions

Ethylene, a plant growth hormone (PGR), which regulates several aspects of fruit development and cell metabolism like initiation of ripening cum senescence, principally in climacteric fruits. Ethrel (2-chloro ethyl phosphonic acid) degrades itself to produce ethylene and this gaseous hormone, has been proved to affect the ripening of fruits (Prasanna *et al* 2007). Ethylene released from ethrel was more effective in causing fruit ripening than dipping guava fruits in aqueous solution of ethrel. Depending on concentration, ripening was 2-6 days earlier in fruits, immersed in aqueous solutions of ethrel and 6-9 days earlier in fruits treated with ethylene released from ethrel, compared with untreated fruits of guava (Nour and Goukh 2010). Similar results regarding ethylene gas in banana were observed by several research workers (Russo *et al* 1968).

2.3.1 Ambient Studies

2.3.1.1 Effect of Ethephon

2.3.1.1.1 Physical Characters of Fruits

2.3.1.1.1.4 Fruit colour

Reyes and Paull (1995) treated guava fruits cv. Beaumont with 100 µl l^{-1} ethylene (C_2H_4) at 20 °C for 24 h and revealed that a significant increase happened in the rate of skin yellowness. Ethrel and ethylene treatments enhanced colour development at Al-Kadaro, Khartoum North in guava fruit. Fruits dipped in aqueous solution of ethrel @250, 500 and 1000 ppm and reached full yellow stage 3, 4 and 6 days earlier than the untreated guava fruits (Nour 2007). Nour and Goukh (2010) revealed that guava fruit peel color score gradually increased during ripening. Ethrel treatments improved color development in guava. Guava fruits dipped in ethrel @ 250, 500 and 1000 ppm reached the full yellow stage 3, 4 and 6 days earlier. Ethrel and ethylene applications/treatments enhanced color development in both fruit types (White- and pink-fleshed guava).

Gill and Bal (2010) worked on application of ethephon in winter season crop of Sardar guava at under Hoshiarpur conditions and concluded that colour development was enhanced by ethephon treatments@ 300, 400 and 500 ppm. Gill *et al* (2016) conducted research studies to improve ripening quality of winter crop of Sardar guava. Trees were sprayed with ethephon @ 300, 400 and 500 ppm. It was recorded that colour development was greatly improved by applications of ethephon. Brar *et al* (2012) revealed that the colour of rainy season fruits of guava cv. Allahabad Safeda was found to be enhanced with ethephon @ 500 and 1000 ppm applications i.e. yellow green (Y 144 C) and yellow (Y 12 C), in that order.

Mohamed *et al* (2016) carried out research studies to evaluate the effect of ethrel on guava fruits. They revealed that that ethrel treatment significantly improved skin colour advancement in the fruit. It was proved in Allahabad Safeda guava at Allahabad that L, a, b parameters (L-value-lightness, a-value-redness and greenness and b-value-yellowness and blueness) were considerably affected by the time and temperature of the blanching procedure. The normalized lightness L (n) values were advanced than that of the control (Parimita *et al*2016).

It was reported that ethephon @ 400 ppm resulted in the highest TSS content in ber fruit and also improved the fruit colour, golden yellow in cv. Umran (Masalkar and Wavhal 1991). Bal *et al* (1992) conducted research work at PAU on papaya cvs. CO_1 and CO_2 and concluded that papaya fruits attained colour development after 4 days of application with ethephon @ 500 and 600 ppm. Jayawickrama *et al* (2001) revealed that recorded sensory assessment scores recorded for colour, aroma, and taste and over all acceptability were considerably higher in ethrel treated fruits of papaya as compared to control. Bal (2006) concluded that highest rating regarding taste of ber fruits and flavor could be obtained with ethephon @ 400 and 500 ppm in polythene bags. The palatability rating of fruits stored in polythene bags was significantly better than those kept in paper bag. Singh *et al* (2012) conducted research studies at Lucknow on papaya cv. Pusa Delicious and found that ethrel treatments had considerably affected the sensory assessment scores for flesh colour, flavour, texture, and aroma and over all satisfactoriness scores. The colour development in papaya fruits was outstandingly influenced by post-harvest ethrel treatment. Ethrel @1500 ppm gave the most appealing and deep coloured papaya fruits.

2.3.1.1.1.5 Fruit firmness

Reyes and Paull (1995) treated guava fruit with 100 µl l^{-1} ethylene (C_2H_4) at 20 °C for 24 hr and revealed the softening of immature-green fruit. Singh *et al* (1996) concluded that ethephon @1800 ppm resulted in better firmness and higher organoleptic quality in crop of guava. Guava fruits with ethrel application in aqueous solution had reached the soft stage 2-6 days prior, while those treated with ethylene released from ethrel had reached final soft stage 6-9 days earlier, compared to the untreated ones (Nour 2007).

Nour and Goukh (2010) reported the effect on flesh firmness in guava fruit and revealed that flesh firmness of the two guava types had exhibited a progressive decline during ripening with ethrel. The decline in flesh firmness was recorded in untreated guava fruits and it was about 15-folds, from the hard mature-green stage to the final soft ripe stage. This was reached in 16 days in both guava types. Mohamed *et al* (2016) found that ethrel treatment resulted a decrease in guava fruit firmness in both seasons under Sudan conditions. The softening of guava fruit cv. Sardar with ethrel may be explained through its action on cell wall hydrolysis and changes in complex materials to simpler ones, which occurred during ripening due to ethylene (Jain and Dashora 2011).

Ethylene (100 µl L-1) was applied to loquat fruits to study the effect on fruit quality and stored at 0°C and 20°C and It was observed that ethylene treatment enhanced the post-harvest firmness significantly (Cai *et al* 2006). Hazarika *et al* (2016) reported that ethrel @ 400 ppm reduced the fruit pressure in papaya cv. Red Lady, which is an index of fruit hardness or softness. Praveena (2011) found that sapota cv. Kalipatti fruits treated with ethrel had lower firmness (kg/cm^2) compared to the fruits stored under ambient and low temperature.

2.3.1.1.1.6 Palatability rating

Yadav *et al* (2001) recorded highest palatability rating of guava cv. L-49 fruits with ethrel @1000 ppm. Singh and Bal (2006) reported that palatability was maximum in treatment of ethephon @1000 ppm in guava cv. Allahabad Safeda. Gill and Bal (2010) carried out an experiment to improve quality of winter Sardar guava at PAU, Ludhiana. They subjected trees to ethephon spray (300, 400 and 500 ppm) and recorded that palatability rating was improved along with TSS, total sugars and vitamin C. Brar *et al* (2012) concluded in guava cv. Allahabad Safeda that application of ethephon @ 1000 ppm resulted in highest palatability and closely followed by ethephon @ 500 ppm while palatability rating was at its lowest in control fruits. Mohamed *et al* (2016) found under Sudan conditions that ethrel treatment resulted an increase in fruit taste of guava.

Bal *et al* (1990) applied ethephon @ 300, 400 or 500 to ber cv. Umran, at colour break stage of fruit development and observed highest organoleptic rating with higher concentration of ethephon. Olaeta and Undurraga (2003) applied ethephon at early stage in loquat cv. 'Golden Nugget' and revealed that it did not affect the sweetness of the fruit. Bal (2006) found in ber trees cv. Umran that taste and flavour of the pre-harvest growth regulators treated ber fruits were considerably better than the untreated fruits after 10 days of keeping in storage. The considerably high rating was noted with ethephon @ 400,500 ppm in polythene bags. Hazarika *et al* (2016) recorded in sapota that application of ethrel @ 400 ppm resulted in fruits with higher organoleptic score compared to other treatments. The maximum organoleptic score in ethrel treated plants may be because ethrel, as a ripening hormone, increased the sugar: acid ratio. Bal *et al* (1992) concluded that highest palatability rating in papaya cvs. CO_1 and CO_2 could be obtained in the fruits treated with ethephon @ 500 ppm.

2.3.1.1.1.8 Physiological loss in weight

Studies conducted at Pantnagar in guava fruit cv. Sardar showed that fruit trees sprayed with ethephon @200, 400, 600, 800 and 1000 ppm and stored at ambient conditions (21°C) showed overall lowest weight loss of the fruit with ethephon treatment @400 ppm. It was concluded that higher concentration of ethephon resulted in higher weight loss in guava fruits (Singh *et al*1994). Mahajan *et al* (2004) recorded the effect of ethephon on guava fruit var. Allahabad Safeda at PAU, Ludhiana. Uniform, hard green fruits of guava were dipped in ethrel for 5 minutes then packed in corrugated fiber board cartons and stored at ambient conditions (14-16° C and 65-70% RH). They concluded that ethephon @ 500 ppm resulted into minimum weight loss of the fruit and it was closely followed by ethephon @1000 ppm in 2 to 6 days of storage. Nour and Goukh, (2010) concluded in white and pink- fleshed guava that fruits treated with ethylene @ 250 ppm were similar to those dipped in aqueous solution of ethrel @ 1000 ppm.

The fruits of full grown ber trees were sprayed with ethephon @ 300, 400, 500 ppm. The fruits from all the treatments were packed in paper and 100-gauge thick polythene bags and stored room temperature (22-28°C). Minimum spoilage was noted in ethephon @300-500 ppm in paper bags (Bal 2006). Singh *et al* (2012) concluded in papaya cv. Pusa Delicious at Lucknow that the physiological loss in weight of fruit was notably enhanced with the increase in ethrel concentrations. The highest weight loss was noted in ethrel @1500 ppm whereas lowest in control. Similar type of decrease in fruit weight during storage was also recorded by Gupta *et al* (1983) in citrus fruits by dipped in 250-500 ppm ethrel for 5 minutes.

2.3.1.1.1.9 Fruit spoilage

Mahajan *et al* (2004) concluded that dipping of guava in ethephon @1000 ppm resulted into minimum spoilage of the fruit under ambient storage conditions and it was closely followed by ethephon @ 500 ppm 4 to 6 days of storage while fruit spoilage was nil up to 2 days of storage. Nour and Goukh (2010) concluded that guava fruits treated with ethylene @ 250 ppm were similar to those dipped in aqueous solution of ethrel @ 1000 ppm.

Ismail *et al* (2010) reported that various treatments including hot water treatment gave a longer storage life than control, since occurrence of decayed fruits were about 7-8 per cent for the control fruits stored in 20°C for 15 days. Chlorflurenol methyl ester 74050 (chlorflurecol) @ 10-1000 ppm applied to guava cv. Allahabad Safeda as a post-harvest treatment and it resulted into prevention of fungal decay of the fruit. Advanced concentrations of the morphactin, >200 ppm, injured the soft skin of the fruit. 100 ppm was the most effective concentration in retaining the market value of the fruits by retarding various harmful physiological, textural and biochemical changes (Gupta and Mukherjee 1980). Dipping of guava fruit in hot water (46^0 C) for 35 minutes resulted into increased fruit decay in storage (McGuire 1997).

Minimum spoilage in ber fruit was resulted in ethephon @300-500 ppm in paper bag (Bal 2006).Ber fruits trees were sprayed with pre-harvest application of ethephon @ 300, 400, 500 ppm and with other chemicals each during first week of March. The fruits were harvested at maturity (mid-March) and stored at ambient conditions (22-28°C). Praveena (2011) reported at that sapota cv. Kalipatti fruits treated with ethrel had higher ripening and spoilage.

2.3.1.1.2 Bio-chemical Character of Fruits

2.3.1.1.2.1 Total soluble solids

Biswas *et al* (1988) sprayed guava cultivar L-49' with different growth substances, 30 days after fruit set in both rainy and spring seasons. They recorded that application of ethrel @ 0.125 or 0.250 ml/liter resulted in higher TSS content in both seasons. Reyes and Paull (1995) treated guava fruit tree cv. Beaumont with 100 µl l^{-1} ethylene (C_2H_4) at 20 °C for 24 h and revealed that total soluble solids of fruit at mature-green and later stages were not considerably affected. Gill and Bal, (2010) found while working on winter season crop of Sardar guava that highest TSS with ethephon @ 400 ppm treatment. Jain and Dashora (2010) studied at Rajasthan that highest TSS and minimum acidity of guava fruits can be obtained with 500 ppm ethrel treatment. Nour and Goukh (2010) studied the effect of ethrel on TSS of guava fruit that ethrel treatments increased TSS in the both guava types (white and pink-fleshed guava). Maximum TSS value reached after 16 days in both types. Fruits dipped in ethrel @ 250, 500 and 1000 ppm, showed the maximum TSS value 2, 4 and 6 days earlier than the untreated fruits, respectively.

Brar *et al* (2012) found that guava fruits cv. Allahabad Safeda in winter season resulted in maximum TSS with ethephon @1000 ppm followed by ethephon @ 500 ppm treated plants. The fruits collected from control plants exhibits lowest TSS. Highest TSS with 0.2 % boron + ethrel 1000 ppm was recorded which was at par with the 0.2 % boron + ethrel @ 750 ppm and 0.2 % boron + ethrel 500 ppm (Rajput *et al* 2015). Mohamed *et al* (2016) carried out research on mature-green fruits of guava and treated them with ethrel. It was concluded that ethrel treatment were significantly accelerated total soluble solids in the fruits. Similar results were proved at Jorhat, in guava cv. Allahabad Safeda that ethrel treatment @ 50 and 100 ppm resulted in increase of TSS and was concluded that ethrel @ 50 ppm was much effective than 100ppm (Lal and Das 2017).

Chauhan and Gupta (1985) found that pre-harvest spraying of ber cv. Umran fruits with ethephon resulted in increased TSS. Singh *et al* (1986) observed that spraying of ethrel @ 1000 ppm during pre-harvest stage improved the total soluble solids content (TSS) of phalsa fruits. Ethrel @ 400 ppm was sprayed in ber cv. Umran and reported an increase in TSS content of the fruit (Sandhu *et al* 1989). Bal *et al* (1992) found that ethephon @ 300, 400 or 500 in ber fruits resulted in increased T.S.S. Rema and Sharma (1993) proved that spraying of ethrel @240 ppm and @500 ppm during full bloom stage improved the total soluble solids over control in phalsa fruit. Panwar *et al* (1994) concluded that spraying of ethrel @ 500 ppm at the version stage resulted in higher TSS in berries of Beauty Seedless grapes.

Abbas *et al* (1994) conducted experiment to reveal the effect of ethephon on Jujube fruits of cv. Zaytoni. They dipped ber fruits with ethephon solutions @ 0, 250, 500, 1000 or 1500 ppm. It was established that ethephon @ 500 ppm resulted in increased total soluble solids. Singh *et al* (1986) observed that pre-harvest spraying of ethephon at 500 ppm improved the total soluble solids in phalsa. The reduced T.S.S. content at later on storage might be due to collapse of substrate of conversion i.e. starch (Leopold 1964). It was reported that ethrel @ 200 ppm sprayed after fruit set was more effectual in increasing TSS and least was in control of mango fruit cv. Langra (Koruna *et al* 2007). Debnath (2010) described that ethrel @ 500 ppm resulted in maximum total soluble solids content and minimum in control in phalsa fruits.

The increase in total soluble solids of papaya fruit cv. Red Lady may be the result of a higher buildup of metabolites and a quick alteration of starch into soluble sugars during sapota fruit development in response to plant growth regulators (Agrawal and Dikshit 2010). Kumar and Singh (1993) accessed the effect of ethrel on ripening and quality of mango fruit cv. Amrapali and reported that pre-harvest sprays of ethrel enhanced fruit quality in terms of total soluble solid content. Kacha *et al* (2014) carried reported that total soluble solids in phalsa fruit were significantly increased with treatment of ethrel @ 1000 ppm followed by ethrel 750 ppm. Similar results with regard to TSS were recorded by Singh and Chundawat (1978) in grape and Sandhu *et al* (1990) in ber.

2.3.1.1.2.2 Acidity

The highest decrease in acid content of guava fruits was observed under urea + ethrel treatment by Pandey *et al* (1988).Reyes and Paull (1995) treated guava fruits with 100 µl l−1 ethylene (C_2H_4) at 20 °C for 24 hr and revealed that titratable acidity was not significantly affected in this treatment. Yadav *et al* (2001) reported that there were no significant effects of ethrel on the acidity of guava fruits. It was reported that ethephon spray affected the acidity of the fruit and the acidity was significantly decreased by higher dose of ethephon during both rainy and winter season fruits of guava cv. Sardar (Suleman *et al* 2006). Rajput (2008) revealed acidity in guava cv. L-49 was significantly higher in combination of treatment boron @ 0.2% and ethrel @ 500/ 750 ppm. Brar *et al* (2012) recorded that acid content in guava cv. Allahabad Safeda was highest in plants kept as control in both rainy and winter season crops. The plants sprayed with ethephon @1000 ppm in winter season showed lowest acid content.

Nour (2007) showed in guava that ripening was improved with ethrel. The developing rate gradually augmented with the increase in concentration. Ethylene released from ethrel was effective in starting ripening of the fruit than dipping fruits in aqueous solution of ethrel. This effect on fruit ripening was specified by improved climacteric peak of respiration increased fruit surface colour, increased TSS and declined flesh firmness. Ethrel treatment @ 50 and 100 ppm decreased the titrable acidity (%) of Allahabad Safeda guava fruit. Both doses of tried ethrel were effective in lowering the acidity of guava (Lal and Das 2017). The reduction in titratable acidity with ethrel may be due to its action by fast conversion of organic acids and their derivatives through higher respiration and carbon assimilation activity during rapid ripening process in guava (Yadav *et al* 2001).

Baskran and Sathiamurty (2008) reported that spraying of ethrel @ 350 ppm twice before flowering stage increased acidity over control in papaya. Panwar *et al* (1994) found that spraying of ethrel @ 500 ppm at the veraison stage reduced acidity while acidity was recorded higher in control in ripe berries of Beauty Seedless grapes. Chauhan and Gupta (1985) observed that pre-harvest spraying with ethephon in case of ber cv. Umran fruits resulted in decreased acidity. Rema and Sharma (1993) discovered that the spraying of ethrel @ 960 and @1920 ppm before harvest decreased the acidity and spraying of ethrel @ 240 ppm and @ 480 ppm twice at full bloom stage improved the acidity and while it was higher in control in phalsa.Abbas *et al* (1994) treated (dipped) ber fruits cv. Zaytoni in ethephon solutions @ 0, 250, 500, 1000 or 1500 ppm and found that ethephon @ 500 ppm resulted in decrease of tiratable acids in ber fruits and ripening was advanced by 6 days compared to controls. Similar observations were also noted in guava (Singh *et al* 1979).

Olaeta and Undurraga (2003) reported that ethephon affected loquat fruit acidity as ethylene acts on enzyme activity and controlling the expression of mRNA that promote ripening of ‘Golden Nugget' loquat. They noted no effect of ethephon on titratable acidity at later stages of development of Golden Nugget' loquat under Central Chile conditions. Riberau-Gayon (1968) concluded that conversion of organic acids into sugars was one of the causes for declining organic acids during ripening. Another alternative seemed that ethrel might augment the conversion of organic acids to sugars (Singh *et al* 2012). Debnath (2010) found in phalsa that ethrel @ 500 ppm resulted in minimum titratable acidity of the fruit. Hazarika *et al* (2016) observed that application of ethrel @ 400 ppm resulted in lowest titrable acidity in papaya fruit cv. Red Lady.

In Iran, Shaybany and Sharifi (1973) accessed the effect of ethrel @1500 and @2000 ppm 18 days before harvest in Rabbab pomegranate and noticed reduced TSS: acidity ratio with increase in concentration of ethrel from 0 to 2000 ppm. Ghazi *et al* (1979) reported that ethephon spray at 100, 250 and 500 ppm concentration at version stage in Thompson Seedless grape showed lower acidity. Singh and Singh (1981) described that two ethrel sprays @ 250 ppm concentration decreased incidence of granulation in Kaula mandarin along with reduction in total acidity. Singla *et al* (1992) examined the effect of ethephon on grape cultivars @ 250, 500, 750 and 1000 ppm concentration and recorded that 750-ppm followed by 1000 ppm concentration was most effectual for advancing the ripening process by 7 and 9 days in cvs. Champion and Thompson Seedless, respectively. Further, they also observed noteworthy improvement in acidity and TSS.

2.3.1.1.2.3 Vitamin C

Rajput (2008) revealed that foliar application of Boron + Ethrel on guava cv. L-49 at FRS Junagadh resulted in marked increase of vitamin content of vitamin C (Boron@ 0.2% and Ethrel @ 500/ 750 ppm). Gill and Bal (2010) studied the influence of the application of $KNO_{3,}$ SADH and ethephon in winter season crop of Sardar guava at KVK, Hoshiarpur and described the advancement of vitamin C with application of ethephon @ 400 ppm treatment. Brar *et al* (2012) revealed that ethephon treatments improved the vitamin C content in guava cv. Allahabad Safeda fruits. Maximum content of vitamin C was recorded in guava fruit obtained from trees with ethephon @1000 ppm application and it was followed by ethephon @ 500 ppm treatment.

Mohamed *et al* (2016) found that ethrel treatment resulted an increase in vitamin C content of guava fruit. Lal and Das (2017) carried out research in guava cv. Allahabad Safeda at Jorhat and revealed that ethrel treatment @ 50 and 100 ppm increased ascorbic acid (mg/100g) of the guava fruit. They explained that both doses of tried ethrel (50 ppm and 100 ppm) were effective in increasing ascorbic acid of guava.

Singh *et al* (2012) conducted studies on papaya cv. Pusa Delicious and revealed that the ascorbic acid improved considerably up to 6 days of storage for all the treatment (except ethephon @1500 ppm) and reduced thereafter but the highest ascorbic acid content was recorded in ethephon @1500 ppm. The papaya fruits during storage showed a decreasing trend in ascorbic acid notably irrespective of the applications but the value was inclined with equivalent increase in concentration of ethrel. Bal *et al* (1992) found in papaya cvs. CO_1 and CO_2 that vitamin C content could be improved by concentration of ethephon and higher values were recorded with treatment of ethephon 600 ppm in both the cultivars. Praveena (2011) observed that sapota cv. Kalipatti fruits treated with ethrel had higher ascorbic acid content and higher TSS. Shaybany and Sharifi (1973) accessed the effect of ethrel @1500 and @ 2000 ppm 18 days before harvest in Rabbab pomegranate in Iran and noticed reduced vitamin 'C with increase in concentration of ethrel from 0 to 2000 ppm. Singh and Singh (1981) described that two ethrel sprays @ 250 ppm concentration decreased incidence of granulation in Kaula mandarin and increase in ascorbic acid. Bal *et al* (1990) found that ethephon @ 300, 400 or 500 in ber fruits resulted in increased total phenolic and vitamin 'C' content.

2.3.1.1.2.4 Total sugars

Biswas *et al* (1988) observed in guava fruit cv. L-49 that application of ethrel @ 0.125b or 0.250 ml/liter after 30 days of fruit set in both spring and rainy season conditions, resulted in higher sugar content of the fruits. Yadav *et al* (2001) applied ethrel @ 50, 75 and 100 ppm, to guava tree and discovered that total sugar had increased considerably in the fruit. Rajput (2008) conducted research studies on guava cv. L-49 at JAU and revealed that marked increase in total sugars content of the fruit of guava could be recorded in ethrel only. It was proved at Udaipur (Rajasthan) that ethrel @ 500 ppm treatment resulted in highest total sugars and reducing sugars, non-reducing sugars in guava cv. Sardar (Jain and Dashora 2010).

Rajput *et al* (2015) recorded highest total sugar in the 0.2 % boron + ethrel 1000 ppm, which was at par with the 0.2 % boron + ethrel 750 ppm and 0.2 % + ethrel 500 ppm. The influence of the application of KNO_3, SADH and ethephon in winter season crop of Sardar guava was studied at KVK Hoshiarpur and highest TSS was recorded with application ethephon@ 400 ppm treatment (Gill and Bal 2010). Lal and Das (2017) at Jorhat revealed that ethrel treatment @ 50 and 100 ppm increased total sugar (%) of the guava fruit cv. Allahabad Safeda.

Bal *et al* (1992) revealed in ber cv. Umran that sugars were greatly increased with ethephon applications and highest contents were recorded with 500 ppm ethephon.

Gaidi and Bohra (2003) found that ethephon trea vtment @ 960 ml ethephon/liter (73.009 mg/g fwt.) in ber resulted in the highest total sugar content of the fruit. The fruits of ber cv. Umran fruit were sprayed with ethephon @ 300, 400, 500 ppm. The fruits from all the treatments were packed in paper and 100-gauge thick polythene bags and stored room temperature (22-28°C) and highest total sugars were reported in ethephon 500 and 400 ppm

(Bal 2006). Singh *et al* (2012) reported that in papaya cv. Pusa Delicious total sugars increased with increasing ethrel dose. Maximum total sugar was recorded in ethephon @1500 ppm treated fruits. Sugar content increased up to 6 days after storage and decreased there after excepting in ethrel @ 1500 ppm treated fruits where the value declined on 6 days of storage. Ethrel improved the rate of accumulation of sugar in fruits. Similar findings were reported by Kumar and Singh (1993) who recorded that higher per cent of sugar in ethrel @ (750 and 500 ppm) treated mango fruits over control.

Debnath (2010) proved in phalsa at Rajendra Nagar that ethrel @ 500 ppm resulted in maximum reducing sugars, pulp weight pulp to stone ratio and TSS to acid ratio. Bal *et al* (1992) found in their research studies on papaya cvs. CO_1 and CO_2 that highest palatability rating total sugars were obtained in the fruits treated with 500 ppm of ethephon in both the cultivars. Praveena (2011) concluded that sapota cv. Kalipatti fruits treated with ethrel had higher sugars content. Kacha *et al* (2014) reported that reducing sugars were considerably increased by application of ethrel @ 1000 ppm followed by ethrel 750 ppm. Similar results are reported by Sandhu *et al* (1989) in ber, who recorded that ethrel @ 400 ppm was found most effective in increasing the reducing sugars content in Umran ber. It might be happened due to the ethrel encouraged hydrolysis of starch into sugars. Singh and Singh (1981) reported that two ethrel sprays @ 250 ppm concentration in Kaula mandarin increased in total sugars, reducing sugars and non-reducing sugars distinctly compared to control. Singla *et al* (1992) examined the effect of ethephon on grape cultivars @ 250 ppm, 500 ppm, 750 ppm and 1000 ppm concentration and observed noteworthy improvement in sugar content.

Chapter III

MATERIALS AND METHODS

The present investigations on the "Effect of pre- and post-harvest treatments on ripening and storage life of winter season guava (*Psidium guajava* L.) cv. Allahabad Safeda" were conducted in guava orchard of progressive farmer under Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara during the year 2015-16 and 2016-17.

Plant and Fruit Material

The fruits of guava cv. Allahabad Safeda were sprayed with naphthalene acetic acid (NAA), salicylic acid (SA) and ascorbic acid (AA), twice (firstly- in the first week of November at colour break stage and second at 15th November of each year). After attaining uniform colour and size (as for as possible), the fruits were harvested, and were analyzed after their storage at ambient and cold store (4-6^{o}C).

Fruits for Experiment No.1 were taken as under.

Treatments =10

Replications = 3

Storage types = 2

Intervals =4

Fruits taken / tree = 6

Total no. of fruits =10 x 3 x 2 x 4 x 6= **1440**

Fruits for Experiment No.2 were taken as under.

Treatments =10

Replications = 3

Storage types = 2

Intervals = 3

Fruits taken / tree = 6

Fruit for 0 days= 36

Total no. of fruits =10 x 3 x 2 x 3 x 6 +36= **1116**

Fruits for Experiment No. 3 were taken as under.

Treatments = 4

Replications = 3

Intervals = 4

Fruits taken / tree = 6

Total no. of fruits= 4 x 3 x 4 x 6 = **288**

Total requirement of fruits =1440 +1116 +288= 2844

Treatments

Growth Regulators: Naphthalene acetic acid (NAA@100 ppm, 200 ppm and 300 ppm) and salicylic acid (SA@100 ppm, 200 ppm and 300 ppm) were sprayed in present studies.

Antioxidant: To prevent the oxidation, ascorbic acid was used at three concentrations i.e. @75ppm, 150 ppm and 300 ppm.

Ripening Hormone: To encourage ripening ethrel was sprayed @ 250 ppm, 500 ppm, 750 ppm and 1000 ppm.

Methodology

Physical characters like fruit weight, fruit colour, specific gravity, palatability rating score, seed weight and chemical characters like total soluble solids, acidity, vitamin C and total sugars were recorded as per standard methods of A.O.A.C (2010).

Location and Place of Work

These investigations were carried out in Department of Horticulture, SAGR, Lovely Professional University, Phagwara during the year 2015-16 and 2016-17. The orchard for study was selected of guava cv. Allahabad Safeda of progressive farmer.

Studies were carried out by conducting three different experiments-

Experiment 3.1: Pre-harvest applications of Chemicals on Shelf Life of Winter Guava

Pre-harvest sprays of naphthalene acetic acid, salicylic acid and ascorbic acid were given at below mentioned stage.

A. First spray was given four weeks before harvest.

B. Second spray was superimposed on the same tree two weeks before harvest.

For spraying at desired concentration motorized spray pump was used. The control trees were sprayed with water. The fruits were harvested after 15 days of second spray. The fruit samples were taken separately in two lots. The fruits of lot no.1 were meant for ambient studies and of lot no. 2 for cold storage studies. They were placed in CFB boxes (4 kg capacity). The details of different treatments are given below-

Treatment No.	Name of the Chemical	Concentration
T_1	Naphthalene acetic acid	100 ppm
T_2	Naphthalene acetic acid	200 ppm
T_3	Naphthalene acetic acid	300 ppm
T_4	Salicylic acid	100 ppm

T_5	Salicylic acid	200 ppm
T_6	Salicylic acid	300 ppm
T_7	Ascorbic acid	75 ppm
T_8	Ascorbic acid	150 ppm
T_9	Ascorbic acid	300 ppm
T_{10}	Control	

Storage Type

The fruits were stored at ambient and cold storage (4-6^{o}C and RH 85-90%).

Storage Period

The treated fruits packed in Corrugated Fiber Board boxes (CFB) were kept at ambient storage studies in research laboratory and Cold Storage for cold storage studies. The fruits were analyzed for physico-chemical properties after three days interval viz. 0, 3, 6 and 9 days in ambient storage and seven days interval viz. 0, 7, 14 and 21 days in cold storage.

Observations Recorded

3.1.1 Ambient Storage Studies

3.1.1.1 Effect of Naphthalene Acetic Acid (NAA)

3.1.1.1.1 Physical Characters of Fruits

3.1.1.1.1.1 Fruit size

The fruit size (cm) in terms of length and diameter were recorded with Vernier Caliper.

3.1.1.1.1.2 Fruit weight

Fruit weight was observed with the help of weighing balance and unit for taking observations, was grams.

3.1.1.1.1.3 Specific gravity

The weight of randomly selected fruits was recorded. These fruits were placed in a glass jar full of water and the volume of replaced water was measured with the help of measuring cylinder. The specific gravity was calculated as per the formula given below.

$$\text{Specific gravity} = \frac{\text{Total weight of fruit}}{\text{Total volume of replaced water by fruits}} \times 100$$

3.1.1.1.1.4 Fruit colour

The skin colour of guava fruits was recorded by matching the fruits with Royal Horticultural Colour Chart (Wilson 1938).

3.1.1.1.1.5 Fruit firmness

The fruit firmness was noted with the help of Pressure Tester 'Penetrometer' after removing skin. It was recorded in units of lbs/cm^2.

3.1.1.1.1.6 Palatability rating

The slices of guava fruit were removed and tasted by a panel of five judges. The parameters were taste, flavor (10 marks) and general appearance (10 marks). Palatability rating score was worked out as under-

16-20	-	Excellent
14-16	-	Very Good
12-14	-	Good
10-12	-	Fair
Below 10	-	Poor

3.1.1.1.1.7 Seed weight

After seed extraction, they were washed and weighed with digital weighing balance. The unit in this case was grams.

3.1.1.1.2 Bio-chemical Characters of the Fruits

3.1.1.1.2.1 Total soluble solids

Total soluble solids of the fruit were determined by using a hand refractometer (0-30 % range). A droplet of fruit juice was placed on the prism of the refractometer and percent TSS was noted directly. The values were adjusted at 20^0C (A.O.A.C. 2010).

3.1.1.1.2.2 Acidity

The acidity was determined by diluting the known volume of juice with distilled water and titrating it against standard 0.1N NaOH solution using phenolphthalein as an indicator until faint pink colour appeared. The results were expressed in terms of percent acidity of the fruit juice in citric acid (A.O.A.C. 2010) by using the following formula-

$$\text{Acidity (\%)} = \frac{0.0064 \times \text{Volume of 0.1N (ml) NaOH}}{\text{Volume of the juice taken (ml)}} \times 100$$

(1 ml of N NaOH=0.0064 g of citric acid)

3.1.1.1.2.3 Vitamin C

Ten gm finely chopped fruit flesh was macerated in pestle and mortar containing 10 ml of 3 percent metaphosphoric acid. The final content was transformed into 100ml volumetric flask and final volume was made by adding metaphosphoric acid solution. Aliquots of the filtrate (5 ml) were titrated against 2, 6, dicholorophenol indophenol dye to light pink end point which persisted for 15-20 seconds (A.O.A.C. 2010). The results were expressed as ascorbic acid mg/100g of the fruit pulp.

3.1.1.1.2.4 Total sugars

Ten ml of juice was taken in conical flask. One-gram lead acetate was added to it as external material. One gm potassium oxalate was added to remove excess lead from juice. The hydrolysis was done with HCl to convert non-reducing sugars to reducing sugars. It was then neutralized for excess acid with 40 % NaOH (0.1 N was used at final neutralization). Prepared aliquot was used for recording total sugars by titrating it against the standard Fehling solution using methylene blue indicator. The end point was noted when colour was changed to brick red. The percent total sugars were deliberated by using the following formula-

$$\text{Total sugars (\%)} = \frac{\text{Fehling factor (0.05)}}{\text{Volume of filtrate used}} \times \frac{\text{Dilution made - I}}{\text{Volume of juice taken}} \times \frac{\text{Dilution made - I}}{\text{Volume of aliquot taken}}$$

3.1.1.2 Effect of Salicylic Acid (SA)

3.1.1.2.1 Physical Characters of Fruits

3.1.1.2.1.1 Fruit size

3.1.1.2.1.2 Fruit weight

3.1.1.2.1.3 Specific gravity

3.1.1.2.1.4 Fruit colour

3.1.1.2.1.5 Fruit firmness

3.1.1.2.1.6 Palatability rating

3.1.1.2.1.7 Seed weight

3.1.1.2.2 Bio-chemical Characters of Fruits

3.1.1.2.2.1 Total soluble solids

3.1.1.2.2.2 Acidity

3.1.1.2.2.3 Vitamin C

3.1.1.2.2.4 Total sugars

3.1.1.3 Effect of Ascorbic Acid (AA)

3.1.1.3.1 Physical Characters of Fruits

3.1.1.3.1.1 Fruit size

3.1.1.3.1.2 Fruit weight

3.1.1.3.1.3 Specific gravity

3.1.1.3.1.4 Fruit colour

3.1.1.3.1.5 Fruit firmness

3.1.1.3.1.6 Palatability rating

3.1.1.3.1.7 Seed weight

3.1.1.3.2 Bio-chemical Characters of Fruits

3.1.1.3.2.1 Total soluble solids

3.1.1.3.2.2 Acidity

3.1.1.3.2.3 Vitamin C

3.1.1.3.2. 4 Total sugars

3.1.2 Cold Storage Studies

3.1.2.1 Effect of Naphthalene Acetic Acid

3.1.2.1.1 Physical Characters of Fruits

3.1.2.1.1.1 Fruit size

3.1.2.1.1.2 Fruit weight

3.1.2.1.1.3 Specific gravity

3.1.2.1.1.4 Fruit colour

3.1.2.1.1.5 Fruit firmness

3.1.2.1.1.6 Palatability rating

3.1.2.1.1.7 Seed weight

3.1.2.1.2 Bio-chemical Characters of Fruits

3.1.2.1.2.1 Total soluble solids

3.1.2.1.2.2 Acidity

3.1.2.1.2.3 Vitamin C

3.1.2.1.2.4 Total sugars

3.1.2.2 Effect of Salicylic Acid

3.1.2.2.1 Physical Characters of Fruits

3.1.2.2.1.1 Fruit size

3.1.2.2.1.2 Fruit weight

3.1.2.2.1.3 Specific gravity

3.1.2.2.1.4 Fruit colour

3.1.2.2.1.5 Fruit firmness

3.1.2.2.1.6 Palatability rating

3.1.2.2.1.7 Seed weight

3.1.2.2.2 Bio-chemical Characters of Fruits

3.1.2.2.2.1 Total soluble solids

3.1.2.2.2.2 Acidity

3.1.2.2.2.3 Vitamin C

3.1.2.2.2.4 Total sugars

3.1.2.3 Effect of Ascorbic Acid

3.1.2.3.1 Physical Characters of Fruits

3.1.2.3.1.1 Fruit size

3.1.2.3.1.2 Fruit weight

3.1.2.3.1.3 Specific gravity

3.1.2.3.1.4 Fruit colour

3.1.2.3.1.5 Fruit firmness

3.1.2.3.1.6 Palatability rating

3.1.2.3.1.7 Seed weight

3.1.2.3.2 Bio-chemical Characters of Fruits

3.1.2.3.2.1 Total soluble solids

3.1.2.3.2.2 Acidity

3.1.2.3.2.3 Vitamin C

3.1.2.3.2.4 Total sugars

Experiment 3.2:Post-harvest Application of Chemicals on Shelf Life of Winter Guava

The fruits samples for post-harvest dipping were taken separately in two lots i.e. for ambient storage studies and cold storage studies. The fruits from untreated guava trees were taken and dipped in above said chemicals with different concentrations for 4-5 minutes. The fruits were wiped with clean cloth after dipping treatment and taken to laboratory for recording of physical and bio chemical observations. The details of different treatments are given below-

Treatment No.	Name of the Chemical	Concentration
T_1	Naphthalene acetic acid	100 ppm
T_2	Naphthalene acetic acid	200 ppm
T_3	Naphthalene acetic acid	300 ppm
T_4	Salicylic acid	100 ppm
T_5	Salicylic acid	200 ppm
T_6	Salicylic acid	300 ppm
T_7	Ascorbic acid	75 ppm
T_8	Ascorbic acid	150 ppm
T_9	Ascorbic acid	300 ppm
T_{10}	Control	--

3.2.1 Ambient Storage Studies

The treated fruits packed in Corrugated Fiber Board boxes (CFB) of 2 kg capacity were kept at ambient storage studies in research laboratory. The fruits were analyzed for physico-chemical traits after three days interval viz. 0, 3, 6 and 9 days.

3.2.1.1 Effect of Naphthalene Acetic Acid

3.2.1.1.1 Physical Characters of Fruits

3.2.1.1.1.4 Fruit colour

3.2.1.1.1.5 Fruit firmness

3.2.1.1.1.6 Palatability rating

3.2.1.1.1.8 Physiological loss in weight

The fruit weight was measured after each interval of ambient/cold storage and percent PLW was calculated by using following formula:

$$PLW (\%) = \frac{\text{Initial Weight} - \text{Final Weight}}{\text{Initial Weight}} \times 100$$

3.2.1.1.1.9 Spoilage percentage

The fruits spoiled or rotted or turn unfit for consumption was counted physically. The spoilage of fruits was worked out as given below on the number basis and expressed in percentage.

$$\text{Spoilage percentage} = \frac{\text{Number of spoiled fruits}}{\text{Total Number of fruits}} \times 100$$

3.2.1.1.2 Bio-chemical Character of Fruits

3.2.1.1.2.1 Total soluble solids

3.2.1.1.2.2 Acidity

3.2.1.1.2.3 Vitamin C

3.2.1.1.2.4 Total sugars

3.2.1.2 Effect of Salicylic Acid

3.2.1.2.1 Physical Characters of Fruits

3.2.1.2.1.4 Fruit colour

3.2.1.2.1.5 Fruit firmness

3.2.1.2.1.6 Palatability rating

3.2.1.2.1.8 Physiological loss in weight

3.2.1.2.1.9 Spoilage percentage

3.2.1.2.2 Bio-chemical Characters of Fruits

3.2.1.2.2.1 Total soluble solids

3.2.1.2.2.2 Acidity

3.2.1.2.2.3 Vitamin C

3.2.1.2.2.4 Total sugars

3.2.1.3 Effect of Ascorbic Acid

3.2.1.3.1 Physical Characters of Fruits

3.2.1.3.1.4 Fruit colour

3.2.1.3.1.5 Fruit firmness

3.2.1.3.1.6 Palatability rating

3.2.1.3.1.8 Physiological loss in weight

3.2.1.3.1.9 Spoilage percentage

3.2.1.3.2 Bio-chemical Characters of Fruits

3.2.1.3.2.1 Total soluble solids

3.2.1.3.2.2 Acidity

3.2.1.3.2.3 Vitamin C

3.2.1.3.2.4 Total sugars

3.2.2 Cold Storage Studies

The treated fruits were packed in Corrugated Fiber Board boxes (CFB) of 2 kg capacity and kept at cold store, Ludhiana for cold storage studies. The fruits were analyzed for physico-chemical properties after seven days interval viz. 0, 7, 14 and 21 days in cold storage.

3.2.2.1 Effect of Naphthalene Acetic acid

3.2.2.1.1 Physical Characters of Fruits

3.2.2.1.14 Fruit colour

3.2.2.1.1.5 Fruit firmness

3.2.2.1.1.6 Palatability rating

3.2.2.1.1.8 Physiological loss in weight

3.2.2.1.1.9 Spoilage percentage

3.2.2.1.2 Bio-chemical Characters of Fruits

3.2.2.1.2.1 Total soluble solids

3.2.2.1.2.2 Acidity

3.2.2.1.2.3 Vitamin C

3.2.2.1.2.4 Total sugars

3.2.2.2 Effect of Salicylic Acid

3.2.2.2.1 Physical Characters of Fruits

3.2.2.2.1.4 Fruit colour

3.2.2.2.1.5 Fruit firmness

3.2.2.2.1.6 Palatability rating

3.2.2.2.1.8 Physiological loss in weight

3.2.2.2.1.9 Spoilage percentage

3.2.2.2.2 Bio-chemical Characters of Fruits

3.2.2.2.2.1 Total soluble solids

3.2.2.2.2.2 Acidity

3.2.2.2.2.3 Vitamin C

3.2.2.2.2.4 Total sugars

3.2.2.3 Effect of Ascorbic Acid

3.2.2.3.1 Physical Characters of Fruits

3.2.2.3.1.4 Fruit colour

3.2.2.3.1.5 Fruit firmness

3.2.2.3.1.6 Palatability rating

3.2.2.3.1.8 Physiological loss in weight

3.2.2.3.1.9 Spoilage percentage

3.2.2.3.2 Bio-chemical Characters of Fruits

3.2.2.3.2.1 Total soluble solids

3.2.2.3.2.2 Acidity

3.2.2.3.2.3 Vitamin C

3.2.2.3.2.4 Total sugars

Experiment 3.3 Ripening Studies in Winter Guava under Ambient Conditions

Ethephon was sprayed for enhancing the ripening with following concentrations. The fruits were harvested after 15 days when they had attained uniform size and maturity.

Treatment	Name of the Chemical	Concentration
T_1	Ethephon	250 ppm
T_2	Ethephon	500 ppm
T_3	Ethephon	750 ppm
T_4	Ethephon	1000 ppm
T_5	Control	--

Fruits were packed in CFB boxes (32 X16 X 16 cm) and were brought to laboratory for recording of following physical and chemical changes after 2 days interval viz. 0, 2, 4 and 6 days under ambient conditions.

Observations Recorded-

3.3.1 Ambient Storage Studies

3.3.1.1 Effect of Ethephon

3.3.1.1.1 Physical Characters of Fruits

3.3.1.1.1.4 Fruit colour

3.3.1.1.1.5 Fruit firmness

3.3.1.1.1.6 Palatability rating

3.3.1.1.1.8 Physiological loss in weight

3.3.1.1.1.9 Spoilage percentage

3.3.1.1.2 Bio-chemical Characters of Fruits

3.3.1.1.2.1 Total soluble solids

3.3.1.1.2.2 Acidity

3.3.1.1.2.3 Vitamin C

3.3.1.1.2.4 Total sugars

Statistical Analysis

The data were analyzed statistically conferring to completely randomized block design (CRBD) with factorial arrangement as defined by Singh *et al* (1998).

CHAPTER IV

RESULTS AND DISCUSSION

The present study was carried out by formulating three experiments in the year 2015-16 and 2016-17 with objectives to find out the influence of different chemicals (pre/post-harvest application) on the shelf life of guava under ambient and cold storage temperature and effect of ethephon on the ripening of winter guava for improving the shelf life and quality along with earliness in cv. Allahabad Safeda. The results of all the experiments are displayed in tabular form and are conversed under various heads in the light of prevailing literature**.**

4.1 Effect of Pre-Harvest Treatments on Shelf Life of Guava cv. Allahabad Safeda under Ambient and Cold Storage Conditions

4.1.1 Ambient Storage Studies

4.1.1.1 Physical Characters of Fruits

4.1.1.1.1 Fruit size

The results reveal that fruit size of winter guava fruits was statistically influenced with the various pre-harvest applications of different plant growth regulators and antioxidants viz. NAA, salicylic acid and ascorbic acid under ambient storage conditions. Presented data showed positive results towards fruit size in comparison to control. Fruit size is significant indicator of marginal quality for decisive of harvest date. It is decided by genetic, environmental and cultural factors. Various plant growth regulators are used widely in horticulture crops to enhance plant growth and improve yield by increasing fruit number and size (Batlang 2008 and Serrani *et al* 2007).Hence effect on both, fruit length and breadth were carried out individually and discussed separately.

4.1.1.1.1(a) Fruit Length-

The data regarding length is presented in Table 1 reveals that length of the fruit showed steady and constant decline under ambient storage conditions. It had been observed that fruit length values were the highest during preliminary stage of storage period. As the storage period was advanced the values of fruit length go on decreasing. The values are bottommost towards end of the storage period.

During the first year, the highest values were recorded in 100 ppm NAA during initial day of storage. As the storage progressed fruit length declined after 3rd day to the tune of 5.75 cm followed by further decreased value of 5.60 cm on 6th day.

Table 1. Effect of pre-harvest treatments of chemicals on fruit length (cm) of guava cv. in Allahabad Safeda fruit under ambient storage conditions

Treatment		Storage days (2015-16)					Storage days (2016-17)				
		0 day	3rd day	6th day	9th day	Mean	0day	3rd day	6th day	9th day	Mean
NAA	100 ppm	5.85	5.75	5.60	5.42	5.66	5.79	5.74	5.64	5.51	5.67
	200 ppm	5.61	5.49	5.33	5.14	5.39	5.76	5.70	5.59	5.46	5.63
	300 ppm	5.52	5.41	5.23	5.04	5.30	5.71	5.64	5.52	5.39	5.57
Salicylic acid	100 ppm	5.43	5.31	5.12	4.92	5.20	5.58	5.50	5.37	5.23	5.42
	200 ppm	5.39	5.25	5.03	4.83	5.13	5.56	5.47	5.33	5.18	5.39
	300 ppm	5.53	5.38	5.15	4.94	5.25	5.67	5.57	5.43	5.27	5.49
Ascorbic acid	75 ppm	5.37	5.21	4.97	4.76	5.08	5.40	5.29	5.14	4.97	5.20
	150 ppm	5.27	5.10	4.84	4.62	4.96	5.33	5.21	5.06	4.88	5.12
	300 ppm	5.23	5.05	4.78	4.56	4.91	5.20	5.07	4.91	4.72	4.98
Control		5.14	4.94	4.65	4.41	4.79	4.91	4.76	4.59	4.39	4.66
Mean		5.43	5.29	5.07	4.86	5.16	5.49	5.40	5.26	5.10	5.31

Factors	**C.D. ($p \geq 0.05$)**	**Factors**	**C.D. ($p \geq 0.05$)**
Storage days (A)	0.27	Storage days (A)	0.24
Treatments (B)	0.43	Treatments (B)	0.38
Interaction (A X B)	N S	Interaction (A XB)	N S

This trend of reduction continued, and length was recorded 5.42 cm on 9th day. At the end of ambient storage period the average fruit length among all the treatments was noted highest (5.66 cm) in NAA 100 ppm treatment. It was followed by application of NAA 200 ppm, where fruit length was found to be 5.61 cm on storage day. Likewise 100 ppm NAA, it was decreased on 3rd day to the tune of 5.49 cm and reduced further with advancement of storage period i.e. on 6th day and noted as 5.33 cm. The fruit length declined more towards the end of storage and remained 5.14 cm on 9th day. Therefore, the mean length of fruit at the end of storage was reduced to 5.39 cm. On the other hand, much less values with declining trend were recorded in control treatment. The value of fruit length on storage day was recorded, 5.14 cm. The fruit length reduced with same manner and recorded 4.41 cm after 9 days of storage. Whereas the mean value was calculated as 4.79 cm. It may be generalized that fruit length goes on decreasing till its senescence under ambient conditions.

During second year of study, highest average value at the end of storage period among all the treatments found highest in NAA 100 ppm with average value of 5.67 cm. With the advancement of storage days, fruit length showed declining trend. After 3rd day of storage fruit length was noted as 5.74 cm and decreased further during 6th day and 9th day to the tune of 5.64 cm and 5.51cm, respectively. It was trailed by NAA 200 ppm treatment where fruit length exhibited continuous declining trend throughout 3rd, 6th and 9th day with corresponding value of 5.70 cm, 5.59 cm and 5.46 cm, respectively. On the contrary, declining trend and least average fruit length (4.66 cm) was observed in control treatment.

It may be concluded that NAA 100 ppm is unsurpassed treatment followed by NAA 200 ppm. Significantly lesser values have been obtained in control treatment during both years of study. As reported by various researchers that fruit size can be improved by several cultural methods, such as external chemical applications in the early stages of the fruit development. The increase in size of the fruit is due to enhanced rate of cell division and enlargement and more intercellular space with the application of higher concentration of plant growth substances. Singh *et al* (2017) obtained the highest fruit size with application of NAA in guava. The enrichment in size of guava fruits due to foliar application of various concentration of NAA might be result of improved inner physiology during development which encouraged efficient utilization of various resources like water, nutrients and other dynamic compounds. Improvement in fruit size has been noted with the help of the NAA in guava by Jain and Dashora (2010). Similar findings have been reported by Pandey *et al* (1999); Amoros *et al* (2004) in loquat and Singh and Bal (2006) in ber.

Table 2. Effect of pre-harvest treatments of chemicals on fruit breadth (cm) of guava cv. Allahabad Safeda under ambient storage conditions

Treatment		**Storage days (2015-16)**					**Storage days (2016-17)**				
		0 day	**3rd day**	**6th day**	**9th day**	**Mean**	**0 day**	**3rd day**	**6th day**	**9th day**	**Mean**
NAA	100 ppm	6.10	6.01	5.86	5.63	5.90	6.12	6.07	5.96	5.75	5.98
	200 ppm	5.87	5.77	5.61	5.37	5.66	6.05	5.99	5.87	5.64	5.89
	300 ppm	5.81	5.70	5.53	5.28	5.58	6.00	5.93	5.80	5.56	5.82
Salicylic acid	100 ppm	5.72	5.61	5.43	5.18	5.49	5.76	5.68	5.54	5.30	5.57
	200 ppm	5.69	5.57	5.38	5.12	5.44	5.6	5.51	5.35	5.10	5.39
	300 ppm	5.83	5.71	5.51	5.24	5.57	5.8	5.70	5.54	5.28	5.58
Ascorbic acid	75 ppm	5.67	5.54	5.33	5.05	5.40	5.55	5.44	5.27	5.00	5.32
	150 ppm	5.58	5.44	5.22	4.93	5.29	5.52	5.40	5.22	4.93	5.27
	300 ppm	5.55	5.40	5.17	4.87	5.25	5.48	5.35	5.16	4.86	5.21
Control		5.34	5.18	4.94	4.62	5.02	5.10	4.96	4.76	4.44	4.82
Mean		5.72	5.59	5.40	5.13	5.46	5.70	5.60	5.45	5.19	5.48
Factors		**C.D. (p≥0.05)**					**Factors**		**C.D. (p≥0.05)**		
Storage days (A)		0.24					Storage days (A)		0.21		
Treatments (B)		0.38					Treatments (B)		0.33		
Interaction (A X B)		N S					Interaction (A XB)		N S		

4.1.1.1.1(b) Fruit Breadth-

The data presented in Table 2, shows that the breadth of Allahabad Safeda guava fruits constantly decreased with advancement of storage period. It has been generalized that fruit breadth values were maximum during preliminary stage of storage.

During 2015-16, the highest values were noted in 100 ppm NAA during first day of ambient storage. As the storage progressed, fruit length was decreased after 3rd day to the value of 6.01 cm followed by further declined value of 5.86 cm on 6th day. This trend of reduction continued and length was noted 5.63 cm on 9th day. At the end of storage period the average fruit length among all the treatments was recorded highest (5.90 cm) in NAA 100 ppm treatment. It was followed by application of NAA 200 ppm, where fruit length was noted as 5.87 cm on storage day. Further, it was declined on 3rd day to the tune of 5.77 cm and reduced further with advancement of storage period i.e. on 6th day and it was as noted 5.61 cm. This declining trend continued towards end of storage and remained 5.37 cm on 9th day. The mean fruit breadth at the end of ambient storage was declined and recorded as 5.66 cm. On the other hand, much less values with decreasing trend were observed in control treatment. Fruit breadth value on storage day was recorded as 5.34 cm. It reduced in similar manner and recorded 4.62 cm after 9 days of storage. Mean value was calculated as 5.02 cm.

During second year of study, at the end of ambient storage period, the average fruit breadth among all the treatments was found highest in NAA 100 ppm with average value of 5.98 cm. With the advancement of storage period, breadth showed decreasing trend. After 3rd day of storage it was observed as 6.07 cm and lessened further during 6th day and 9th day to the tune of 5.96 cm and 5.75cm respectively. It was followed by NAA 200 ppm treatment where fruit breadth showed continuous decreasing trend throughout 3rd, 6th and 9th day with corresponding value of 5.99 cm, 5.87 cm and 5.64 cm, respectively with average of 5.89 cm. The minimum average fruit length i.e. 4.82 cm was recorded in control treatment.

Fruit size of guava was accessed after treatment with NAA, salicylic acid and ascorbic acid under ambient storage condition in contrast to control. NAA 100 ppm was considered as the best treatment. However, significantly lower values were recorded in control treatment. A declining trend during storage has been noted in all the treatments. Significantly reduced values were noted in control treatment during both years of the research work.

Size of the guava fruit inclined due to improved rate of cell division and enlargement and more intercellular space with the application of various plant growth substances. Singh *et al* (2017) proved that application of NAA results in increase in size of various fruits which ultimately reflects increase in yield along with and quality of guava fruit. Highest fruit volume along with fruit diameter of guava cv. Allahabad Safeda' at harvest was observed with foliar spray of NAA @100 ppm (Sharma 2013). Singh *et al* (2001) described in ber' cv. Umran that foliar application of NAA (10 ppm) at flowering stage, 40 and 120 days of first application increased fruit size which was at par with NAA 20 ppm and 40 ppm. Singh and Bal (2006) found that application of NAA 60 ppm at active growth phase resulted in higher fruit size and yield in ber cv. Umran. Greenberg *et al* (2006) sprayed NAA (300 ppm) in mandarins and recorded increased fruit size without disturbing total yield.

4.1.1.1.2 Fruit weight

The data presented in Table 3 shows that the weight of guava fruits continuously decreased with advancement of storage period. It may be stated that fruit weight values were at its highest during initial stage of ambient storage period.

During first year of study, the highest values were recorded in salicylic acid 200 ppm during first day of storage. As the storage advanced fruit weight was decreased after 3rd day to the value of 187.10 g followed by further declined value of 186.25 g on 6th day. This trend of reduction continued, and fruit weight was noted 185.76 g on 9th day. At the end of ambient storage period the average fruit weight among all the treatments was observed highest (186.96 g) in salicylic acid 200 ppm. It was followed by application of salicylic acid 300 ppm, where fruit weight was noted as 187.70 g on storage day. The fruit weight declined on 3rd day to the value of 185.72 g and reduced further with advancement of storage period i.e. on 6th day and noted as 183.85 g. This decreasing trend continued towards end of storage and remained 183.00 g on 9th day. Consequently, the mean fruit weight at the end of storage ambient storage was decreased and recorded as 185.07 g. On the other hand, much lower values with decreasing trend were recorded in control treatment. Fruit weight value on storage day was recorded, 99.10 g. It declined in analogous manner and recorded 93.00 g after 9 days of storage. The average fruit weight was calculated as 95.63 g.

During 2016-17, at the end of ambient storage period, the average guava fruit weight among all the treatments was also found highest in salicylic acid 200 ppm with average value 185.28 g. With the advancement of storage duration, guava fruit weight showed declining trend. After 3rd day of storage it was observed as 185.72 g and decreased further on 6th day and 9th day to the tune of 184.77 g and 183.93g, respectively. It was followed by salicylic acid 300 ppm treatment where fruit weight showed continuous declining trend throughout 3rd, 6th and 9th day with equivalent value of 174.76 g, 173.75 g and 172.80 g, respectively with average 174.27 g. On the other hand, declining trend and minimum average fruit weight i.e. 131.33 g was recorded in control treatment.The interaction between storage days and treatments was found to be significant in both years of study.

Fruit weight declined considerably in all the treatments during storage. It kept on decreasing with progress in storage duration. During initial stage of storage fruit weight values were at their highest while lowest at the end of the storage period. Maximum guava fruit weight was retained in salicylic acid 200 ppm treatment followed by salicylic acid 300 ppm. Significantly reduced values were observed in control treatment during both years of the study. The results reported by Wolucka *et al* (2005) are in line with findings of present study. They reported that various fruits which received salicylic acid in their nutrient solution had less weight loss than the fruits without salicylic acid. It is an electron donor and yields free radicals which prevent usual respiration and salicylic acid can also decrease rate of respiration process and fruit weight loss by stomata closing (Manthe *et al* 1992; Zheng and Zhang 2004).

4.1.1.1.3 Specific gravity

The data on specific gravity of guava fruit for various chemical treatments and storage days are displayed in Table 4. Various chemical applications resulted into very little or non-significant differences among themselves. Specific gravity declines constantly in guava fruits with the increase in storage period (Singh *et al* 2017).

During first year of study, it was observed that as the storage period advanced, the specific gravity of guava fruit was decreased. However, the highest mean specific gravity (0.96) was observed in guava fruits treated with NAA 200 ppm. On the other hand, lowest mean specific gravity (0.80) of fruit was recorded in control fruits.

During 2016-17, a declining trend with respect to specific gravity of Allahabad Safeda was recorded irrespective of various treatments and this trend continues till end of storage. The interaction between storage days and treatments was found to be non-significant in both the years of study.

Specific gravity of guava fruit increased during the storage. NAA 200 ppm resulted in maximum specific gravity of the fruits while lowest mean specific gravity was recorded in control. There were non-significant differences in specific gravity of fruits under different treatments which might be due to proportionate enhancement in the volume and weight of fruits in trees sprayed with different PGRs. Dastjerdi *et al* (2014) concluded that salicylic acid treatment had no substantial effects on gravity in the case of mango. Champa *et al* (2014) reported in grapes cv. Flame Seedless that salicylic acid applications did not affect berry specific gravity considerably in two crop seasons study.

Table 3. **Effect of pre-harvest treatments of chemicals on fruit weight (g) of guava cv. Allahabad Safeda under ambient storage conditions**

Treatment		Storage days (2015-16)					Storage days (2016-17)				
		0 day	3rd day	6th day	9th day	Mean	0day	3rd day	6th day	9th day	Mean
NAA	100 ppm	149.54	147.00	145.52	144.18	146.56	157.59	155.20	153.10	150.37	154.07
	200 ppm	153.19	150.78	148.62	147.87	150.12	164.73	162.23	159.93	157.83	160.00
	300 ppm	174.00	172.36	170.73	169.21	171.58	169.79	168.75	167.73	166.73	168.25
Salicylic acid	100 ppm	166.00	163.67	161.75	161.15	163.14	165.49	164.39	163.32	162.27	163.87
	200 ppm	188.73	187.10	186.25	185.76	186.96	186.70	185.72	184.77	183.93	185.28
	300 ppm	187.70	185.72	183.85	183.00	185.07	175.78	174.76	173.75	172.80	174.27
Ascorbic acid	75 ppm	142.90	141.41	138.44	137.22	139.99	142.90	140.48	138.28	136.08	139.43
	150 ppm	141.03	138.14	136.00	135.16	137.58	139.30	136.85	134.60	132.37	135.78
	300 ppm	129.34	126.40	124.00	123.25	125.75	137.25	134.75	132.43	130.16	133.65
Control		99.10	96.58	93.83	93.00	95.63	134.95	132.45	130.10	127.81	131.33
Mean		153.15	150.92	148.90	147.98	150.24	157.45	155.56	153.80	152.04	154.59

Factors	**C.D. (p≥0.05)**	**Factors**	**C.D. (p≥0.05)**
Storage days (A)	0.30	Storage days (A)	0.25
Treatments (B)	0.47	Treatments (B)	0.40
Interaction (A X B)	0.94	Interaction (A XB)	0.79

4.1.1.1.4 Fruit colour

The data pertaining to guava fruit colour is displayed in Table 5. The fruit colour changed progressively with advancement of ambient storage.

During first year of study, guava fruits showed various colours like light yellow to yellow green (YG11A,11B,10B,GG135D,135A,YG9C,11B and YGG154A) in different treatments at 0 day of storage. Colour changes were very clear as the storage progressed and best colour was obtained in salicylic treatments. In this treatment the colour was light green (GG135A, D) after 3 days of storage and it had changed to light yellow green (YGG154A) after storage of 6 days. While at 9th day of storage it was of yellow green colour (YGG154A). However, fruits in control treatment showed their colour to light yellow (YG 9C) after storage of 6th days and creamish yellow (YG10B) at 9th day of storage period.

Similarly, best colour development was recorded in salicylic acid application during the year 2016-17. On the 3rd day of storage the fruits were of light green (GG 135A, B and D) and it was changed to light yellow green (YGG145A and B) after 6 days of storage in salicylic acid 200 and 300 ppm. At 9th day of storage, skin colour was observed as yellow green (YGG154B and 154D). However, the fruits in control treatment were observed light yellow (YGG 154B) at 0 and 3rd day of storage and creamish yellow orange colour (YOG154A) on 9th day of storage.

The change of skin colour from green to yellow in fruits is an indication of fruit ripening process. Salicylic acid was found to be best treatment with respect to skin colour development of the fruit. It may be due to preventing the degradation of chlorophyll and deferring the gathering of carotenoids or gibberellins possibly have a senescence postponing action by obstructing ethylene in ber (Selvin 2002). Madhav *et al* (2016) also described that guava fruits treated with salicylic acid resulted in colour change and minimum weight loss but sustained ascorbic acid content along with maximum firmness. Treated fruits with salicylic acid, exhibited lower and/or delayed the respiration rate and ethylene production. Similar changes in fruit colour had been described by Singh (1998) in guava fruit. Ranjbaran *et al* (2011) proved that salicylic acid treatment also enhanced the total phenolic content of berry skin in grape. The maximum phenolic components were found in the berries treated with salicylic acid. They noted that salicylic acid treatments significantly delayed rachis discoloration along with browning.

Table 4. **Effect of pre-harvest treatments of chemicals on specific gravity of guava cv. Allahabad Safeda under ambient storage conditions**

Treatment		Storage days (2015-16)					Storage days (2016-17)				
		0day	3rdday	6thday	9thday	Mean	0day	3rdday	6thday	9thday	Mean
NAA	100 ppm	0.95	0.83	0.81	0.81	0.85	0.88	0.86	0.84	0.82	0.85
	200 ppm	1.17	0.90	0.89	0.89	0.96	0.95	0.93	0.91	0.89	0.92
	300 ppm	0.96	0.89	0.88	0.87	0.90	0.93	0.91	0.89	0.87	0.90
Salicylic acid	100 ppm	0.94	0.85	0.81	0.81	0.85	0.88	0.86	0.84	0.82	0.85
	200 ppm	1.02	0.88	0.87	0.87	0.91	0.89	0.87	0.85	0.83	0.86
	300 ppm	0.88	0.87	0.87	0.86	0.87	0.89	0.88	0.87	0.82	0.86
Ascorbic acid	75 ppm	0.86	0.85	0.85	0.83	0.85	0.86	0.85	0.84	0.82	0.84
	150 ppm	0.85	0.84	0.81	0.81	0.83	0.85	0.85	0.84	0.82	0.84
	300 ppm	0.85	0.85	0.84	0.82	0.84	0.84	0.83	0.83	0.81	0.82
Control		0.81	0.80	0.80	0.80	0.80	0.84	0.83	0.81	0.80	0.82
Mean		0.93	0.86	0.84	0.84	0.87	0.88	0.87	0.85	0.83	0.86

Factors	C.D. ($p \geq 0.05$)	Factors	C.D. ($p \geq 0.05$)
Storage days (A)	0.04	Storage days (A)	0.02
Treatments (B)	0.06	Treatments (B)	0.04
Interaction (A X B)	N S	Interaction (A XB)	N S

Table 5. Effect of pre-harvest treatments of chemicals on fruit colour of guava cv. Allahabad Safeda under ambient storage conditions

Treatment		Storage days(2015-16)				Storage days (2016-17)			
		0 day	3rd day	6th day	9th day	0 Day	3rd day	6th day	9th Day
NAA	100 ppm	YG11A	YG12B	YG13C	YG10A	YG12A	YG12A	YG13C	YG10C
	200 ppm	YG11B	YG11B	YG10C	YG12C	YG11B	YG11B	YG10C	YG12C
	300 ppm	YG10B	YG11A	YG11A	YG12C	YG10B	YG11B	YG11C	YG12C
Salicylic acid	100 ppm	GG135D	GG135D	YGG145A	YGG154A	GG135B	GG135B	GG135A	YGG154B
	200 ppm	GG135A	GG135A	YGG145A	YGG154A	GG136A	GG135A	YGG145A	YGG154D
	300 ppm	GG135A	GG135D	YGG145A	YGG154A	GG135A	GG135D	YGG145B	YGG154D
Ascorbic acid	75ppm	YG11B	YG9C	YG11A	YG11B	YG9B	YG9B	YG11B	YG11B
	150 ppm	YG9C	YG12B	YG13C	YG10C	YG11B	YG12B	YG13C	YG13D
	300 ppm	YG9C	YG10B	YG11B	YG11C	YG9C	YG10B	YG12B	YG12B
Control		YGG154A	YGG154A	YG9C	YG10B	YGG154B	YGG154B	YG12B	YOG154A

HCC	**Visual Colour**
GG135A, B, D	: Light green
YG10A, B; 11B; 12C	: Creamish yellow
YG9C; 11A; 11C 12B; 13C, D	: Light yellow
YGG145A, B, D	: Light yellow green
YGG154A, B, D	: Yellow green
YOG154 A	: Creamish yellow orange

4.1.1.1.5 Fruit firmness

The data presented in Table 6 and graphically delineated in Fig. 1 and 2 reveals that the guava fruit firmness was significantly affected with pre-harvest sprays of different chemicals and storage days. Application of NAA, salicylic acid and ascorbic acid were resulted in higher guava firmness as compared to control treatment. Firmness is a major characteristic feature which commands the postharvest life and quality of the fruit. It is one of the most significant physical parameters to screen the ripening and advancement.

During 2015-16, maximum fruit firmness along with declining trend was observed in salicylic acid 200 ppm under ambient storage conditions. On day of storage firmness of guava fruit was recorded 16.00 lbs/cm^2. Corresponding lower values were recorded on 3rd, 6th day and 9th day i.e. 15.41 lbs/cm^2, 14.84 lbs/cm^2, 14.37 lbs/cm^2 with average of 15.16 lbs/cm^2. This treatment was followed by salicylic acid 300 ppm application with average value of 15.04lbs/cm^2. Likewise salicylic acid 200 ppm, declining trend along with reduced values were noted in salicylic acid 300 ppm treatment. On the day of fruit storage, the value was noted16.86 lbs/cm^2; it reduced to the tune of 15.29 lbs/cm^2, 14.20 lbs/cm^2 and 13.82 lbs/cm^2, respectively on 3rd day, 6th day and 9th day. On the other hand, minimum average values of firmness along with lower values of firmness were observed in control treatment with average of 12.27 lbs/cm^2.

During second year of study, salicylic acid 200 ppm application had also shown maximum fruit firmness. In this treatment mean was calculated as 15.11 lbs/cm^2 and firmness had shown declining trend. Correspondingly, after 3rd day value of firmness was noted as 15.31 lbs/cm^2 and it reduced further to 14.64 lbs/cm^2 on 6th day and 14.32 lbs/cm^2 on 9th day. It was trailed behind salicylic acid 300 ppm with same decreasing trend. Lowest values of fruit firmness were observed in control treatment where average firmness was recorded as 13.11 lbs/cm^2.

Steady decline of fruit firmness was observed with the increase in storage duration under all the applications. Maximum fruit firmness was retained with the application of salicylic acid 200 ppm while control treatment had shown significantly lower values. A fresh fruit is always firm, and it starts losing its firmness during storage period and the firmness is associated with tissue softening which is generally followed by ripening process of the fruit. Softening is apparently due to change in various compounds of the cell wall like polysaccharides and lessening in cell wall uronic acid.

Table 6. Effect of pre-harvest treatments of chemicals on fruit firmness (lbs/cm^2) of guava cv. Allahabad Safeda under ambient storage conditions

Treatment		Storage days (2015-16)					Storage days (2016-17)				
		0day	**3rd day**	**6th day**	**9th day**	**Mean**	**0day**	**3rdday**	**6th day**	**9thday**	**Mean**
NAA	100 ppm	16.64	14.38	12.33	12.00	13.84	16.35	14.29	12.24	12.00	13.72
	200 ppm	16.88	14.22	13.71	12.61	14.36	16.05	14.00	13.00	12.80	13.96
	300 ppm	16.85	15.10	14.37	12.84	14.79	16.94	14.85	14.23	14.00	15.01
Salicylic acid	100 ppm	16.96	15.10	13.76	13.00	14.71	17.00	15.78	13.74	13.05	14.89
	200 ppm	16.00	15.41	14.84	14.37	15.16	16.18	15.31	14.64	14.32	15.11
	300 ppm	16.86	15.29	14.20	13.82	15.04	16.74	15.10	14.50	13.82	15.04
Ascorbic acid	75 ppm	16.34	13.49	12.10	11.21	13.29	16.24	13.30	12.00	11.60	13.29
	150 ppm	16.33	12.85	12.28	11.10	13.14	16.40	13.00	12.00	11.41	13.20
	300 ppm	16.58	13.25	11.90	10.65	13.10	16.85	13.58	11.15	11.00	13.15
Control		16.27	12.07	10.51	10.21	12.27	16.87	13.35	11.23	11.00	13.11
Mean		16.57	14.12	13.00	12.18	13.97	16.56	14.26	12.87	12.50	14.05

Factors	C.D. ($p \geq 0.05$)	Factors	C.D. ($p \geq 0.05$)
Storage days (A)	0.11	Storage days (A)	0.14
Treatments (B)	0.17	Treatments (B)	0.23
Interaction (A X B)	0.35	Interaction (A XB)	0.46

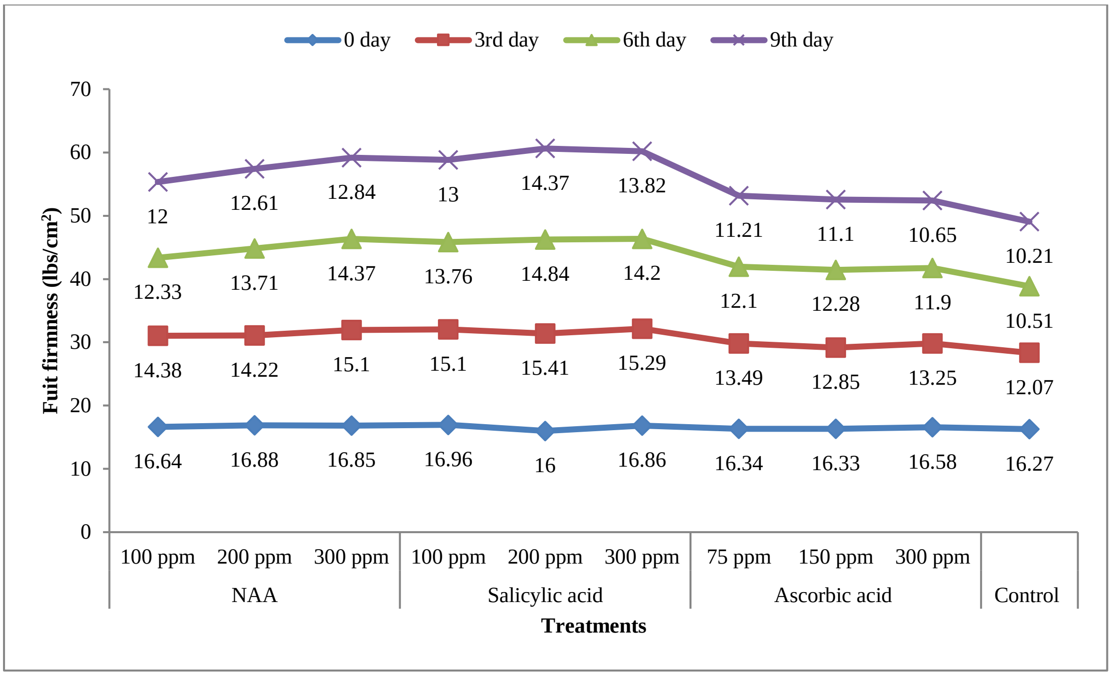

Fig. 1: Effect of pre-harvest application of chemicals on fruit firmness (lbs/cm2) of guava under ambient storage (2015-16)

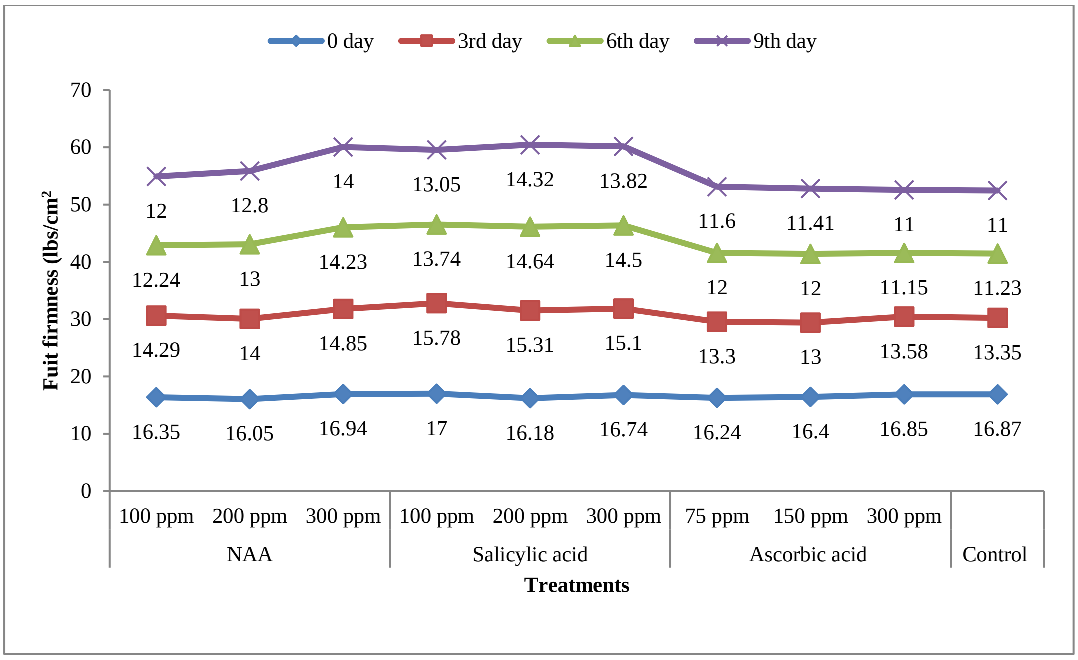

Fig. 2: Effect of pre-harvest application of chemicals on fruit firmness (lbs/cm2) of guava under ambient storage (2016-17)

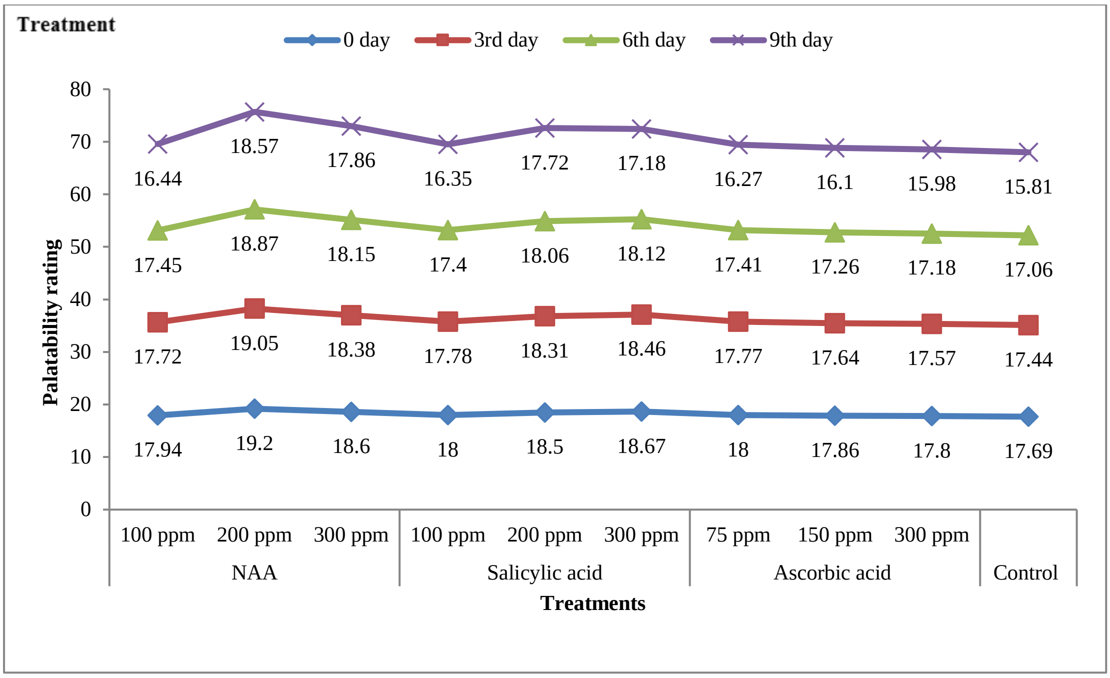

Fig. 3:Effect of pre-harvest application of chemicals on palatability rating (out of 20) guava under ambient storage (2015-16)

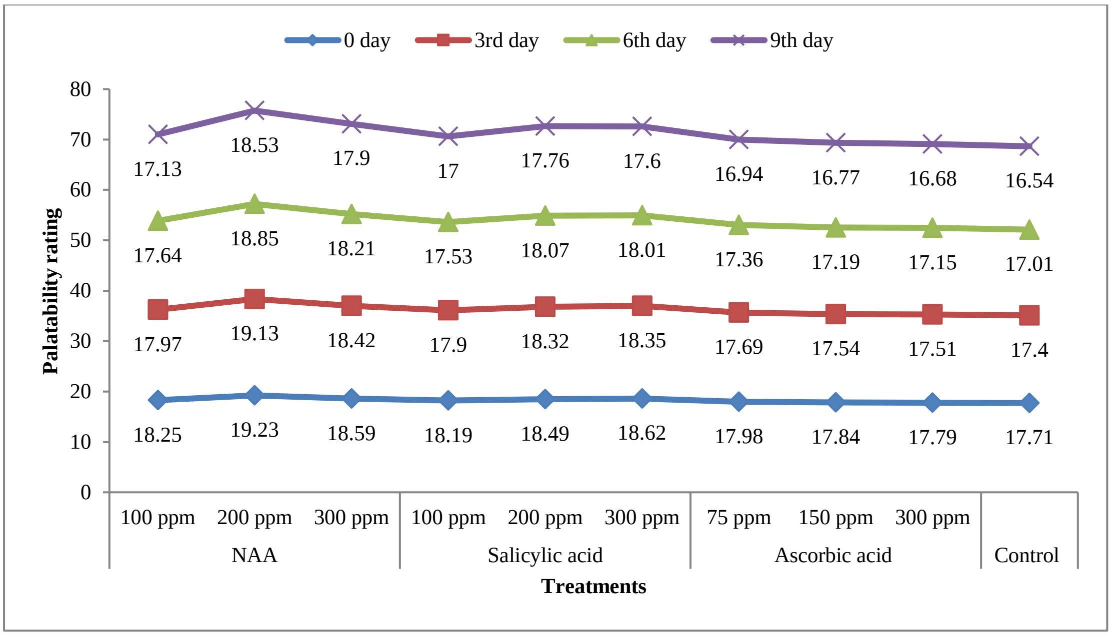

Fig. 4:Effect of pre-harvest application of chemicals on palatability rating (out of 20) guava under ambient storage (2016-17)

The interaction between storage days and treatments was recorded significant during the course of study. As for the role of salicylic acid in maintaining firmness, it was reported to be via its effectiveness in decreasing ethylene production. This effect is attributed to the key role ethylene plays in triggering the induction of cell wall hydrolyzing enzymes (Wills *et al* 1998).Present results corroborate well with that of Selvan and Bal (2005) and Kaur (2016) in guava. The retention in firmness of salicylic acid treated fruits may be because of inhibition of cell wall and membrane degrading enzymes such as lipoxygenase, cellulase and pectin methyl esterase and also due to lesser rate of ethylene production (Khademi and Ershadi 2013) in peach.

4.1.1.1.6 Palatability rating

The data presented in Table 7 and graphically represented in Fig. 3 and 4 shows that deterioration in taste and appearance of guava fruits continuously increased with advancement of ambient storage period. Quality of the fruit is the most important factor from a consumer's viewpoint, which comprises nutritive as well as visual and organoleptic measures.

The highest values of palatability rating were recorded in NAA 200 ppm during initial day of storage period in first year of study. As the storage advanced, palatability rating of guava fruit was decreased after 3rd day to the value of 19.05 followed by further declined up to18.87 on 6th day. This trend of reduction was constant, and palatability rating was noted 18.57 on 9th day. At the end of ambient storage period the average palatability rating among all the treatments was observed highest (18.92) in NAA 200 ppm followed by NAA 300 ppm, where the value was noted 18.60 on storage day. Likewise NAA 200 ppm, it declined on 3rd day (18.38), reduced further with advancement of storage period i.e. on 6th day, and noted as 18.15. This decreasing trend continued more towards end of storage and remained 17.86 on 9th day. Consequently, the mean palatability rating at the end of ambient storage period was decreased and recorded as 18.25. The lesser values of palatability rating with decreasing trend were recorded in control treatment. On storage day it was recorded, 17.69 which declined in corresponding manner and recorded 15.81 after 9 days of storage and mean value was calculated as 17.00.

During second year of study, highest average value of fruit palatability rating was recorded at the end of ambient storage period and found highest in NAA 200 ppm with average value of 18.94. With the advancement of storage, palatability rating shown decreasing trend. At 3rd day of storage, it was observed as 19.13 and decreased further during 6th day and 9th day to the value of 18.85 and 18.53, respectively. It was followed by NAA 300

Table 7. Effect of pre-harvest treatments of chemicals on palatability rating score (Out of 20.0) of guava cv. Allahabad Safeda under ambient storage conditions

Treatment		Storage days (2015-16)					Storage days (2016-17)				
		0day	3rd day	6th day	9th day	Mean	0day	3rd day	6th day	9th day	Mean
NAA	100 ppm	17.94	17.72	17.45	16.44	17.39	18.25	17.97	17.64	17.13	17.75
	200 ppm	19.20	19.05	18.87	18.57	18.92	19.23	19.13	18.85	18.53	18.94
	300 ppm	18.60	18.38	18.15	17.86	18.25	18.59	18.42	18.21	17.90	18.28
Salicylic acid	100 ppm	18.00	17.78	17.40	16.35	17.38	18.19	17.90	17.53	17.00	17.66
	200 ppm	18.50	18.31	18.06	17.72	18.15	18.49	18.32	18.07	17.76	18.16
	300 ppm	18.67	18.46	18.12	17.18	18.11	18.62	18.35	18.01	17.60	18.15
Ascorbic acid	75 ppm	18.00	17.77	17.41	16.27	17.36	17.98	17.69	17.36	16.94	17.49
	150 ppm	17.86	17.64	17.26	16.10	17.22	17.84	17.54	17.19	16.77	17.34
	300 ppm	17.80	17.57	17.18	15.98	17.13	17.79	17.51	17.15	16.68	17.28
Control		17.69	17.44	17.06	15.81	17.00	17.71	17.40	17.01	16.54	17.17
Mean		18.23	18.01	17.70	16.83	17.69	18.27	18.02	17.70	17.29	17.82

Factors	**C.D. (p≥0.05)**	**Factors**	**C.D. (p≥0.05)**
Storage days (A)	0.37	Storage days (A)	0.27
Treatments (B)	0.58	Treatments (B)	0.43
Interaction (A X B)	N S	Interaction (A XB)	N S

ppm treatment where palatability rating showed continuous decreasing trend throughout 3rd, 6th and 9th day with equivalent value of 18.42, 18.21 and 17.90, respectively. On the other hand, declining trend and minimum palatability rating i.e. 17.17 was recorded in control treatment. The interaction between storage days and treatments was found to be non-significant in both years of study.

Palatability rating of the fruits increased firstly and then decreased as the storage period progressed. Highest palatability was retained by NAA 200 treatment throughout the study while significantly lesser values of fruit palatability have been observed in control treatment during both years of the research work. The findings of several research workers are in synchronization of outcome of current study. Singh *et al* (2017) obtained the highest mean palatability rating in guava fruits treated with NAA 300 ppm in storage closely followed by NAA 200 ppm. Reddy (1992) found in guava that application of NAA @ 200 ppm at pre-harvest stage caused higher organoleptic rating during the storage. Arora and Singh (2014) obtained maximum palatability rating in ber fruit with NAA treatments.

4.1.1.1.7 Seed weight

The results on seed weight of guava fruit for various chemical treatments and storage days are presented in Table 8. The perusal of the data shows that various chemical applications resulted into very little or non-significant differences among themselves. Seed weight declines constantly with the increase in storage period.

During first year, the seed weight of guava fruit showed non-significant trend with advancement of storage period. However, the highest mean seed weight (6.98 g) was observed in guava fruits treated with NAA 100 ppm. On the other hand, lowest mean seed weight (5.25 g) of guava was recorded in control fruits.

During second year same declining trend with respect to seed weight of Allahabad Safeda was recorded irrespective of various treatments and this trend continues till end of storage period. The highest seed weight (6.81g) was recorded best in NAA 100 ppm.

Seed weight continuously decreased during storage period. Throughout experiment maximum seed weight was retained with application of NAA 100 ppm. Significantly lower mean seed weight of guava was recorded in untreated fruits. This decrease in seed weight of guava fruits with NAA treatments might be due to reduction in number of fit/healthy seeds especially at higher dose of NAA concentrations (Singh *et al* 2017). Several research workers have supported the outcome of this study. Sharma (2013)and Yadav *et al* (2001)also submitted similar results to the current study that maximum seed weight was recorded in NAA in guava crop. Results on similar line were also observed by Iqbal *et al* (2009) in guava.

Table 8. **Effect of pre-harvest treatments of chemicals on seed weight (g) of guava cv. Allahabad Safeda under ambient storage conditions**

Treatment		Storage days (2015-16)					Storage days (2016-17)				
		0 day	3rd day	6th day	9th day	Mean	0 day	3rd day	6th day	9th day	Mean
NAA	100 ppm	7.14	7.08	7.00	6.87	6.98	6.98	6.89	6.77	6.61	6.81
	200 ppm	6.97	6.89	6.80	6.66	6.78	6.87	6.77	6.65	6.48	6.69
	300 ppm	6.94	6.85	6.75	6.61	6.74	6.84	6.74	6.62	6.45	6.66
Salicylic acid	100 ppm	5.86	5.75	5.63	5.48	5.62	5.89	5.76	5.62	5.42	5.67
	200 ppm	5.80	5.68	5.55	5.39	5.54	5.82	5.68	5.53	5.32	5.59
	300 ppm	5.97	5.87	5.76	5.62	5.75	6.73	6.61	6.48	6.29	6.53
Ascorbic acid	75 ppm	5.79	5.66	5.52	5.35	5.51	5.80	5.65	5.49	5.27	5.55
	150 ppm	5.77	5.63	5.48	5.31	5.47	5.67	5.51	5.33	5.10	5.40
	300 ppm	5.72	5.58	5.42	5.24	5.41	5.62	5.45	5.26	5.02	5.34
Control		5.59	5.44	5.26	5.05	5.25	5.64	5.46	5.24	4.98	5.33
Mean		6.16	6.04	5.92	5.76	5.91	6.19	6.05	5.90	5.69	5.96

Factors	**C.D. ($p \geq 0.05$)**	**Factors**	**C.D. ($p \geq 0.05$)**
Storage days (A)	N S	Storage days (A)	N S
Treatments (B)	0.46	Treatments (B)	0.74
Interaction (A X B)	N S	Interaction (A X B)	N S

4.1.1.2 Bio-chemical Characters of Fruits

4.1.1.2.1 Total soluble solids

The data pertaining to total soluble solids of guava fruit under ambient storage conditions has been presented in Table 9 and Fig. 5 and 6. It reveals that TSS content of the fruit decreased during the storage in all chemical treatments and at various intervals.

During first year of study, it was reported that treatments varied significantly among themselves with respect to total soluble solids of Allahabad Safeda. The highest mean total soluble solids (11.71%) were recorded in NAA 200 ppm treatment. At 0 day it was noted as 12.40 per cent with declining trend and thereafter 3rd day it was recorded as 12.14 per cent. This decreasing trend continued up to end of the storage while at 6th day it was 11.50 per cent and at 9thday 10.79 per cent. It was followed by NAA 300 ppm. In this treatment TSS reduced with decreasing trend to the value of 11.05 per cent. Similar declining trend was also seen during control treatment where it showed least values of TSS with average value of 8.50 per cent.

Throughout 2016-17, the highest total soluble solids were recorded in NAA 200 ppm treatment. At 0 day the value of TSS was recorded as 11.67% and it showed reduced values of 3rd, 6th and 9th day as 11.43%, 10.70% and 9.83%, respectively but with declining trend and average value 10.91 %. It was trailed by NAA 300 ppm where TSS reduced from 11.16 % (0 day) to 9.39% (9th day) with average of value of 10.44 %. Significantly lower values of TSS were recorded in control treatment with mean value 7.63 %.

A reduction in TSS content was observed during ambient storage conditions in all the treatments; however, its content was sustained to an appreciable level irrespective of the treatments. But highest value of TSS during ambient storage period was recorded in NAA 200 treatment followed by NAA 300 ppm. Bottommost values of guava TSS were recorded in controlled fruits. The interaction between storage days and treatments was found to be significant in both years. TSS was improved due to its action on altering complex materials into simple ones, which inclined the metabolic activity in fruits. The intensification might be due to improvement in the utilization of carbohydrates from the source of sink by auxins. This might be accredited to the reason that NAA might have improved amylase activity and thus there was fast metabolic conversion of starch into soluble sugars and swift ripening in response to growth substances lead to an incline in TSS. The results of present study are in agreement with the findings of Selvan and Bal (2005) in guava who displayed that TSS continued declined after storage. Similar results were accomplished by Mandal *et al* (2012) who found in winter guava that NAA has maintained highest mean of TSS in storage.

Table 9. Effect of pre-harvest treatments of chemicals on total soluble solids (%) of guava cv. Allahabad Safeda under ambient storage conditions

Treatment		Storage days (2015-16)					Storage days (2016-17)				
		0 day	3rd day	6th day	9th day	Mean	0 day	3rd day	6th day	9th day	Mean
NAA	100 ppm	10.77	10.59	10.04	9.45	10.21	10.31	10.15	9.48	8.65	9.65
	200 ppm	12.4	12.14	11.50	10.79	11.71	11.67	11.43	10.70	9.83	10.91
	300 ppm	11.7	11.46	10.85	10.17	11.05	11.16	10.94	10.25	9.39	10.44
Salicylic acid	100 ppm	10.49	10.33	9.78	9.21	9.95	10.06	9.91	9.26	8.46	9.42
	200 ppm	11.18	10.97	10.38	9.76	10.57	10.84	10.66	9.97	9.12	10.15
	300 ppm	10.94	10.73	10.16	9.57	10.35	10.59	10.42	9.75	8.91	9.92
Ascorbic acid	75 ppm	9.54	9.35	8.84	8.29	9.01	9.63	9.50	8.86	8.11	9.03
	150 ppm	9.4	9.23	8.73	8.21	8.89	9.29	9.16	8.54	7.79	8.70
	300 ppm	9.21	9.06	8.58	8.07	8.73	8.44	8.33	7.71	6.96	7.86
Control		8.94	8.82	8.35	7.88	8.50	8.19	8.10	7.48	6.74	7.63
Mean		10.46	10.27	9.72	9.14	9.90	10.02	9.86	9.20	8.40	9.37
Factors		**C.D. (p≥0.05)**					**Factors**		**C.D. (p≥0.05)**		
Storage days (A)		0.13					Storage days (A)		0.10		
Treatments (B)		0.21					Treatments (B)		0.16		
Interaction (A X B)		0.42					Interaction (A XB)		N S		

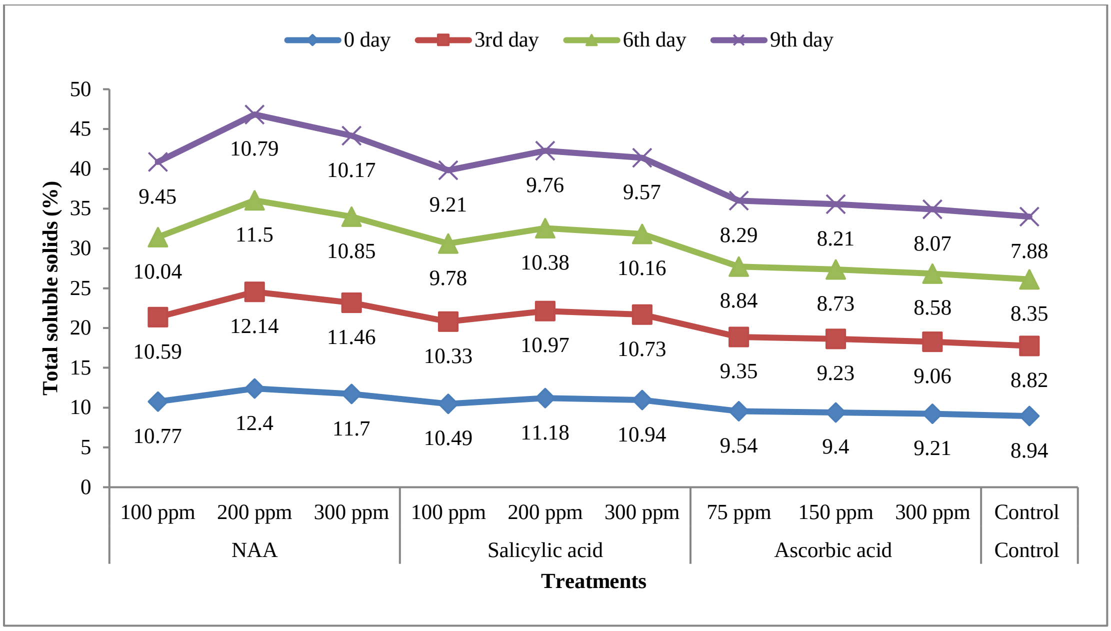

Fig. 5 Effect of pre-harvest application of chemicals on total soluble solids (%) of guava under ambient storage (2015-16)

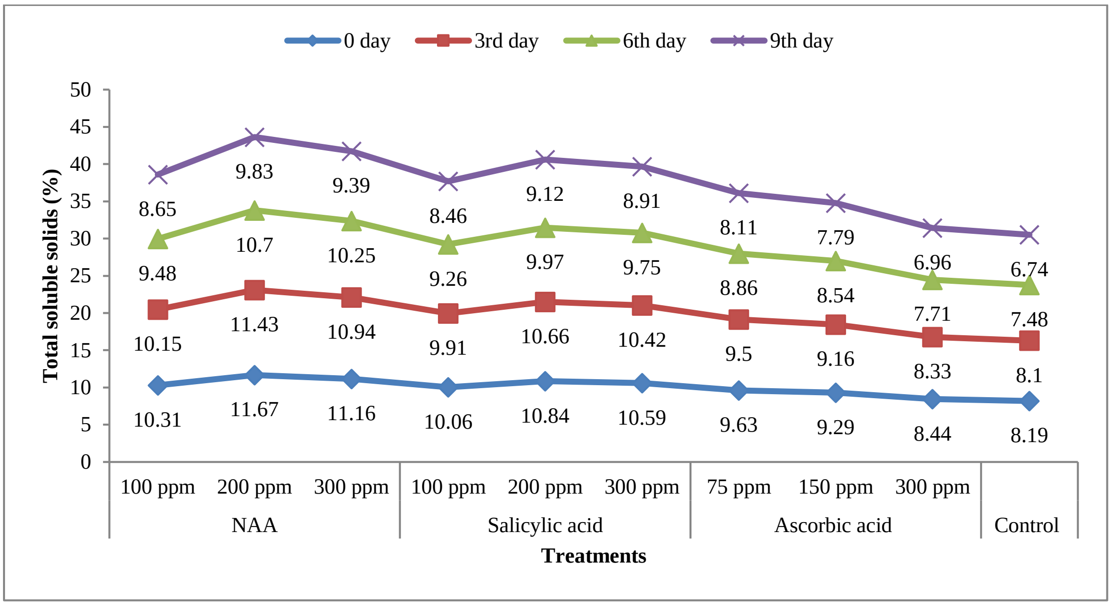

Fig. 6 Effect of pre-harvest application of chemicals on total soluble solids (%) of guava under ambient storage (2016-17)

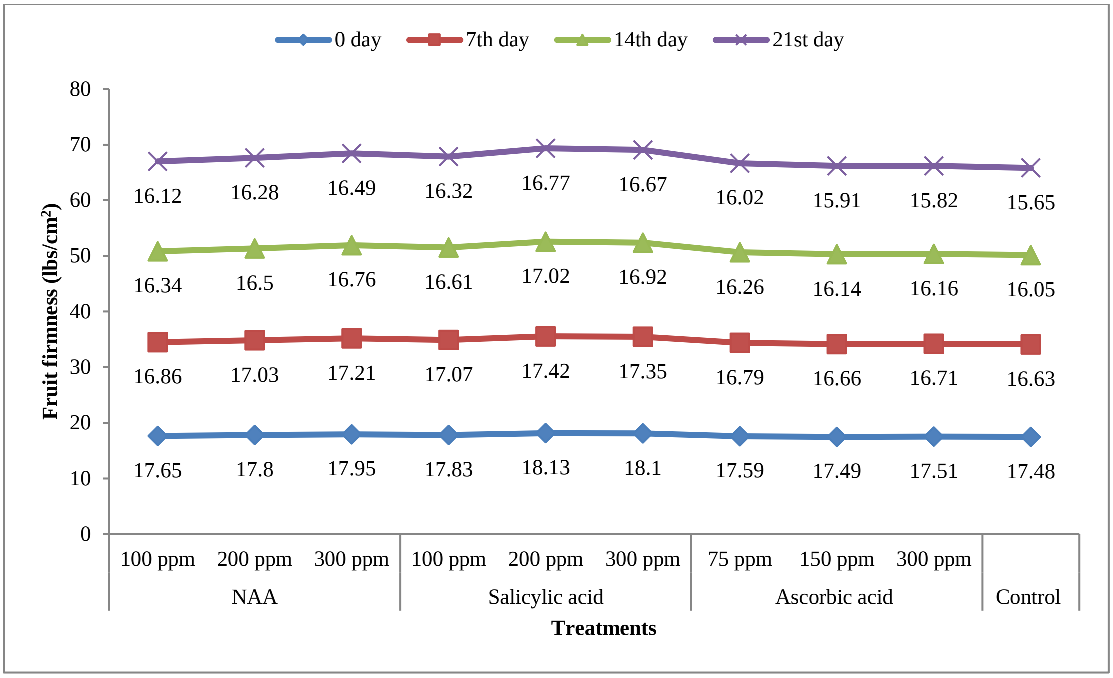

Fig. 7 Effect of pre-harvest application of chemicals on fruit firmness (lbs/cm^2) of guava under cold storage (2015-16)

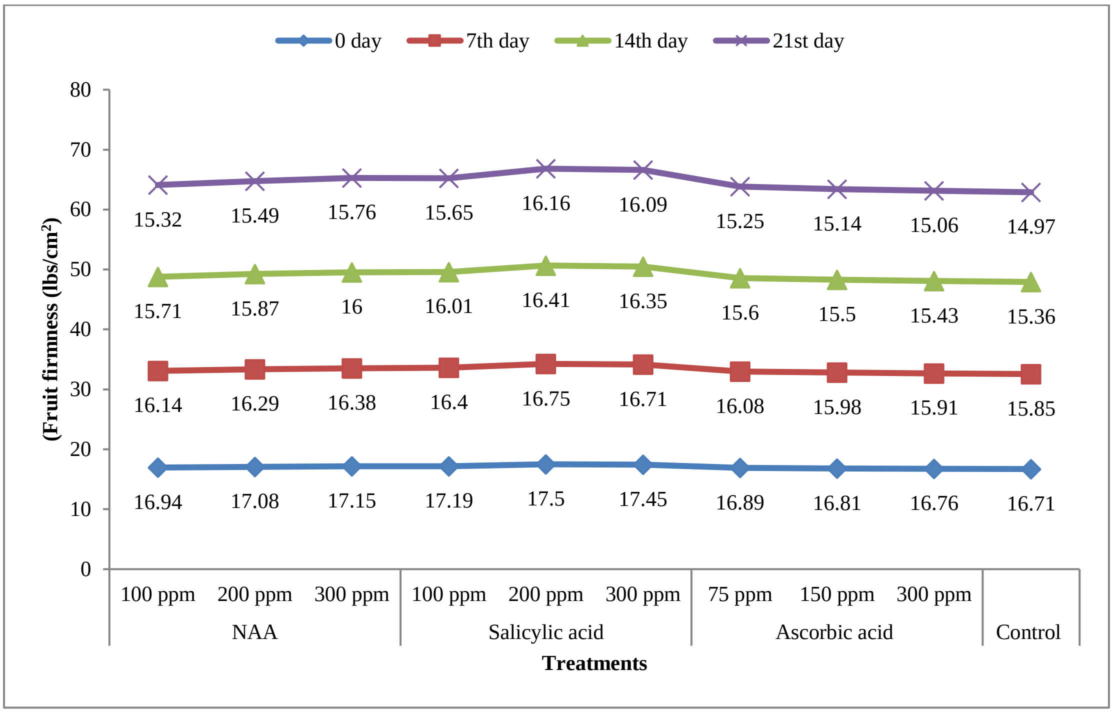

Fig. 8 Effect of pre-harvest application of chemicals on fruit firmness (lbs/cm^2) of guava under cold storage (2016-17)

4.1.1.2.2 Acidity

The data presented in Table 10 reveals that acidity in the guava fruits was significantly affected with pre-harvest sprays of different chemicals and storage days. Application of NAA, salicylic acid and ascorbic acid resulted in lower acidity in compared to control treatment.

During 2015-16, minimum fruit acidity along with declining trend was observed in NAA 200 ppm under ambient storage conditions. On day of storage, acidity of guava fruit was recorded 0.85 per cent. Likewise lower values were recorded on 3rd, 6th day and 9th day i.e. 0.73 per cent, 0.60 per cent, 0.47 per cent with mean value of 0.66 per cent. This treatment was followed by NAA 300 ppm application. Similarly a declining trend along with reduced values was noted in NAA 300 ppm treatment.

During second year of study, NAA 200 ppm application has shown minimum acidity. In this treatment mean was calculated as 0.50 per cent with declining trend. Correspondingly, after 3rd day value of acidity was noted as 0.56 per cent and it reduced further to 0.44 per cent on 6th day and 0.32 per cent on 9th day. It was trailed by NAA 300 ppm (0.51%). Lowest values of fruit firmness were obtained in control treatment where average acidity was recorded as 0.65 per cent.

Acidity in guava fruits declined during storage period. NAA 200 ppm application was proved to be best as it sustained lowest acidity followed by NAA 300 ppm treatment. Highest acidity values were recorded in control treatment. The interaction was found to be significant between storage days and treatments in both years of study. Thus, with NAA treatment the titratable acidity was diminished which may be due to early ripening of fruits caused by its application, where acid might have been used during respiration activity or rapidly transformation into sugars of various kinds by different reactions involving reverse glycolytic pathways (Agnihotri *et al* 2013). Similar observations were reported by several researchers and supported the results of present study. Iqbal *et al* (2009) in guava fruit observed results on similar line that pre-harvest application of NAA decreased the acidity. These results corroborate well with Selvan and Bal (2005) and Killadi *et al* (2007) in guava fruits. Kaur and Kaur (2017) applied various plant growth regulators in guava fruit and discovered that acidity had declined with NAA treatment.

Table 10. Effect of pre-harvest treatments of chemicals on acidity (%) in guava fruits cv. Allahabad Safeda under ambient storage conditions

Treatment		Storage days (2015-16)					Storage days (2016-17)				
		0 day	**3rd day**	**6th day**	**9th day**	**Mean**	**0 day**	**3rd day**	**6th day**	**9th day**	**Mean**
NAA	100 ppm	0.92	0.84	0.75	0.66	0.79	0.75	0.67	0.58	0.48	0.62
	200 ppm	0.85	0.73	0.60	0.47	0.66	0.67	0.56	0.44	0.32	0.50
	300 ppm	0.86	0.75	0.64	0.52	0.69	0.68	0.57	0.46	0.34	0.51
Salicylic acid	100 ppm	0.93	0.86	0.78	0.70	0.82	0.78	0.70	0.62	0.53	0.66
	200 ppm	0.88	0.79	0.69	0.57	0.73	0.70	0.60	0.50	0.39	0.55
	300 ppm	0.89	0.81	0.72	0.62	0.76	0.74	0.65	0.55	0.44	0.60
Ascorbic acid	75 ppm	0.94	0.87	0.79	0.69	0.82	0.79	0.72	0.65	0.57	0.68
	150 ppm	0.95	0.87	0.79	0.70	0.83	0.85	0.78	0.71	0.63	0.74
	300 ppm	0.97	0.90	0.83	0.76	0.87	0.87	0.81	0.74	0.67	0.77
Control		0.98	0.93	0.88	0.82	0.90	0.91	0.86	0.80	0.73	0.83
Mean		0.92	0.84	0.75	0.65	0.79	0.77	0.69	0.61	0.51	0.65

Factors	**C.D. (p≥0.05)**	**Factors**	**C.D. (p≥0.05)**
Storage days (A)	0.01	Storage days (A)	0.01
Treatments (B)	0.01	Treatments (B)	0.01
Interaction (A X B)	0.02	Interaction (A XB)	0.01

4.1.1.2.3 Vitamin C

The data in Table 11 reveals the vitamin C content of the fruits of Allahabad Safeda under different treatments and storage days. Different chemicals viz. NAA, salicylic acid and ascorbic acid have affected vitamin C content of guava fruit in a different way in comparison to control. It has may be generalized from the presented data that vitamin C content was at higher end during the initial stage of the experiment. As the storage progressed it kept on decreasing. Throughout storage period, various oxidizing enzymes like catalase, ascorbic acid oxidase, polyphenol oxidase and peroxidase etc. might be lessened in ascorbic acid content (Mapson 1970).

During 2015-16-year, highest values of vitamin C were recorded immediately after harvesting fruits. A declining trend was noted with the advancement of storage time. Vitamin C was found the highest in NAA 200 ppm. Further declined values of 3rd day (220.26 mg/100g), 6th day (206.77 mg/100g) and 9th day (195.69 mg/100g) under storage conditions also confirmed the declining trend. It was followed by NAA 300 ppm with average value of 203.10 mg/100g. While at 0 day the mean value of vitamin C was 228.80 mg/100g. On the other hand, minimum vitamin C was noted in control treatment to the value of 167.06 mg/100g.

Highest values of vitamin C were recorded in NAA 200 ppm treatment during second year of study. Declined values were recorded during 3rd day (217.99 mg/100g) and declined further during 6th day (201.87 mg/100g) and 9th day (186.79 mg/100g), respectively. At end of storage period average of vitamin C was calculated as 202.22 mg/100g. It was followed by NAA 300 ppm treatment, where vitamin C of cv. Allahabad Safeda also exhibited diminishing trend throughout 3rd,6th and 9th day to the value of 218.58 mg/100g, 201.58 mg/100g and 185.03 mg/100g, respectively, with average of 201.73 mg/100g. Least amount of vitamin C was noted in control treatment with average of 171.66 mg/100g with declining trend.

Higher values of vitamin C content were estimated during the initial phase of this experiment. As the storage progressed it declined till the end of storage irrespective of treatment. Maximum vitamin C was recorded in fruits which were sprayed with NAA 200 ppm followed by NAA 300 ppm while least vitamin C was observed in case of untreated fruits. The interaction between storage days and treatments was found to be significant during both the years. The results are in conformity with the findings of Garasiya *et al* (2013) and Mandal *et al* (2012) in guava fruits. These conclusions are in agreement with those of Selvan and Bal (2005) in guava and Singh *et al* (2009) in mango.

Table 11. Effect of pre-harvest treatments of chemicals on vitamin C (mg/100 g) in guava cv. Allahabad Safeda under ambient storage conditions

Treatment		Storage days (2015-16)					Storage days (2016-17)				
		0day	3rdday	6thday	9thday	Mean	0day	3rdday	6thday	9thday	Mean
NAA	100 ppm	238.05	189.54	170.97	153.78	188.09	235.51	205.76	191.87	171.00	189.54
	200 ppm	235.98	220.26	206.77	195.69	214.68	234.58	217.99	201.87	186.79	202.22
	300 ppm	228.80	210.53	193.72	179.34	203.10	238.13	218.58	201.58	185.03	201.73
Salicylic acid	100 ppm	231.92	182.79	163.21	145.61	180.88	232.45	198.18	180.08	166.97	181.74
	200 ppm	223.46	202.92	184.46	167.93	194.69	233.51	213.05	194.62	177.02	194.90
	300 ppm	221.67	199.48	179.75	161.72	190.66	229.31	208.57	189.07	172.46	190.03
Ascorbic acid	75 ppm	224.82	179.65	152.62	134.77	172.97	228.61	193.45	172.97	154.76	173.73
	150 ppm	227.14	176.08	146.62	130.30	170.04	233.51	197.08	171.17	151.00	173.08
	300 ppm	226.05	170.92	142.40	129.06	167.11	234.18	197.10	170.94	150.64	172.89
Control		229.37	173.27	138.00	127.61	167.06	235.11	196.00	169.12	149.86	171.66
Mean		228.73	190.54	167.85	152.58	184.93	233.49	204.57	184.32	166.55	185.15

Factors	**C.D. (p≥0.05)**	**Factors**	**C.D. (p≥0.05)**
Storage days (A)	9.96	Storage days (A)	10.77
Treatments (B)	15.75	Treatments (B)	17.02
Interaction (A X B)	N S	Interaction (A XB)	N S

4.1.1.2.4 Total sugars

The data regarding the total sugars are presented in Table 12. The total sugars increased significantly during ambient storage. Slow increase was recorded during initial stages and thereafter increase was somewhat sharp and again decreasing trend was noted. Singh and Chauhan (1982) also described that the total sugars improved initially up to 2 days of room temperature storage and showed a declining trend with the advancement of the storage duration.

During first year of study, maximum mean total sugars (7.46%) were observed in fruits treated with NAA 200 ppm. Total sugars increased during 3rd and 6th to the value were recorded7.63 per cent, 8.01 per cent respectively. Then again decline (6.93%) was noted on 9th day. This treatment was followed by NAA 300 ppm with similar trend and average value of 7.34 per cent. Similar trend and reduced values were recorded in control treatment on 0,3rd, 6th and 9th day as 6.18 per cent, 6.40 per cent, 6.62 per cent and 5.42 per cent, respectively with average of 6.16 per cent.

During 2016-17, the highest total sugar was estimated in NAA 200 treatment with analogous trend and average value 7.58 per cent. Initially total sugar inclined to 8.03 per cent (6th day) and then again declined during 9th day i.e. 7.17 per cent. This treatment was trailed by NAA 300 ppm with average of 7.42 per cent. While much lower values were registered in control treatment (6.63%).

In general, total sugars in guava fruits increased during storage period and recorded highest in NAA 200 ppm. It was followed by NAA 300 ppm treatment while bottommost had been verified in control. The interaction between storage days and treatments was found to be non-significant during both years of study. This increase was possibly due to dehydration, as in most of the treatments fruits showed high PLW. The results are in accordance with the findings of Selvan and Bal (2005) and Iqbal *et al* (2009) in guava. Anawal *et al* (2016) in the pomegranate cv. Bhagwa and Ray *et al* (1991) in sapota cv. Cricket Ball also confirmed the results of current research.

Table 12. Effect of pre-harvest treatments of chemicals on total sugars (%) of guava cv. Allahabad Safeda under ambient storage conditions

Treatment		Storage days (2015-16)					Storage days (2016-17)				
		0day	3rdday	6thday	9thday	Mean	0day	3rdday	6thday	9th day	Mean
NAA	100 ppm	6.59	6.89	7.19	6.05	6.68	7.19	7.38	7.68	6.86	7.28
	200 ppm	7.25	7.63	8.01	6.93	7.46	7.45	7.68	8.03	7.17	7.58
	300 ppm	7.18	7.53	7.88	6.78	7.34	7.30	7.52	7.86	7.01	7.42
Salicylic acid	100 ppm	6.29	6.57	6.85	5.70	6.35	7.05	7.20	7.49	6.68	7.11
	200 ppm	7.08	7.42	7.76	6.64	7.23	7.24	7.45	7.77	6.93	7.35
	300 ppm	6.90	7.23	7.56	6.43	7.03	7.21	7.41	7.72	6.89	7.31
Ascorbic acid	75 ppm	6.44	6.71	6.98	5.82	6.49	6.90	7.70	7.98	7.18	7.44
	150 ppm	6.34	6.59	6.84	5.67	6.36	6.82	6.99	7.26	6.47	6.89
	300 ppm	6.25	6.49	6.73	5.55	6.26	6.79	6.95	7.22	6.44	6.85
Control		6.18	6.40	6.62	5.42	6.16	6.58	6.73	6.98	6.23	6.63
Mean		6.65	6.95	7.24	6.10	6.73	7.05	7.30	7.60	6.79	7.18

Factors	C.D. (p≥0.05)	Factors	C.D. (p≥0.05)
Storage days (A)	0.21	Storage days (A)	0.29
Treatments (B)	0.33	Treatments (B)	0.38
Interaction (A X B)	N S	Interaction (A X B)	N S

4.1.2 Cold Storage Studies

4.1.2.1 Physical Characters of Fruits

4.1.2.1.1 Fruit size

Effect of plant growth regulators and anti-oxidants on fruit size has been carried out individually and discussed separately under headings of fruit length and fruit breadth-

4.1.2.1.1(a) Fruit Length

The data pertaining to length is presented in Table 13. It is evident from the data that length of the fruit showed continuous declining trend in cold storage. Fruit length values were maximum during initial stage of cold storage. As the storage period advanced the values of fruit length goes on decreasing and recorded lowest towards end of the storage period.

The highest values of fruit length were recorded in NAA 200 ppm during first day of cold storage during 2015-16. As the storage advanced fruit length was declined after 7th day followed by further decrease on 14th day. This trend of declination continued, and length was recorded 6.01 cm on 21th day. At the end of cold storage period the average fruit length among all the treatments was observed highest (6.22cm) in NAA 200 ppm treatment followed by application of NAA 300 ppm. The fruit length in NAA 300 ppm was found to be 6.25 cm on storage day. Likewise 200 ppm NAA, it was decreased on 7th day and reduced further with advancement of storage period i.e. on 14th day and noted as 6.02 cm. The fruit length declined more towards end of storage and remained 5.85 cm on 21st day. Therefore, the mean length of fruit during cold storage was reduced to 6.07 cm. On the other hand, much lower values with declining trend were recorded in control treatment. The value of fruit length on storage day was recorded 5.48 cm. It reduced with identical manner and recorded 4.85 cm after 21st days of storage. While the mean value was calculated as 5.20 cm.

During second year of study, the highest value of fruit length was also observed in NAA 200 ppm. With the progression of storage duration, fruit length showed declining trend. At 7th day of storage fruit length was noted as 6.31 cm and decreased further during 14th day and 21st day to the value of 6.17 cm and 6.02 cm, respectively. At the end of storage period, the average fruit length among all the treatments found highest in NAA 200 ppm with average value of 6.23 cm. It was followed by NAA 300 ppm treatment where fruit length exhibited continuous declining trend throughout 7^{t}, 14th and 21st day with corresponding value of 6.09 cm, 5.95 cm and 5.78 cm, respectively. Declining trend and least average fruit length (5.29 cm) were observed in control treatment.

It is clear from the results that NAA 200 ppm was the best treatment followed by NAA 300 ppm.Significantly lower values have been obtained in control treatment during

Table 13. **Effect of pre-harvest treatments of chemicals on fruit length (cm) of guava cv. Allahabad Safeda under cold storage conditions**

Treatment		**Storage days (2015-16)**					**Storage days (2016-17)**				
		0day	**7th day**	**14th day**	**21st day**	**Mean**	**0day**	**7th day**	**14th day**	**21st day**	**Mean**
NAA	100 ppm	6.16	6.09	5.97	5.82	6.01	6.15	6.06	5.95	5.80	5.99
	200 ppm	6.38	6.30	6.17	6.01	6.22	6.41	6.31	6.17	6.02	6.23
	300 ppm	6.25	6.16	6.02	5.85	6.07	6.20	6.09	5.95	5.78	6.00
Salicylic acid	100 ppm	6.14	6.05	5.90	5.71	5.95	6.15	6.03	5.88	5.68	5.93
	200 ppm	6.27	6.17	6.01	5.82	6.07	6.18	6.05	5.89	5.70	5.95
	300 ppm	6.18	6.07	5.91	5.68	5.96	6.15	6.01	5.84	5.63	5.91
Ascorbic acid	75 ppm	5.76	5.65	5.48	5.23	5.53	5.89	5.77	5.59	5.35	5.65
	150 ppm	5.56	5.44	5.26	4.99	5.31	5.78	5.65	5.47	5.21	5.53
	300 ppm	5.51	5.38	5.19	4.92	5.25	5.69	5.55	5.36	5.09	5.42
Control		5.48	5.33	5.13	4.85	5.20	5.58	5.42	5.21	4.93	5.29
Mean		5.97	5.86	5.70	5.49	5.76	6.02	5.89	5.73	5.52	5.79

Factors	**C.D. (p≥0.05)**	**Factors**	**C.D. (p≥0.05)**
Storage days (A)	0.18	Storage days (A)	0.20
Treatments (B)	0.29	Treatments (B)	0.32
Interaction (A X B)	N S	Interaction (A XB)	N S

both years of the research work. Various studies have supported the results of present work. Augusti *et al* (1995) in citrus stated that auxin cause stimulation and translocation of carbohydrate to the fruits thus increasing cell wall elasticity and induced fruit growth. It was reported that increase in fruit size may be accredited to the increase in cell elongation and cell division caused by NAA (Cleland 1995). Thus, it might have caused substantial role in producing fruits of bigger size. It is recommended that NAA treatment affects fruit development through cell division and elongation (Dutta and Banik 2007).

4.1.2.1.1(b) Fruit Breadth

The data on fruit breadth are presented in Table 14 shows that it constantly decreased with advancement of storage period. The fruit breadth values were maximum during introductory stage of storage.

During first year, the highest values were noted in 200 ppm NAA during first day of cold storage. The fruit breadth decreased after 7th day followed by further declined value on 14th day. This trend of reduction continued, and fruit breadth was noted 6.03 cm on 21st day. At the end of cold storage period the average fruit breadth was recorded highest in NAA 200 ppm treatment (6.25 cm). It was trailed by application of NAA 300 ppm, where fruit length was noted as 6.36 cm on storage day. The fruit breadth was declined on 7th day to the tune of 6.25 cm and reduced further with advancement of storage period i.e. on 14th day and noted as 6.09 cm. This declining trend continued more towards end of storage and remained 5.92 cm on 21st day. Therefore, the mean fruit breadth at the end of storage cold storage was declined and recorded as 6.15 cm. Much lower values with declining trend were observed in control treatment. Fruit breadth value on storage day was recorded, 5.85 cm. It reduced in similar manner and recorded 5.16 cm after 21st days of storage with mean value of 5.53 cm.

During 2016-17 of study, the highest value of fruit breadth was also recorded in starting of storage. With the advancement of storage period, guava length showed decreasing trend. At the end of cold storage period, the average fruit length among all the treatments found highest in NAA 200 ppm with average value 6.48 cm. This treatment was followed by NAA 300 ppm treatment where average fruit breadth was recorded 6.39 cm. Minimum average fruit breadth i.e. 5.61 cm was recorded in control treatment and showed declining trend with progression in storage period. NAA 200 ppm was adjusted the best treatment and it was followed by NAA 300 ppm. Significantly lowered values have been noted in control treatment during both years of the research work. However, the interaction was found non-significant between the storage days and treatments. The fruit size in terms of breadth may be Attributed to the increase in cell elongification and cell division caused by NAA is proved by

Table 14. Effect of pre-harvest treatments of chemicals on fruit breadth (cm) of guava cv. Allahabad Safeda under cold storage conditions

Treatment		Storage days (2015-16)					Storage days (2016-17)				
		0day	7thday	14thday	21stday	Mean	0Day	7thday	14thday	21stday	Mean
NAA	100 ppm	6.17	6.06	5.93	5.77	5.98	6.24	6.15	6.04	5.85	6.07
	200 ppm	6.44	6.34	6.20	6.03	6.25	6.67	6.57	6.45	6.24	6.48
	300 ppm	6.36	6.25	6.09	5.92	6.15	6.59	6.48	6.34	6.16	6.39
Salicylic acid	100 ppm	6.17	6.06	5.89	5.68	5.95	6.21	6.10	5.92	5.69	5.98
	200 ppm	6.31	6.19	6.00	5.80	6.08	6.45	6.32	6.14	5.91	6.21
	300 ppm	6.12	5.98	5.80	5.58	5.87	6.38	6.23	6.06	5.82	6.12
Ascorbic acid	75 ppm	6.05	5.90	5.71	5.46	5.78	6.17	6.01	5.81	5.55	5.89
	150 ppm	5.98	5.81	5.62	5.36	5.69	6.14	5.96	5.75	5.49	5.84
	300 ppm	5.88	5.71	5.52	5.24	5.59	6.07	5.90	5.68	5.39	5.76
Control		5.85	5.67	5.45	5.16	5.53	5.95	5.76	5.52	5.21	5.61
Mean		6.13	6.00	5.82	5.60	5.89	6.28	6.15	5.97	5.73	6.03

Factors	**C.D. (p≥0.05)**	**Factors**	**C.D. (p≥0.05)**
Storage days (A)	0.18	Storage days (A)	0.21
Treatments (B)	0.20	Treatments (B)	0.32
Interaction (A X B)	N S	Interaction (A XB)	N S

several research workers. Arora and Singh (2014) recorded significant increase in ber fruit size traits i.e. fruit length, breadth and volume with treatment of NAA 30 ppm. Singh *et al* (2006) also obtained higher in ber fruit size and yield with NAA 60 ppm spray. Yadav *et al* (2004) studied that NAA 30 ppm + 1.5% urea increased the fruit size in ber. Bhati and Yadav (2003) in ber and Godara *et al* (2001) in cv. Umran ber proved the same results. The foliar application of NAA 25 ppm in ber cv. Gola gave better effect on improvement of fruit length and fruit breadth as reported by Bhatia and Yadav (2005).

4.1.2.1.2 Fruit weight

The weight of guava fruits continuously decreased with advancement of storage period (Table 15). The fruit weight values were noted highest during initial stage of cold storage period.

During first year of study, at the end of cold storage period the average fruit weight among all the treatments was observed highest (192.86 g) in salicylic acid200 ppm treatment. As the storage advanced, fruit weight was decreased (193.24 g) after 7th day followed by further declined with value of 192.26 g on 14th day. This trend of reduction continued and fruit weight was noted 191.58 g on 21st day. Next to this, higher fruit weight was noted in salicylic acid 300 ppm. Accordingly, the mean fruit weight at the end of cold storage was decreased and recorded as 183.25 g. On the other hand, much lower values with lessening trend were recorded in control treatment. Fruit weight value on storage day was recorded, 149.55 g. It declined in analogous manner and recorded 146.68 g after 21st days of storage.

During 2016-17, significantly higher value of fruit weight was recorded in salicylic acid 200 ppm with average value 173.76 g. With the advancement of storage duration, fruit weight showed declining trend. After 7th day of storage it was observed as 174.12 g and decreased further during 14th day and 21st day to the tune of 173.20 g and 172.35 g, respectively. It was followed by salicylic acid 300 ppm treatment where fruit weight showed continuous declining trend throughout 7th, 14th and 21st day with equivalent values of 169.34 g, 168.31 g and 167.45 g, respectively with average value of 168.94 g. Declining trend and minimum average fruit weight i.e. 161.87 g were recorded in control treatment.The interaction between storage days and treatment was found to be non-significant.

As the storage advanced the values of fruit weight kept on declining. The values of fruit weight were at their highest during primary stages while lowest during 9th day of cold storage. Maximum guava fruit weight was retained in salicylic acid 200 treatment while significantly lower fruit weight had been registered in control treatment during both years of study. The results of current studies are corroborating with outcome of earlier studies.

Table 15. **Effect of pre-harvest treatments of chemicals on fruit weight (g) of guava cv. Allahabad Safeda under cold storage conditions**

Treatment		Storage days (2015-16)					Storage days (2016-17)				
		0 day	7th day	14th day	21st day	Mean	0 day	7th day	14th day	21st day	Mean
NAA	100 ppm	171.25	170.05	168.87	167.79	169.49	167.82	165.91	164.15	162.42	165.08
	200 ppm	171.56	170.41	169.36	168.33	169.92	168.38	166.48	164.73	163.00	165.65
	300 ppm	178.76	177.61	176.54	175.57	177.12	168.18	166.83	165.68	164.59	166.32
Salicylic acid	100 ppm	173.00	171.80	170.70	169.73	171.31	167.57	166.22	164.97	163.88	165.66
	200 ppm	194.34	193.24	192.26	191.58	192.86	175.38	174.12	173.20	172.35	173.76
	300 ppm	184.77	183.65	182.64	181.94	183.25	170.64	169.34	168.31	167.45	168.94
Ascorbic acid	75 ppm	168.40	167.13	165.90	164.82	166.56	167.49	165.54	163.78	162.03	164.71
	150 ppm	159.43	158.13	156.89	155.81	155.69	167.19	165.22	163.42	161.66	164.37
	300 ppm	154.77	153.42	152.16	151.01	152.84	166.67	164.67	162.85	161.02	163.80
Control		149.55	149.55	148.10	146.68	145.48	165.10	162.92	160.75	158.72	161.87
Mean		170.58	170.58	169.35	168.20	167.21	168.44	166.72	165.18	163.71	166.02

Factors	C.D. (p≥0.05)	Factor	C.D. (p≥0.05)
Storage days (A)	1.16	Storage days (A)	1.28
Treatments (B)	1.83	Treatments (B)	2.03
Interaction (A X B)	N S	Interaction (A XB)	N S

Application of NAA was positive for quality retaining is due to its stimulatory effect on metabolism process of the plant and could be accompanying with decrease or disruption in rate of respiration by NAA, thus reduced the loss of water which is the measure of guava fruit weight (Singh *et al* 2017). El-Sherif *et al* (2000) and Singh *et al* (2004) in guava proved the same results. Bal *et al* (1988) reported in ber that fruit weight was increased with different concentrations of naphthalene acetic acid.

4.1.2.1.3 Specific gravity

The data on specific gravity of guava fruit for different chemicals and storage day's interval are presented in Table 16. It is evident that various chemical applications resulted into very little differences among themselves.

During first year of study, it was observed that as the cold storage advanced, the specific gravity of guava fruit was decreased. However, the highest mean specific gravity (0.96) was observed in guava fruits treated with NAA 200 ppm. On the other hand, lowest mean specific gravity (0.83) of fruit was recorded in control fruits. During second year of study, declined trend with respect to specific gravity of Allahabad Safeda was recorded irrespective of various treatments and this trend continues till 21^{st} day of cold storage. The interaction between storage days and treatments was found to be non-significant in both year of the study.

Specific gravity of guava fruit increased as the fruit matures. A declined trend with respect to specific gravity of fruits was recorded irrespective of various treatments. Similar outcomes have been obtained by various research workers. Singh *et al* (2018) described that decrease in specific gravity in guava fruit might be attributed to loss of weight and volume and also due to the change of starch into sugar. Use of NAA was effective for retention of quality and could be accompanied with hindrance in fruit respiration process by NAA, thus decreased the loss of water which is responsible of fruit weight (Blankenship and Dole 2003).

4.1.2.1.4 Fruit colour

The data relating to guava fruit colour has been displayed in Table 17. The fruit colour changed steadily with advancement of cold storage period as compared to ambient conditions.

Table 16. Effect of pre-harvest treatments of chemicals on specific gravity of guava cv. Allahabad Safeda under cold storage conditions

Treatment		Storage days (2015-16)					Storage days (2016-17)				
		0 day	7th day	14th day	21st day	Mean	0 day	7th day	14th day	21st day	Mean
NAA	100 ppm	0.94	0.92	0.88	0.82	0.89	0.94	0.91	0.87	0.80	0.88
	200 ppm	1.02	0.99	0.94	0.89	0.96	1.10	1.06	1.01	0.95	1.03
	300 ppm	0.98	0.95	0.90	0.83	0.92	0.96	0.94	0.90	0.83	0.91
Salicylic acid	100 ppm	0.94	0.90	0.83	0.75	0.86	0.96	0.93	0.89	0.83	0.90
	200 ppm	0.92	0.90	0.87	0.80	0.87	0.96	0.94	0.91	0.84	0.91
	300 ppm	0.93	0.89	0.84	0.77	0.86	0.95	0.90	0.83	0.74	0.86
Ascorbic acid	75 ppm	0.92	0.88	0.82	0.74	0.84	0.94	0.91	0.86	0.79	0.88
	150 ppm	0.93	0.89	0.82	0.73	0.84	0.96	0.92	0.85	0.77	0.88
	300 ppm	0.94	0.91	0.85	0.77	0.87	0.88	0.86	0.82	0.74	0.83
Control		0.91	0.87	0.81	0.74	0.83	0.89	0.86	0.81	0.74	0.83
Mean		0.94	0.91	0.86	0.78	0.87	0.95	0.92	0.88	0.80	0.89

Factors	**C.D. (p≥0.05)**	**Factors**	**C.D. (p≥0.05)**
Storage days (A)	0.02	Storage days (A)	0.03
Treatments (B)	0.04	Treatments (B)	0.04
Interaction (A X B)	N S	Interaction (A XB)	N S

Table 17. Effect of pre-harvest treatments of chemicals on fruit colour of guava cv. Allahabad Safeda under cold storage conditions

Treatment		Storage days(2015-16)				Storage days (2016-17)			
		0 day	**7th day**	**14th day**	**21st day**	**0 day**	**7th day**	**14th day**	**21st day**
NAA	100 ppm	YG11A	YG12B	YG13C	YG10A	YG10A	YG12A	YG13C	YG10A
	200 ppm	YG11A	YG11B	YG10C	YG12C	YG10B	YG11B	YG10C	YG12C
	300 ppm	YG9C	YG11A	YG11A	YG12C	YG9C	YG11B	YG11C	YG12C
Salicylic acid	100 ppm	GG135A	GG135D	YGG145A	YGG154A	GG135A	GG135B	GG145B	YGG154B
	200 ppm	GG135A	GG135A	YGG145A	YGG154B	YGG145A	GG135A	YGG145A	YGG154A
	300 ppm	GG135B	GG135D	YGG145A	YGG154B	GG135A	GG135D	YGG145B	YGG154A
Ascorbic acid	75ppm	YG9C	YG9C	YG11A	YG11B	YG9C	YG9C	YG11B	YG11B
	150 ppm	YG9C	YG12B	YG13C	YG10C	YG11A	YG12B	YG13C	YG10D
	300 ppm	YG11A	YG10B	YG11B	YG11C	YG10A	YG10B	YG12B	YG12B
Control		YGG154A	YGG145B	YG13C	YOG154A	YGG145A	YGG145B	YG11A	YOG154A

HCC	**Visual Colour**
GG135A, B, D	: Light green
YG10A, B, C, D; 11B, C; 12A, C	: Creamish yellow
YG9C; 11A, C; 12B; 13C	: Light yellow
YGG145A, B, D	: Light yellow green
YGG154A, B, D	: Yellow green
YOG150, 154 A	: Creamish yellow orange

During first year, promising results were obtained in all concentrations of salicylic acid. When fruits were harvest (at 0 day) fruits surface colour was light-green/light green/light yellow/yellow green (YGG 135A, B). After 7 days there was no change in fruit colour in salicylic acid treatments. But, it was recorded light yellow green (YGG145A) on 14th day. Finally, at 21st days it was noted as light yellow green to yellow green (YGG154A/YGG154B) in different salicylic acid treatments. In contrast to it, fruits in control treatment changed their colour to light yellow (YG 13C) on 14th day and creamish yellow orange (YOG154A), on 21st day od cold storage.

During second year of study, the guava fruits were also found best regarding colour development in salicylic acid treatment. On the 7th day of storage, light green (GG135A, B, D) fruit colour was noted. But it had changed to light yellow green (GG145A/YGG145B) during 14th day of storage. At the 21st days of storage, skin colour was observed as yellow green, (YGG154 A/154 B). Whereas in control treatment fruits had shown light yellow green (YGG145B) on 0 and 7th day while on 21st day it was noted as creamish yellow orange (YOG154).

During experimentation, best development was found in all concentrations of salicylic acid while control fruits had shown faster loss of green colour in storage thereby resulted in excessive and early ripening. Treated fruits with salicylic acid, exhibited lower and/or delayed the respiration rate and ethylene production. The change of skin colour from green to yellow in fruits is an indication of fruit ripening process. Salicylic acid was found to be best treatment with respect to skin colour development of the fruit. It may be due to preventing the degradation of chlorophyll and deferring the gathering of carotenoids or gibberellins possibly have a senescence postponing action by obstructing ethylene in ber (Selvin 2002). Results submitted by various research workers are in line with current study. Madhav *et al* (2016) also described that guava fruits treated with salicylic acid resulted in colour change. Singh (1998) had described similar changes in fruit colour in guava fruit. Ranjbaran *et al* (2011) noted that salicylic acid treatments significantly delayed rachis discoloration along with browning in grapes.

4.1.2.1.5 Fruit firmness

The data presented in Table 18 and graphically explained in Fig. 7, 8 reveals fruit firmness. It was significantly affected with pre-harvest sprays of different chemicals and cold storage period intervals. Application of NAA, salicylic acid and ascorbic acid were resulted in higher guava firmness as compared to control treatment.

Table 18. **Effect of pre-harvest treatments of chemicals on fruit firmness (lbs/cm^2) of guava cv. Allahabad Safeda under cold storage conditions**

Treatment		Storage days (2015-16)					Storage days (2016-17)				
		0 day	**7th day**	**14th day**	**21st day**	**Mean**	**0Day**	**7th day**	**14th day**	**21st day**	**Mean**
NAA	100 ppm	17.65	16.86	16.34	16.12	16.74	16.94	16.14	15.71	15.32	16.03
	200 ppm	17.80	17.03	16.50	16.28	16.90	17.08	16.29	15.87	15.49	16.18
	300 ppm	17.95	17.21	16.76	16.49	17.10	17.15	16.38	16.00	15.76	16.32
Salicylic acid	100 ppm	17.83	17.07	16.61	16.32	16.96	17.19	16.40	16.01	15.65	16.32
	200 ppm	18.13	17.42	17.02	16.77	17.34	17.50	16.75	16.41	16.16	16.71
	300 ppm	18.10	17.35	16.92	16.67	17.26	17.45	16.71	16.35	16.09	16.65
Ascorbic acid	75 ppm	17.59	16.79	16.26	16.02	16.67	16.89	16.08	15.60	15.25	15.96
	150 ppm	17.49	16.66	16.14	15.91	16.55	16.81	15.98	15.50	15.14	15.86
	300 ppm	17.51	16.71	16.16	15.82	16.55	16.76	15.91	15.43	15.06	15.79
Control		17.48	16.63	16.05	15.65	16.45	16.71	15.85	15.36	14.97	15.72
Mean		17.75	16.97	16.48	16.21	16.85	17.05	16.25	15.82	15.49	16.15

Factors	**C.D. ($p \geq 0.05$)**	**Factors**	**C.D. ($p \geq 0.05$)**
Storage days (A)	0.17	Storage days (A)	0.20
Treatments (B)	0.27	Treatments (B)	0.32
Interaction (A X B)	N S	Interaction (A XB)	N S

During the year 2015-16, maximum fruit firmness along with declining trend was observed in salicylic acid 200 ppm under cold storage conditions. The firmness of guava fruit was recorded 18.13 lbs/cm^2 on storage day, while on 7th day it was noted as 17.42 lbs/cm^2. Corresponding lower values were recorded on 14th day and 21st day i.e. 17.02 lbs/cm^2, 16.77 lbs/cm^2.The average at the end of cold of storage period was 17.34 lbs/cm^2. This treatment was followed by salicylic acid 300 ppm application with decreasing trend and corresponding values of 18.10 lbs/cm^2, 17.35 lbs/cm^2, 16.92 lbs/cm^2 and 16.67 lbs/cm^2, respectively at 0,7th,14th and 21st days of cold storage with average of 17.26 lbs/cm^2. On the other hand, minimum average value of fruit firmness along with lower figures was observed in control treatment with average of 16.45 lbs/cm^2.

During next year of study, salicylic acid 200 ppm application had also shown maximum fruit firmness but with declining trend. Correspondingly, after 7th day value of firmness was noted as 16.75 lbs/cm^2 and it reduced further to the tune of 16.41 lbs/cm^2 on14th day and 16.16 lbs/cm^2 on 21st day whereas the average was 16.71lbs /cm^2. Next to this better fruit firmness was recorded in salicylic acid 300 ppm with equivalent decreasing trend. Significant lower values of fruit firmness were obtained in control treatment where average firmness was recorded as 15.72 lbs/cm^2. However, the interaction among treatments and storage was found to be non-significant.

Mandal *et al* (2012) reported that fruit firmness followed a declining trend in proportionate with advancement of storage time. Treatment of guava fruits with NAA 100 ppm resulted in highest mean fruit firmness within the specified storage period. Whereas, control fruits had shown faster loss of firmness in storage thereby resulted in excessive softening and shriveling of guava fruits. Higher firmness in fruits due to NAA might be due to postponing senescence, conserving cellular organization and delaying respiration process rate. The results of current study are in agreement with that of Selvan and Bal (2005) in guava and Martinsson *et al* (2006) in strawberry.

4.1.2.1.6 Palatability rating

The data presented in Table 19 and graphically represented in Fig. 9 and 10 showed that decline in taste and appearance of guava fruits continuously and reduced with advancement of cold storage period.

The highest values were recorded in NAA 200 ppm during initial day of storage period during previous year of study. As the storage progressed, palatability rating of guava fruit was decreased after 7th day and further declined on 14th day. This trend of reduction was constant and palatability rating was noted 18.15 on 21th day.

Table 19. **Effect of pre-harvest treatments of chemicals on palatability rating (out of 20.0) of guava cv. Allahabad Safeda under cold storage conditions**

Treatment		Storage days (2015-16)					Storage days (2016-17)				
		0 day	**7th day**	**14th day**	**21st day**	**Mean**	**0 Day**	**7th day**	**14th day**	**21st day**	**Mean**
NAA	100 ppm	18.05	17.80	17.53	17.26	17.66	18.07	17.67	17.31	17.13	17.55
	200 ppm	18.82	18.62	18.40	18.15	18.39	19.20	19.02	18.82	18.61	18.91
	300 ppm	18.76	18.54	18.31	18.02	18.29	18.60	18.41	18.21	18.00	18.31
Salicylic acid	100 ppm	17.82	17.56	17.26	16.95	17.40	18.10	17.70	17.32	17.07	17.55
	200 ppm	18.55	18.32	18.08	17.79	18.19	18.50	18.28	18.05	17.82	18.16
	300 ppm	18.47	18.22	17.97	17.71	18.09	18.62	18.20	17.98	17.80	18.15
Ascorbic acid	75 ppm	17.79	17.53	17.22	16.88	17.36	18.00	17.58	17.19	16.91	17.42
	150 ppm	17.68	17.41	17.07	16.72	17.22	17.86	17.30	16.90	16.55	17.15
	300 ppm	16.85	16.54	16.23	15.88	16.38	17.80	17.14	16.69	16.33	16.99
Control		16.89	16.54	16.18	15.81	16.36	17.68	17.01	16.51	16.14	16.84
Mean		17.96	17.71	17.43	17.12	17.53	18.24	17.83	17.50	17.24	17.70

Factors	**C.D. (p≥0.05)**	**Factors**	**C.D. (p≥0.05)**
Storage days (A)	0.25	Storage days (A)	0.26
Treatments (B)	0.39	Treatments (B)	0.42
Interaction (A X B)	N S	Interaction (A XB)	N S

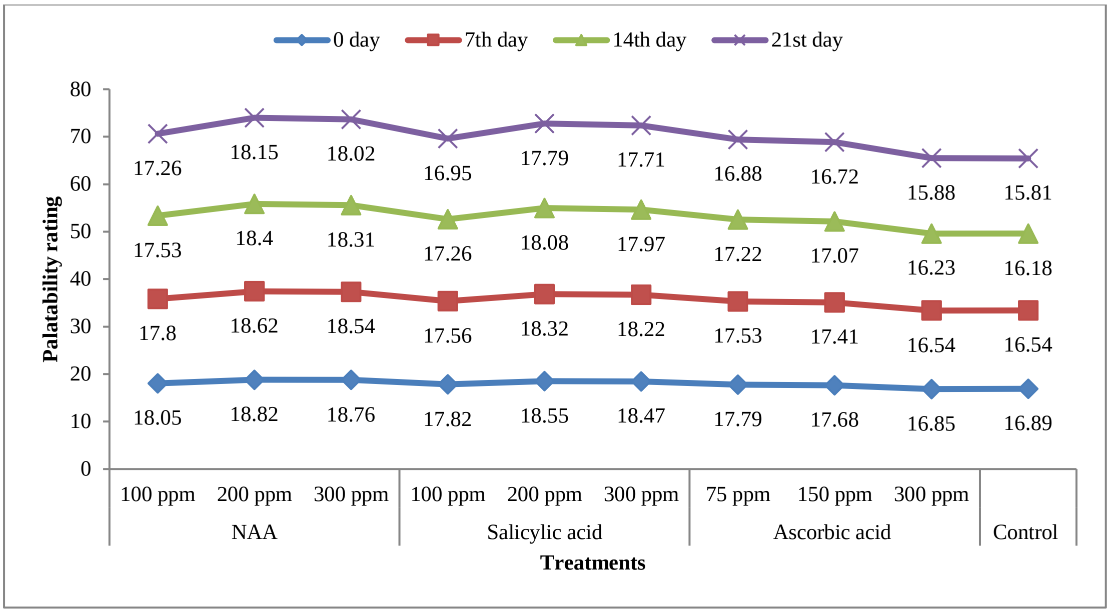

Fig. 9 Effect of pre-harvest application of chemicals on palatability rating (out of 20) of guava under cold storage (2015-16)

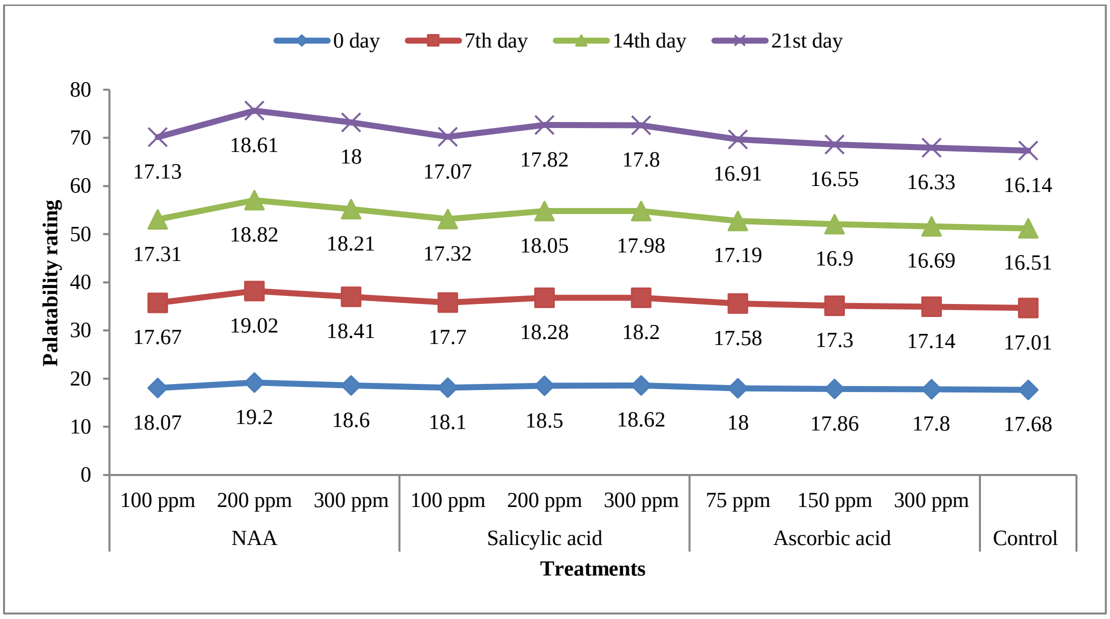

Fig. 10 Effect of pre-harvest application of chemicals on palatability rating (out of 20) of guava under cold storage (2016-17)

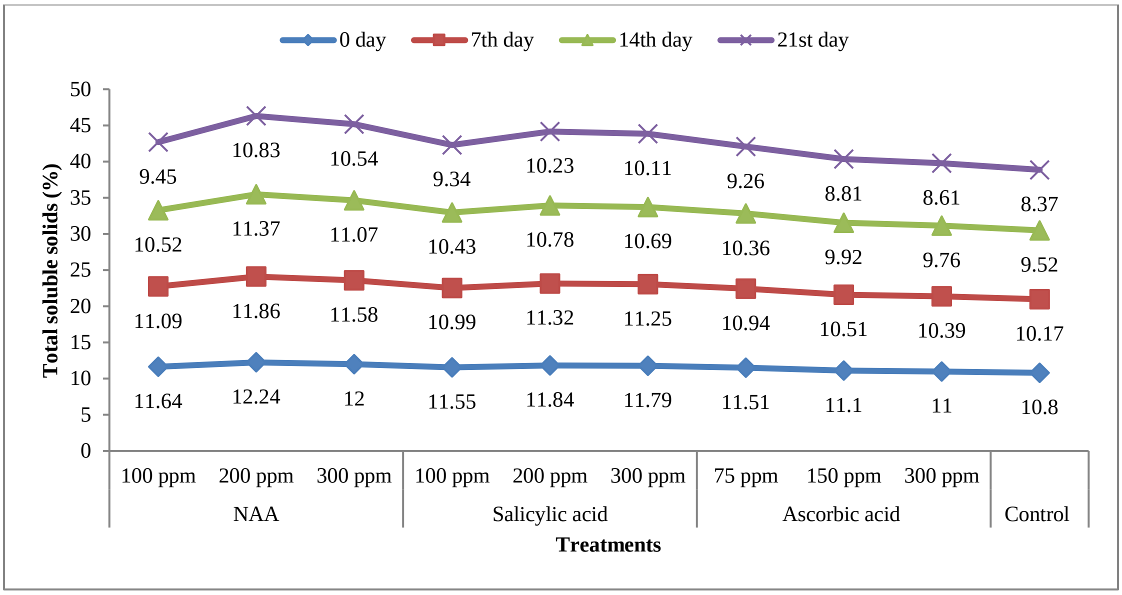

Fig. 11 Effect of pre-harvest application of chemicals on total soluble solids (%) of guava under cold storage (2015-16)

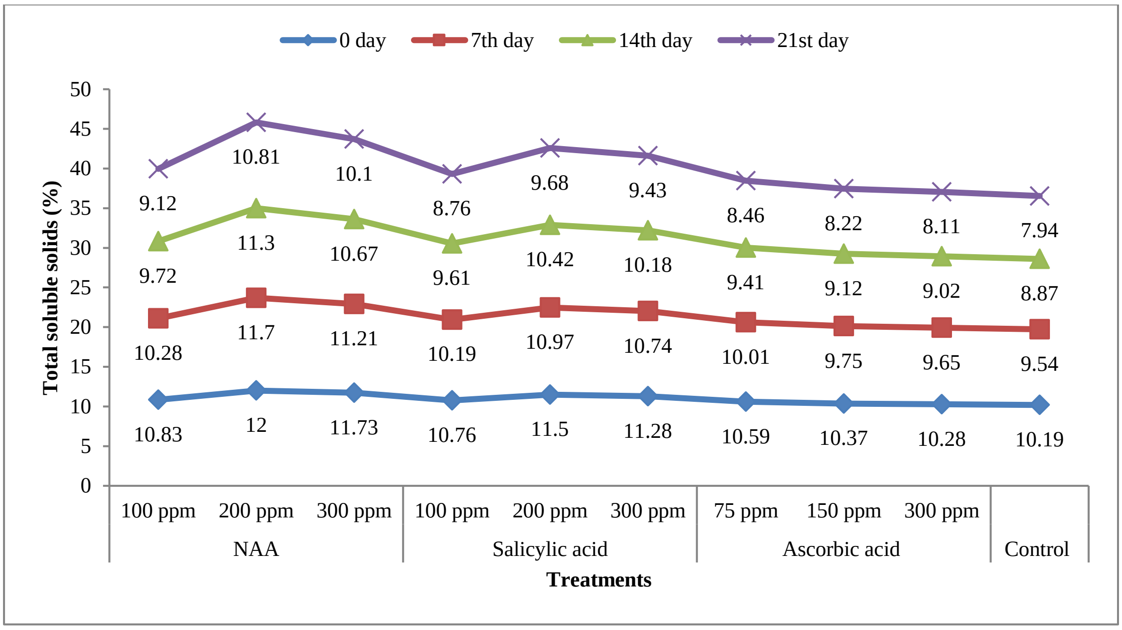

Fig. 12 Effect of pre-harvest application of chemicals on total soluble solids (%) of guava under cold storage (2016-17)

At the end of cold storage period the average palatability rating among all the treatments was observed highest (18.39) in NAA 200 ppm treatment. Higher rating was also noted in fruits treated with NAA 300 ppm, where the mean palatability rating at the end of cold storage period was decreased and recorded as 18.02. Obviously, lower values with decreasing trend were recorded in control treatment. On storage day it was recorded, 16.89, which declined in corresponding manner, and recorded 16.18 after 9 days of storage.

During second year of study, highest value of fruit palatability rating was also recorded at initial stages of storage. With the advancement of storage, guava fruit palatability rating showed decreasing trend. At the end of cold storage period, the average palatability rating of guava fruit, among all the treatments found highest in NAA 200 ppm with average value 18.91. During 7th day of storage it was observed as 19.02 and decreased further during 14th day and 21th day to the tune of 18.82 and 18.61respectively. It was followed by NAA 300 ppm treatment where palatability rating showed continuous decreasing trend throughout 7th, 14th and 21th day with equivalent value of 18.41, 18.21 and 18.00, respectively. Minimum mean, palatability rating (16.84) was recorded in control treatment.

Throughout storage duration the palatability kept on decreasing. NAA 200 ppm treatment is the premium treatment followed by NAA 300 ppm. Here also lowest values were experienced in control treatment. With the advancement of storage, guava fruit palatability rating showed decreasing trend. The interaction between storage days and treatments was found non-significant. The results of current study are in agreement with Singh *et al* (2017) who reported that guava fruits treated with NAA at different days of storage get the highest score and considered 'excellent' with respect to palatability. Deepthi and Sekhar (2015) proved in guava fruit that BA exhibited longer shelf life with maximum TSS, sugars and ascorbic acid content along with highly acceptable fruit quality during cold storage.

4.1.2.1.7 Seed weight

The data on seed weight of guava fruit for various chemical treatments and storage days are presented in Table 20. It was generalized that various chemical applications resulted into non-significant differences among themselves. Seed weight declines constantly with the increase in storage period.

During the first year of study, it was observed that as the storage progressed, the seed weight of guava fruit decreased. However, the highest mean seed weight (6.20 gm) was observed in guava fruits treated with NAA 100 ppm. On the other hand, lowest mean seed weight (5.22 gm) of guava was recorded in control fruits. The highest mean value of seed weight in second year was obtained 6.86 g in NAA 100 ppm.

Table 20. **Effect of pre-harvest treatments of chemicals on seed weight (g) per fruit of guava in cv. Allahabad Safeda under cold storage conditions**

Treatment		**Storage days (2015-16)**					**Storage days (2016-17)**				
		0 day	**7th day**	**14th day**	**21st day**	**Mean**	**0 Day**	**7th day**	**14th day**	**21st day**	**Mean**
NAA	100 ppm	6.29	6.24	6.17	6.08	6.20	7.02	6.94	6.82	6.66	6.86
	200 ppm	6.17	6.11	6.01	5.90	6.05	6.81	6.72	6.59	6.41	6.63
	300 ppm	6.02	5.95	5.84	5.71	5.88	6.31	6.2	6.06	5.85	6.11
Salicylic acid	100 ppm	5.70	5.61	5.48	5.33	5.53	6.00	5.87	5.72	5.49	5.77
	200 ppm	5.68	5.57	5.43	5.27	5.49	5.95	5.81	5.65	5.41	5.71
	300 ppm	5.74	5.66	5.54	5.40	5.59	6.12	6.01	5.87	5.66	5.92
Ascorbic acid	75 ppm	5.64	5.51	5.35	5.20	5.43	5.90	5.75	5.57	5.31	5.63
	150 ppm	5.60	5.46	5.29	5.11	5.37	5.86	5.7	5.51	5.25	5.58
	300 ppm	5.57	5.42	5.25	5.06	5.33	5.83	5.66	5.46	5.19	5.54
Control		5.49	5.33	5.14	4.92	5.22	5.79	5.59	5.36	5.07	5.45
Mean		5.79	5.69	5.55	5.40	5.61	6.16	6.03	5.86	5.63	5.92
Factors		**C.D. (p≥0.05)**					**Factors**		**C.D. (p≥0.05)**		
Storage days (A)		N.S.					Storage days (A)		N.S.		
Treatments (B)		N.S.					Treatments (B)		0.08		
Interaction (A X B)		N S					Interaction (A X B)		N.S.		

Higher seed weight values were recorded during initial phases of storage period than end of the storage. Throughout cold storage a decreasing trend was accessed. NAA 100 ppm is the unsurpassed treatment followed NAA 200 ppm whereas control treatment displayed lowest values throughout the course of study. The interaction between storage days and treatments was found to be non-significant. Several research workers, Singh *et al* (2017) and Lal and Das (2017) in guava crop are in close conformity with the findings of present studies.

4.1.2.1.2 Bio-chemical Characters of Fruits

4.1.2.1.2.1 Total soluble solids

The data pertaining to total soluble solids of guava fruit under cold storage conditions has been presented in Table 21 and Fig. 11 and 12. The results reveal that TSS content of the fruit decreased up to end of the storage in all chemical treatments and at various intervals.

During first year of study, total soluble solids of fruits varied significantly among treatments. The highest mean total soluble solids (11.58%) were recorded in NAA 200 ppm treatment. TSS content was noted 12.24 per cent at 0 days of storage but it showed declining trend and after 7th day and it was recorded as 11.86 per cent. This decreasing trend continued up to end of the storage while at 14th day it was recorded 11.37 per cent and 21st day 10.83 per cent. It was followed by NAA 300 ppm and TSS reduced with decreasing trend to the average of 11.30 per cent. Similar declining trend was also seen during control treatment where it showed least values of TSS with average of 9.72 per cent.

During second year of study, the highest total soluble solids (11.45%) were recorded in NAA 200 ppm treatment. It showed reduced values from 12.00 per cent on storage day to 11.70 per cent, 11.30 per cent and 10.81 per cent on 7th, 14th and 21st days, respectively but with declining trend. It was trailed by NAA 300 ppm where TSS reduced from 11.73 per cent (0 day) to 10.10 per cent (at end of the storage) with average of 10.93 per cent. Significantly lower values of TSS were recorded in control treatment with average of 9.14 per cent. A reduction in TSS content was observed under storage in all the treatments; however, its content was sustained to an appreciable level irrespective of the treatments.

Maximum TSS was recorded in NAA 200 ppm treatment followed by NAA 300 ppm treatment. Total soluble solids of guava fruits improved gradually with the advancement of storage period. Control treatment had lowermost values concerning TSS. The interaction was found to be significant between storage days and treatments during both the years. Similar results were also observed by Selvan and Bal (2005) in guava. However, Mandal *et al* (2012) reported that TSS content of guava fruits increased initially up to 20 days of cold storage period and thereafter started diminishing gradually. Iqbal *et al* (2009) recorded significant differences among several fruit quality parameters i.e. total sugars and TSS, acidity by the NAA in guava.

Table 21. Effect of pre-harvest treatments of chemicals on total soluble solids (%) of guava cv. Allahabad Safeda under cold storage conditions

Treatment		Storage days (2015-16)					Storage days (2016-17)				
		0 day	7th day	14th day	21st day	Mean	0 Day	7th day	14th day	21st day	Mean
NAA	100 ppm	11.64	11.09	10.52	9.45	10.68	10.83	10.28	9.72	9.12	9.99
	200 ppm	12.24	11.86	11.37	10.83	11.58	12.00	11.70	11.30	10.81	11.45
	300 ppm	12.00	11.58	11.07	10.54	11.30	11.73	11.21	10.67	10.10	10.93
Salicylic acid	100 ppm	11.55	10.99	10.43	9.34	10.58	10.76	10.19	9.61	8.76	9.83
	200 ppm	11.84	11.32	10.78	10.23	11.04	11.50	10.97	10.42	9.68	10.64
	300 ppm	11.79	11.25	10.69	10.11	10.96	11.28	10.74	10.18	9.43	10.41
Ascorbic acid	75 ppm	11.51	10.94	10.36	9.26	10.52	10.59	10.01	9.41	8.46	9.62
	150 ppm	11.10	10.51	9.92	8.81	10.09	10.37	9.75	9.12	8.22	9.37
	300 ppm	11.00	10.39	9.76	8.61	9.94	10.28	9.65	9.02	8.11	9.27
Control		10.80	10.17	9.52	8.37	9.72	10.19	9.54	8.87	7.94	9.14
Mean		11.55	11.01	10.44	9.56	10.64	10.95	10.40	9.83	9.06	10.06

Factors	**C.D. (p≥0.05)**	**Factors**	**C.D. (p≥0.05)**
Storage days (A)	0.27	Storage days (A)	0.25
Treatments (B)	0.41	Treatments (B)	0.39
Interaction (A X B)	0.83	Interaction (A XB)	N S

Table 22. Effect of pre-harvest treatments of chemicals on acidity (%) of guava cv. under cold storage conditions

Treatment		Storage days (2015-16)					Storage days (2016-17)				
		0 day	**7th day**	**14th day**	**21st day**	**Mean**	**0 day**	**7th day**	**14th day**	**21st day**	**Mean**
NAA	100 ppm	0.85	0.78	0.70	0.62	0.74	0.74	0.67	0.58	0.49	0.62
	200 ppm	0.78	0.69	0.59	0.48	0.64	0.69	0.60	0.50	0.40	0.50
	300 ppm	0.80	0.71	0.62	0.52	0.66	0.70	0.61	0.51	0.41	0.56
Salicylic acid	100 ppm	0.86	0.79	0.72	0.65	0.76	0.75	0.68	0.60	0.52	0.64
	200 ppm	0.81	0.73	0.65	0.56	0.69	0.71	0.63	0.54	0.44	0.58
	300 ppm	0.83	0.76	0.68	0.59	0.72	0.73	0.66	0.57	0.48	0.61
Ascorbic acid	75 ppm	0.86	0.80	0.73	0.66	0.76	0.76	0.70	0.63	0.56	0.66
	150 ppm	0.88	0.82	0.76	0.69	0.79	0.78	0.72	0.66	0.59	0.69
	300 ppm	0.9	0.85	0.80	0.73	0.82	0.8	0.75	0.69	0.62	0.72
Control		0.94	0.91	0.86	0.80	0.88	0.84	0.81	0.78	0.73	0.79
Mean		0.85	0.78	0.71	0.63	0.74	0.75	0.68	0.61	0.52	0.64

Factors	**C.D. (p≥0.05)**	**Factors**	**C.D. (p≥0.05)**
Storage days (A)	0.01	Storage days (A)	0.02
Treatments (B)	0.01	Treatments (B)	0.03
Interaction (A X B)	0.02	Interaction (A XB)	0.05

4.1.2.1.2.2 Acidity

The data presented in Table 22 reveals that acidity in guava fruit firmness was significantly affected with pre-harvest sprays of different chemicals and storage days. Application of NAA, salicylic acid and ascorbic acid were resulted in lower acidity of the fruit as compared to control treatment.

Minimum fruit acidity along with declining trend was observed in NAA 200 ppm under cold storage conditions during 2015-16. On day of storage fruit acidity was recorded 0.78 per cent. Likewise, lower values were recorded on 7th, 14th day and 21st day i.e. 0.69 per cent, 0.59 per cent, 0.48 per cent with average of 0.64%. Lower acidity 0.66 per cent was also analyzed in NAA 300 ppm application. Maximum average value of acidity (0.88%) along with higher values was observed in control treatment.

During second year of study, NAA 200 ppm application has also shown minimum acidity. Mean value in this treatment was calculated as 0.50 per cent and fruit acidity had shown declining trend. Correspondingly, after 7th day value of acidity was noted as 0.60 per cent and it reduced further with advancement in storage period. It was trailed by NAA 300 ppm with same decreasing trend. Lowest values of fruit acidity were obtained in control treatment where average acidity was recorded as 0.79 per cent.

Acidity declined during storage period under cold conditions, but decline was very gradual. NAA 200 ppm application was found to best treatment as it continued with lowest acidity values while next to it is NAA 300 ppm treatment. Highest values of acidity were experienced in control treatment. Ingle *et al* (2001) ; Pawar *et al* (2005) and Singh *et al* (1996) in winter guava also recorded that NAA treatment resulted in better quality in terms of lower acidity.

4.1.2.1.2.3 Vitamin C

The data displayed in Table 23 shows that the vitamin C content of 'Allahabad Safeda' guava fruit decreased gradually with the advancement of storage period. The perusal of data showed that vitamin C content was at higher end during the start of storage. As the storage progressed it goes on decreasing till the end of storage.

During the 2015-16, highest values of vitamin C were recorded immediately after harvesting of the fruits. A declining trend in its content was noted with the advancement of storage time. It was found highest in NAA 200 ppm treatment (average 190.64 mg/100g). Further declined values of 7th day (201.64mg/100g), 14th day (176.64 mg/100g) and 21st day (154.64mg/100g) under cold storage conditions also confirmed the same trend. It was followed by NAA 300 ppm with average value of 147.58 mg/100g. On the other hand, minimum vitamin C was noted in control treatment to the tune of 113.78 mg/100g with same declining trend.

Table 23. Effect of pre-harvest treatments of chemicals on vitamin C (mg/100 g) of guava cv. Allahabad Safeda under cold storage Conditions

Treatment		Storage days (2015-16)					Storage days (2016-17)				
		0day	7thday	14thday	21stday	Mean	0day	7thday	14thday	21stday	Mean
NAA	100 ppm	231.66	196.81	165.42	137.23	182.78	230.86	192.10	155.51	120.32	174.70
	200 ppm	229.64	201.64	176.64	154.64	190.64	228.60	196.04	164.55	134.88	181.02
	300 ppm	227.51	197.25	171.34	147.58	185.92	230.64	196.33	164.35	132.77	181.00
Salicylic acid	100 ppm	232.01	196.73	163.11	133.23	181.27	234.10	191.90	153.31	117.07	174.10
	200 ppm	228.60	197.11	169.62	144.01	184.83	231.00	195.29	161.82	128.18	179.07
	300 ppm	230.34	196.86	166.58	140.58	183.59	232.24	195.24	159.14	125.55	178.04
Ascorbic acid	75 ppm	233.00	197.21	162.88	131.00	181.02	229.83	186.19	147.58	110.47	168.52
	150 ppm	232.48	196.00	160.05	126.45	178.75	231.96	186.97	148.17	103.12	167.56
	300 ppm	227.68	189.85	154.75	119.71	173.00	228.00	182.08	138.07	94.01	160.54
Control		225.97	187.33	150.18	113.78	169.32	230.45	180.26	131.61	85.98	157.08
Mean		229.89	195.68	164.06	134.82	181.11	230.77	190.24	152.41	115.24	172.16

Factors	C.D. (p≥0.05)	Factors	C.D. (p≥0.05)
Storage days (A)	7.18	Storage days (A)	6.78
Treatments (B)	11.35	Treatments (B)	10.72
Interaction (A X B)	N S	Interaction (A XB)	N S

During the year 2016-17, highest mean values of vitamin C were recorded in NAA 200 and NAA 300 ppm treatments. The values of vitamin C decreased with extension in storage period from 7th day to 21st day. Overall average vitamin C content was noted 181.02mg/100g in NAA 200 ppm and 181 mg/100 g in NAA 300 ppm. Least amount of vitamin c was noted in control treatment with average value of 157.08 mg/100g.

The interaction was found non-significant between storage days and treatments. NAA 200 was the best treatment followed by NAA 300 ppm with respect to vitamin C of guava fruit. Selvan and Bal (2005) and Mandal *et al* (2012) and observed similar results in winter guava. These findings are in agreement with those of Singh and Bal (2008) in ber and Ahmed and Singh (2000) in mango.

4.1.2.1.2.4 Total sugars

The data regarding the total sugars are presented in Table 24. The total sugars increased significantly up to 14 days of cold storage. It was recorded that after steady increase in total sugars up to 7th day of storage and afterwards increase was slightly sharp up to 14 days and declining trend was noted after that.

During first year of study, maximum mean total sugars (7.16%) were estimated in fruits treated with NAA 200 ppm. After 0 day of storage the value was recorded 7.07 per cent whereas it increased during 7th and 14th to the tune of 7.24 per cent, 7.72 per cent, respectively. Then a decline (6.60 %) was noted on 21st day. This treatment was followed by NAA 300 ppm with corresponding trend and average value 7.09 per cent.

During second year, the highest total sugars were also noted in NAA 200 treatment with similar trend and average value of 7.65 per cent. Total sugar value was 7.57 per cent at time of storage and it inclined to 8.22 per cent (14th day) and then again declined during 21st day i.e. 7.10 per cent. While much lower total sugars were recorded in control treatment (6.81%).

During various storage intervals it was noted that there was an enhancement in total sugar with advancement in storage duration. More over this increase might possibly due to dehydration, as in most of the treatments, fruits showed high physiological weight loss. Increase in total sugars was recorded up to 7th day of storage and afterwards increase was slightly sharp up to 14 days and after that a declining trend was noted. Total sugars were assessed the highest in NAA 200 treatment followed by NAA 300 ppm application while control treatment experienced significantly lowest values. The interaction between storage days and treatments was found non-significant during the course of investigation. The present investigation is in conformity with the results reported by Bisen *et al* (2014) in guava and Bal *et al* (1981), (1982), (1984) in ber.

Table 24. Effect of pre-harvest treatments of chemicals on total sugars (%) of guava cv. Allahabad Safeda under cold storage conditions

Treatment		**Storage days (2015-16)**					**Storage days (2016-17)**				
		0Day	**7th day**	**14th day**	**21st day**	**Mean**	**0day**	**7th day**	**14th day**	**21st day**	**Mean**
NAA	100 ppm	6.45	6.57	6.99	5.92	6.48	7.24	7.36	7.79	6.74	7.28
	200 ppm	7.07	7.24	7.72	6.60	7.16	7.57	7.72	8.22	7.10	7.65
	300 ppm	7.03	7.18	7.63	6.52	7.09	7.46	7.60	8.09	6.98	7.53
Salicylic acid	100 ppm	6.13	6.25	6.66	5.66	6.18	7.18	7.30	7.78	6.75	7.25
	200 ppm	6.94	7.08	7.52	6.42	6.99	7.33	7.46	7.96	6.87	7.41
	300 ppm	6.75	6.87	7.30	6.21	6.78	7.28	7.40	7.89	6.82	7.35
Ascorbic acid	75 ppm	6.23	6.34	6.74	5.79	6.28	7.03	7.14	7.61	6.59	7.09
	150 ppm	6.19	6.30	6.69	5.75	6.23	6.94	7.05	7.51	6.56	7.02
	300 ppm	6.11	6.23	6.61	5.68	6.16	6.83	6.95	7.40	6.47	6.91
Control		6.03	6.14	6.51	5.59	6.07	6.74	6.85	7.29	6.37	6.81
Mean		6.49	6.62	7.04	6.01	6.54	7.16	7.28	7.75	6.72	7.23

Factors	**C.D. (p≥0.05)**	**Factors**	**C.D. (p≥0.05)**
Storage days (A)	0.15	Storage days (A)	0.23
Treatments (B)	0.25	Treatments (B)	0.36
Interaction (A X B)	NS	Interaction (A XB)	NS

4.2 Effect of Post-Harvest Treatments on Shelf Life of Guava cv. Allahabad Safeda under Ambient and Cold Storage Conditions

4.2.1 Ambient Storage Studies

4.2.1.1 Physical Characters of Fruits

4.2.1.1.4 Fruit colour

The data pertaining to guava fruit colour is presented in Table 25. The fruit colour changed progressively with advancement of ambient storage period.

During first year of study, salicylic acid applications found to very effective as for as surface colour of guava fruit is concerned. During harvesting the fruits were light-yellow green (YGG 145A and B) in colour. As the storage advanced the fruits further changed their colour. But comparative to other treatments, changes were slow in salicylic acid treatment. After storage of 3 days the fruit colour was light green or light yellow green (GG135D/YGG145B) while it had changed with storage progression i.e. light yellow/light yellow green/ (YG11A/YGG145A) on 6th day and creamish yellow/ light yellow (YG9C, 10A/11B) on 9th day of storage. On the other hand, fruits in control treatment changed their colour to creamish orange yellow (YOG 150A) with frequent ripening.

During second year of study, same observation was recorded regarding colour development in salicylic acid treatment. On the 3rd day of storage the fruits were of light green/ light yellow green colour (GG135B/GG135A/YGG145D). Fruit colour was changed to light yellow/ light yellow green (YG11A/YGG145A/YGG145B) on 6th day and light yellow/ creamish yellow (YG11C/YG9C/YG10B) on 9th day of storage. Whereas the fruits in control treatment had shown light yellow (YG11D) and creamish orange yellow (YOG150A) on 3rdand 9th day, respectively.

Fruit colour changed gradually with advancement of ambient storage period. Salicylic acid application had exhibited hopeful results. Fruits in control treatment changed their colour to light yellow green/creamish yellow and normal ripening pace was noted. Treated fruits with salicylic acid, exhibited lower respiration rate and ethylene production. The change of skin colour from green to yellow in fruits is an indication of fruit ripening process. Salicylic acid was found to be best treatment with respect to skin colour development of the fruit.

Table 25. Effect of post-harvest treatments of chemicals on fruit colour of guava cv. Allahabad Safeda under ambient storage conditions

Treatment		Storage days(2015-16)			Storage days (2016-17)		
		3rd day	6th day	9th day	3rd day	6th day	9th day
NAA	100 ppm	YG12B	YG13C	YG10A	YG12A	YG13C	YG10C
	200 ppm	YG11C	YG10B	YG12B	YG11B	YG10C	YG12C
	300 ppm	YG11A	YG11A	YG12C	YG11B	YG11C	YG12C
Salicylic acid	100 ppm	GG135D	YG11A	YG11B	GG135B	YG11A	YG11C
	200 ppm	GG135D	YGG145A	YG9C	GG135A	YGG145A	YG9C
	300 ppm	YGG145B	YGG145A	YG10A	YGG145D	YGG145 B	YG10B
Ascorbic acid	75ppm	YG9C	YG10B	YG10B	YG9D	YG10C	YG10B
	150 ppm	YGG145A	YG11B	YG12C	YGG145B	YG11B	YG12D
	300 ppm	YGG145A	YG12C	YOG150A	YGG154D	YG12D	YOG150A
Control		YGG154A	YOG150A	YOG150A	YG11D	YOG150	YOG150A

0 YGG145A and B

HCC	**Visual Colour**
GG135A, B, D	: Light green
YG10A, B, C; 11B; 12C	: Creamish yellow
YG9C, D; 11A, B, C, D; 12A, B, D; 13C	: Light yellow
YGG145A, B, D	: Light yellow green
YGG154A	: Yellow green
YOG150A	: Creamish orange yellow

The change in fruit colour may be due to preventing the degradation of chlorophyll and deferring the gathering of carotenoids or gibberellins possibly have a senescence postponing action by obstructing ethylene in guava (Selvin 2002). Similarly, Reddy *et al* (2016) described that total colour change was improved progressively with increase in the storage duration. Madhav *et al* (2018) also described that guava fruits treated with salicylic acid resulted in colour change and minimum weight loss but sustained ascorbic acid content along with maximum firmness. Salicylic acid treatments significantly delayed rachis discoloration along with browning in grapes (Ranjbaran *et al* 2011).

4.2.1.1.5 Fruit firmness

The data presented in Table 26 and graphically explained in Fig. 13 and 14 reveals that the guava fruit firmness was significantly affected with pre-harvest sprays of different chemicals and storage days. Post-harvest application of NAA, salicylic acid and ascorbic acid were resulted in higher guava firmness as compared to control treatment. Hong *et al* (2012) also supported the fact that guava exhibited a quick loss of firmness which contributes significantly to its short postharvest life and susceptibility to fungal infection.

Maximum fruit firmness along with declining trend was observed in salicylic acid 200 ppm under ambient storage conditions during first year study. On 3rd day of storage, firmness of guava fruit was recorded 15.92 lbs/cm^2 whereas the mean value at time of storage was 16.59 lbs/cm^2. Corresponding lower values were recorded on 6th day and 9th day i.e. 15.53 lbs/cm^2, 15.29 lbs/cm^2. At the end of ambient storage period, the average fruit firmness was recorded 15.95 lbs/cm^2. This treatment was followed by salicylic acid 300 ppm application with decreasing trend and corresponding values of 14.98 lbs/cm^2, 14.82 lbs/cm^2, 14.58 lbs/cm^2 on 3rd, 6thand 9th day of storage respectively with average of 15.25 lbs/cm^2.On the other hand, minimum average values of fruit firmness along with lower figures were observed in control treatment with average of 13.59 lbs/cm^2.

During second year of study, maximum fruit firmness was also reported in salicylic acid 200 ppm. Prior to storage mean was calculated as 16.54lbs/cm^2 and declining trend was recorded. Next to 200 ppm salicylic acid, fruit firmness was also noted higher in 300 ppm salicylic acid with same decreasing trend and average of 14.99 lbs/cm^2. Lowest values of fruit firmness were obtained in control treatment where average firmness was recorded as 11.55 lbs/cm^2.

Table 26. Effect of post-harvest treatments of chemicals on fruit firmness (lbs/cm^2) of guava cv. Allahabad Safeda under ambient storage conditions

Treatment		Storage days (2015-16)				Storage days (2016-17)			
		3rd day	6th day	9th day	Mean	3rd day	6th day	9th day	Mean
NAA	100 ppm	14.03	13.56	13.32	14.37	13.21	12.78	12.63	12.87
	200 ppm	14.15	13.63	13.39	14.45	13.39	12.90	12.75	13.01
	300 ppm	14.64	14.34	14.10	14.95	14.59	14.35	14.20	14.38
Salicylic acid	100 ppm	14.11	13.76	13.52	14.50	14.13	13.88	13.73	13.91
	200 ppm	15.92	15.53	15.29	15.95	15.67	15.36	15.21	15.41
	300 ppm	14.98	14.82	14.58	15.25	15.12	15.00	14.85	14.99
Ascorbic acid	75 ppm	13.92	13.47	13.23	14.28	13.10	12.69	12.54	12.78
	150 ppm	13.84	13.38	13.14	14.19	12.99	12.56	12.41	12.65
	300 ppm	13.82	13.36	13.12	14.19	11.99	11.54	11.39	11.64
Control		13.05	12.60	12.36	13.59	11.80	11.50	11.35	11.55
Mean		13.23	12.71	11.62	13.54	13.60	13.26	13.11	13.32
0 Day Mean		**16.59**				**0 Day Mean**		**16.54**	
Factors		**C.D. (p≥0.05)**				**Factors**		**C.D. (p≥0.05)**	
Storage days (A)		0.28				Storage days (A)		0.32	
Treatments (B)		0.52				Treatments (B)		0.58	
Interaction (A X B)		N S				Interaction (A XB)		N S	

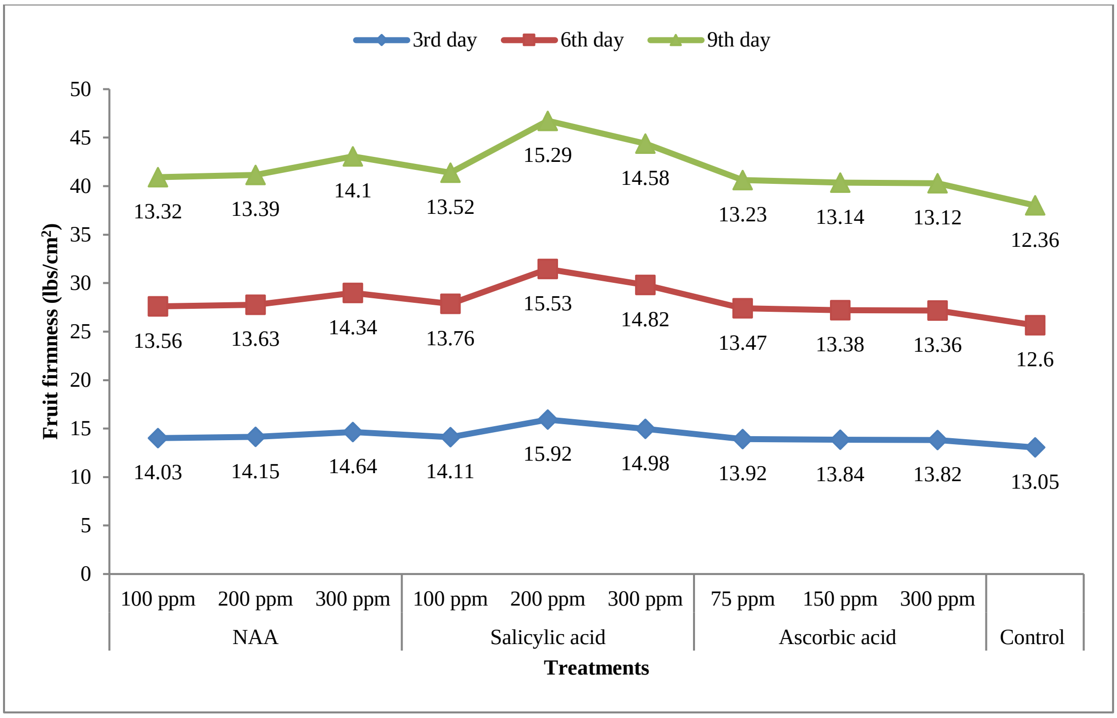

Fig. 13 Effect of post-harvest application of chemicals on fruit firmness (lbs/cm^2) of guava under ambient storage (2015-16)

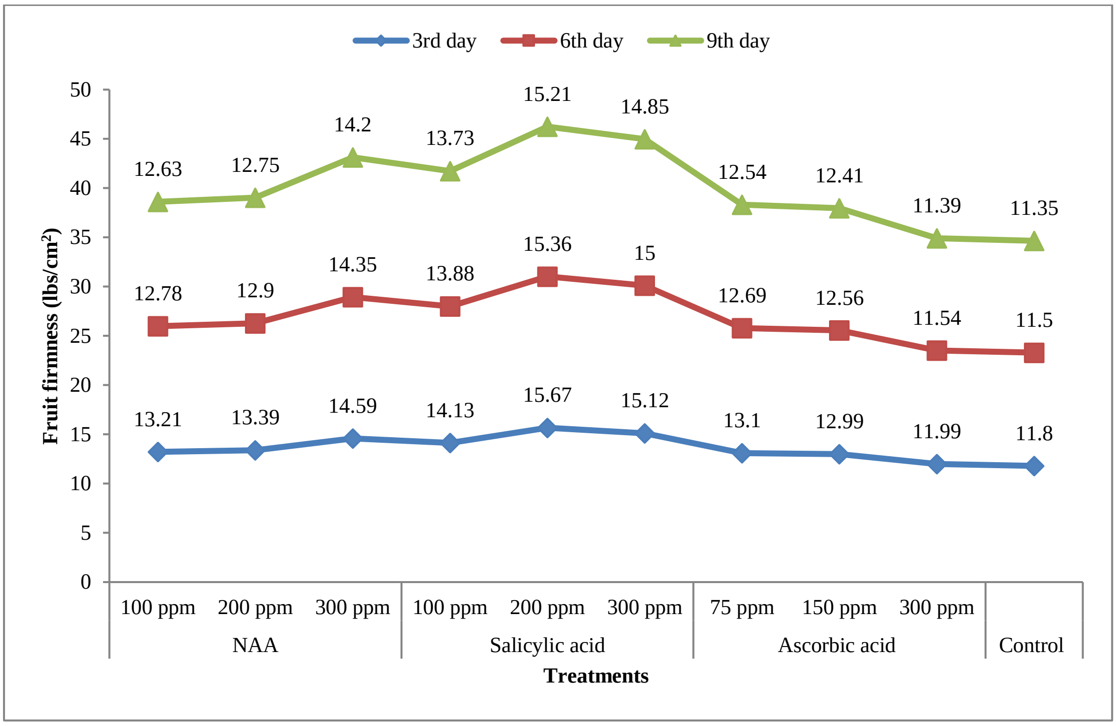

Fig. 14 Effect of post-harvest application of chemicals on fruit firmness (lbs/cm^2) of guava under ambient storage (2016-17)

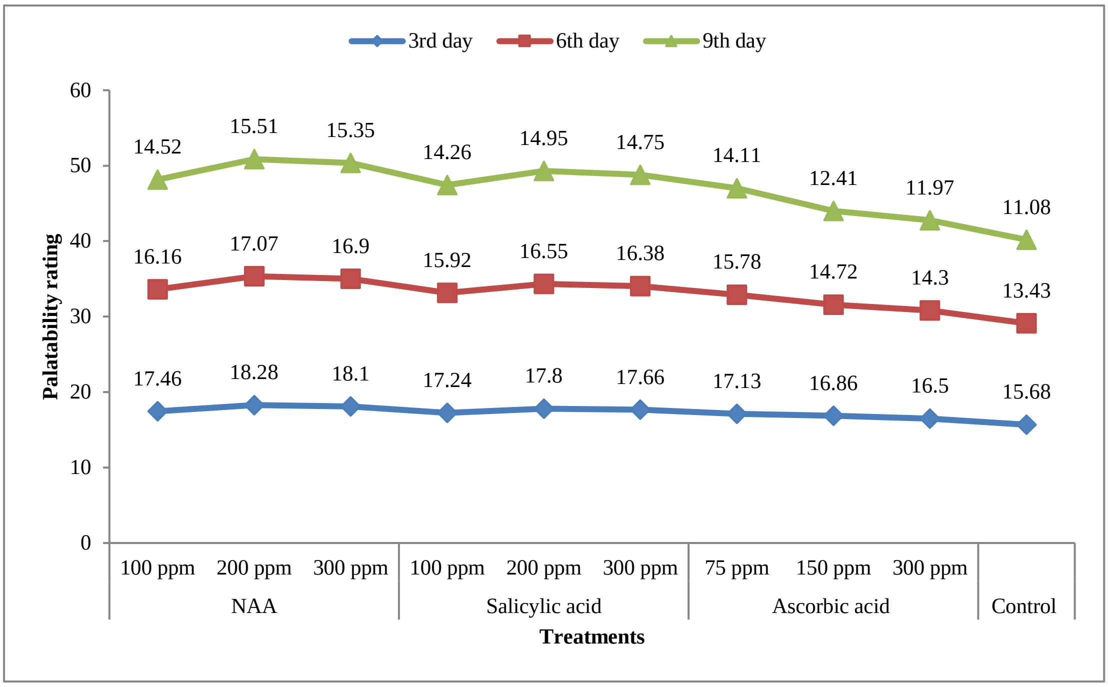

Fig. 15 **Effect of post-harvest application of chemicals on palatability rating (out of 20) of guava under ambient storage (2015-16)**

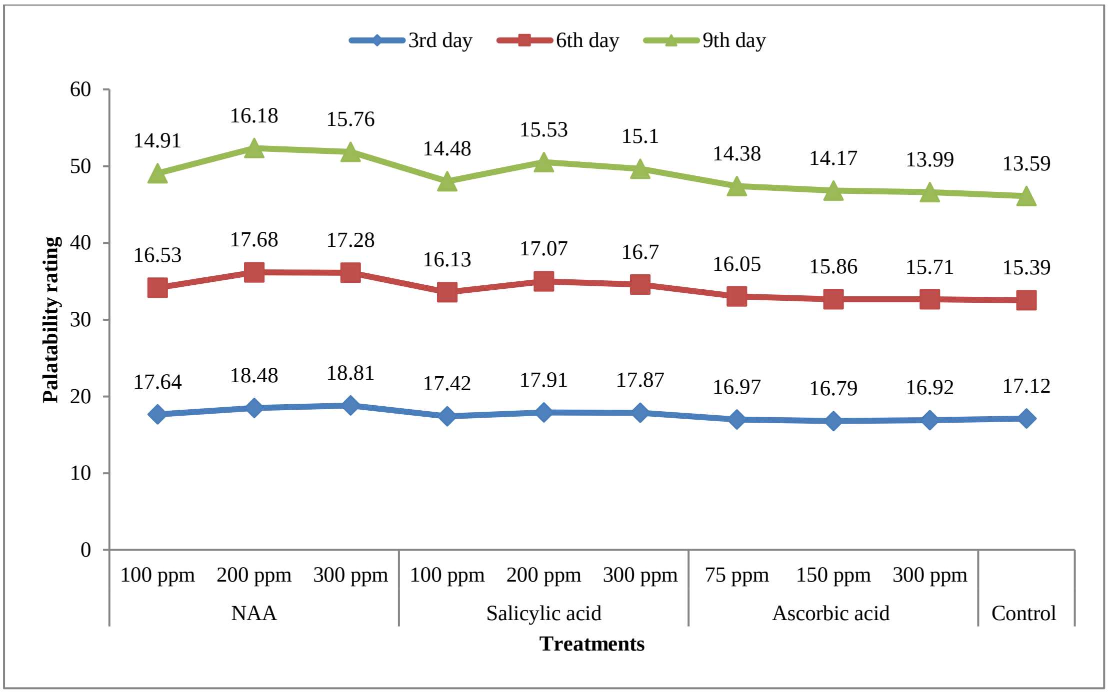

Fig. 16 Effect of post-harvest application of chemicals on palatability rating (out of 20) of guava under ambient storage (2016-17)

The interaction between storage days and treatments was found to be non-significant. Singh *et al* (1998) recorded the highest yield and improved fruit firmness in winter season guava with NAA 600 ppm. Niranjala *et al* (2001) found advanced firmness in bananas fruits treated with NAA and reported that NAA treatment deferred the loss of firmness.

4.2.1.1.6 Palatability rating

The data presented in Table 27 and graphically delineated in Fig. 15 and 16 shows that decline in taste and appearance of guava fruits continuously and rapidly declined with advancement of ambient storage period in all the treatments.

During first year of study, mean rating (16.95) was recorded in NAA 200 ppm at end of ambient storage period. As the storage progressed, palatability rating of guava fruit was decreased after 3rd day to the value of 18.28 followed by further declined value of 17.07 on 6th day. This trend of reduction was continual and palatability rating was noted 15.51 on 9th day. It was followed by application of NAA 300 ppm, where palatability rating was noted as 18.10 on storage day. Palatability rating was declined with advancement of storage period i.e. on 6th day and noted as 16.90. This decreasing trend continued more towards end of storage and remained 15.35 on 9th day. Consequently, the mean palatability rating at the end of storage period was decreased and recorded as 16.78. However, lower values with decreasing trend were recorded in control treatment. On storage day it was recorded 15.68 with average 13.40. It declined in corresponding manner and recorded 11.08 after 9th days of storage.

During second year of study, at the end of ambient storage period, the average palatability rating of guava fruit among all the treatments found highest in NAA 200 ppm with average value 17.45. Highest values of fruit palatability rating were also recorded at initial stages of storage. With the advancement of storage, guava fruit palatability rating revealed decreasing trend. Higher rating was also recorded in NAA 300 ppm where palatability rating showed continuous decreasing trend throughout 3rd, 6th and 9th day with equivalent value of 18.81, 17.28 and 15.76, respectively with mean value of 17.28. Declining trend and average minimum palatability rating i.e. 15.37 were recorded in control treatment.

Decline in taste and appearance of guava fruits continuously and rapidly declined with advancement of ambient storage period in all the treatments. NAA 200 ppm treatment was the premium treatment followed by NAA 300 ppm and decreasing trend continued more towards end of storage. Significantly lower values were observed in control treatment during both years. The interaction among storage days and treatments was found significant in the first year of study.

Table 27. Effect of post-harvest treatments of chemicals on palatability rating (out of 20.00) in guava cv. Allahabad Safeda fruits under ambient storage conditions

Treatment		**Storage days (2015-16)**				**Storage days (2016-17)**			
		3rdday	**6thday**	**9thday**	**Mean**	**3rdday**	**6thday**	**9thday**	**Mean**
NAA	100 ppm	17.46	16.16	14.52	16.05	17.64	16.53	14.91	16.36
	200 ppm	18.28	17.07	15.51	16.95	18.48	17.68	16.18	17.45
	300 ppm	18.10	16.90	15.35	16.78	18.81	17.28	15.76	17.28
Salicylic acid	100 ppm	17.24	15.92	14.26	15.81	17.42	16.13	14.48	16.01
	200 ppm	17.80	16.55	14.95	16.43	17.91	17.07	15.53	16.84
	300 ppm	17.66	16.38	14.75	16.26	17.87	16.70	15.10	16.56
Ascorbic acid	75 ppm	17.13	15.78	14.11	15.67	16.97	16.05	14.38	15.80
	150 ppm	16.86	14.72	12.41	14.66	16.79	15.86	14.17	15.61
	300 ppm	16.50	14.30	11.97	14.26	16.92	15.71	13.99	15.54
Control		15.68	13.43	11.08	13.40	17.12	15.39	13.59	15.37
Mean		17.27	15.72	13.89	15.63	17.59	16.44	14.81	16.28
0 day mean		**18.21**				**0 day mean**		**18.31**	
Factors		**C.D. (p≥0.05)**				**Factors**		**C.D. (p≥0.05)**	
Storage days (A)		0.16				Storage days (A)		0.12	
Treatments (B)		0.28				Treatments (B)		0.26	
Interaction (A X B)		0.49				Interaction (A X B)		N S	

The findings of Singh (1998) and Reddy (1992) in guava cv. Allahabad Safeda are in line with results of current study. Singh *et al* (2017) also recorded the highest mean palatability rating (16.33 out of 20) in guava fruits which were treated with NAA 300 ppm and closely trailed by NAA 200 ppm. Katiyar *et al* (2008) and Singh (2017) has also reported that the maximum organoleptic score with treatment of NAA in guava. Bal *et al* (2010) proved that after 25 days of storage the rating of ber fruits was recorded as 'good' merely in naphthalene acetic acid treated fruits in CFB boxes.

4.2.1.1.8 Physiological loss in weight

The data pertaining to physiological loss in weight of winter guava has been presented in Table 28 and Fig. 17 and 18. Various chemical applications resulted into significant differences among themselves related to physiological loss in weight.

During first year, it was observed that as the storage progressed, physiological loss in weight of guava fruit was increased. However, the minimum mean PLW was recorded (4.75%) in guava fruits treated with 200 ppm salicylic acid. On 3rd day it was loss in weight of the fruit was 0.52 per cent and it showed an inclined trend and at 6th day, it was noted as 2.15 per cent, whereas further sharp increased values were recorded on 9th day i.e. 11.59 per cent. Next to this, PLW was also noted lowest in salicylic acid 300 ppm with mean value 4.83 per cent. On the contrary, the highest mean PLW (7.71%) was noted in control treatment.

During second year, lowest values of PLW (4.62%) were inclining trend in salicylic acid 100 ppm with respect to physiological weight loss was recorded irrespective of various treatments and this trend continues till 9th day of ambient storage. At 3rd day of storage it was observed as 0.67 per cent and increased further during 6th day and 9th day to the value of 2.30 per cent and 10.91 per cent, respectively. Similar increasing trend and lower values were recorded in application of salicylic acid 200 ppm with average value 4.96 per cent. At the end of ambient storage period, the average weight loss of guava fruit, among all the treatments found highest in control with average value 6.70 per cent. The interaction between storage days and treatments was found to be significant in both years of study.

Mandal *et al* (2012) described that guava fruits treated with NAA showed less PLW. This loss of weight on lengthening storage period might be accredited to quick loss of humidity through respiration and evaporation process. Observations of current study are in accordance with the findings of Ladaniya *et al* (2005) in mandarin fruits.

Table 28. Effect of post-harvest treatments of chemicals on physiological loss in weight (%) of guava cv. Allahabad Safeda under ambient storage conditions

Treatment		**Storage days (2015-16)**				**Storage days (2016-17)**			
		3rdday	**6thday**	**9thday**	**Mean**	**3rdday**	**6thday**	**9thday**	**Mean**
NAA	100 ppm	0.75	2.35	11.77	4.96	0.87	2.82	12.43	5.38
	200 ppm	0.72	2.28	11.52	4.84	0.89	2.80	13.46	5.72
	300 ppm	0.69	2.38	12.04	5.03	0.81	2.79	13.97	5.86
Salicylic acid	100 ppm	0.73	2.43	11.97	5.04	0.67	2.30	10.91	4.62
	200 ppm	0.52	2.15	11.59	4.75	0.50	2.32	12.04	4.96
	300 ppm	0.60	2.30	11.60	4.83	0.62	2.48	12.95	5.35
Ascorbic acid	75 ppm	0.93	2.88	13.53	5.78	0.93	2.97	13.83	5.91
	150 ppm	1.08	3.16	14.87	6.37	0.78	2.69	13.95	5.81
	300 ppm	1.27	3.64	16.83	7.25	0.89	2.61	14.94	6.15
Control		2.75	3.46	15.02	7.07	1.46	3.00	15.64	6.70
Mean		1.00	2.70	12.92	5.54	0.87	2.82	12.43	5.38
Factors		C.D. (p≥0.05)				Factors		C.D. (p≥0.05)	
Storage days (A)		0.33				Storage days (A)		0.30	
Treatments (B)		0.61				Treatments (B)		0.55	
Interaction (A X B)		1.05				Interaction (AXB)		0.96	

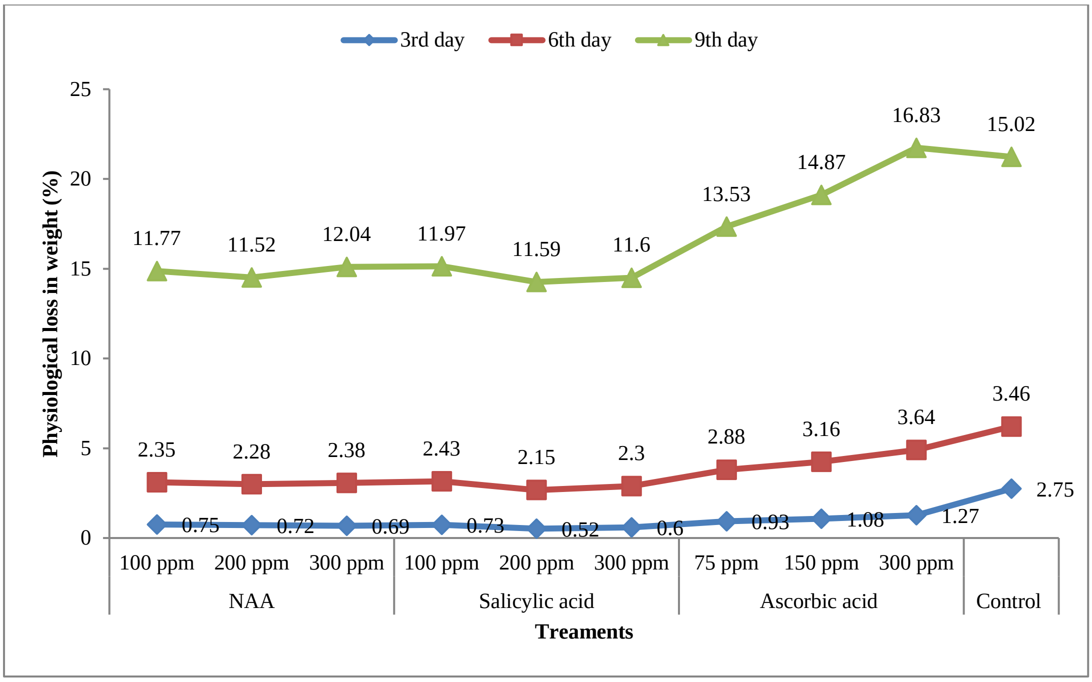

Fig. 17 Effect of post-harvest application of chemicals on physiological loss in weight (%) of guava under ambient storage (2015-16)

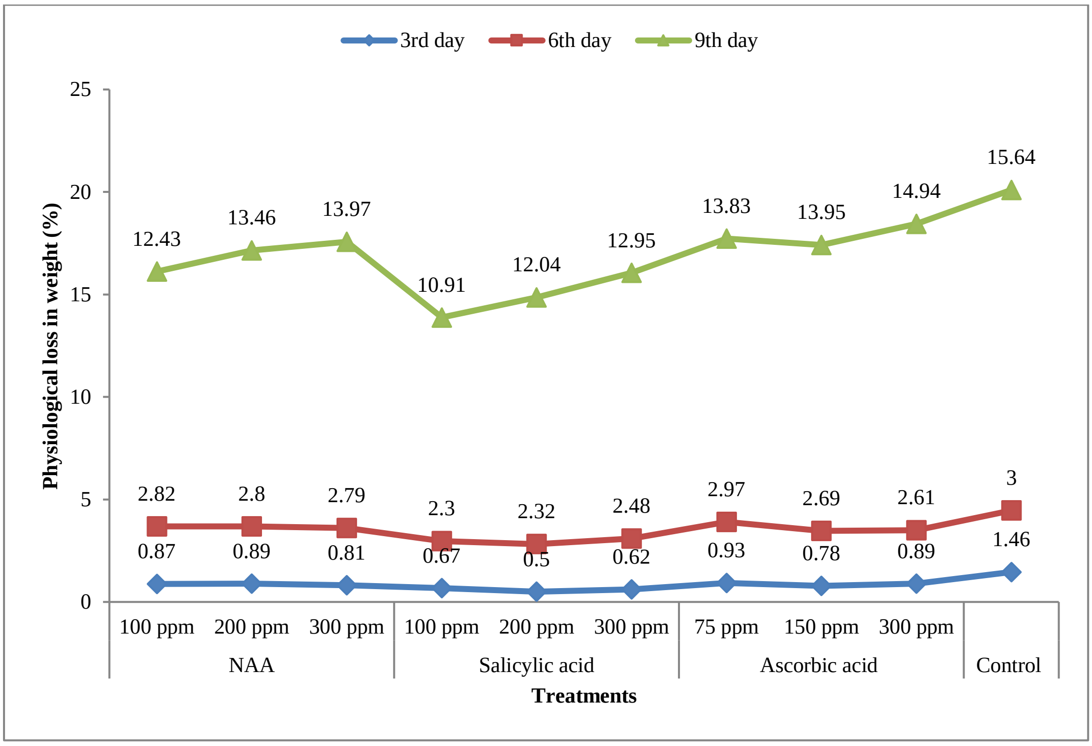

Fig. 18 Effect of post-harvest application of chemicals on physiological loss in weight (%) of guava under ambient storage (2016-17)

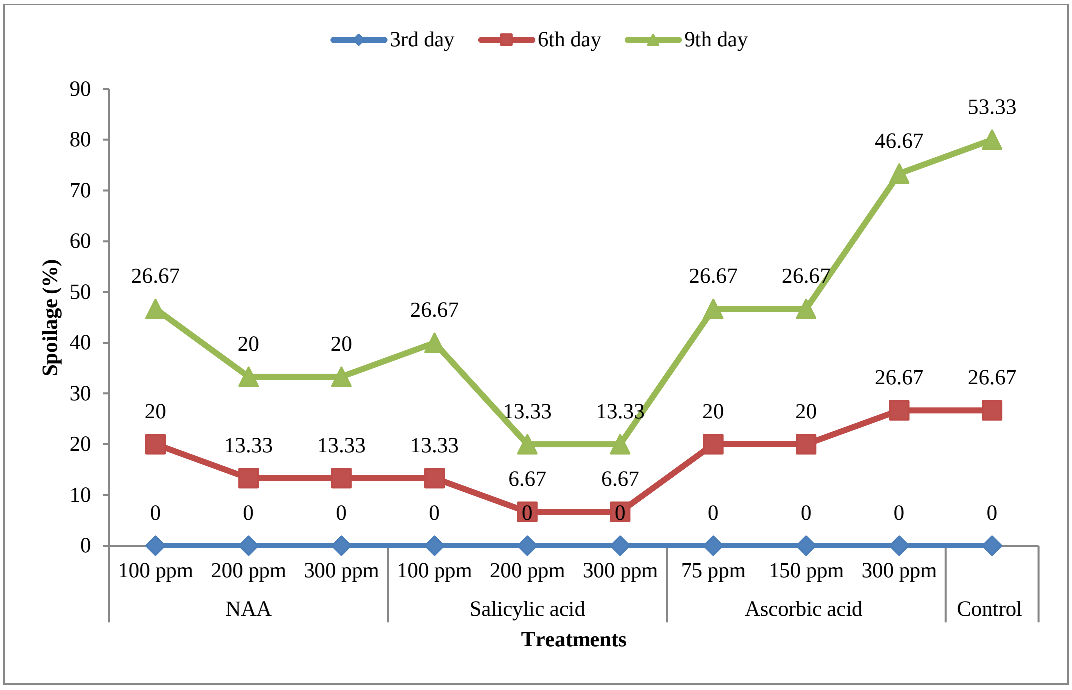

Fig. 19 Effect of post-harvest application of chemicals on spoilage (%) of guava under ambient storage (2015-16)

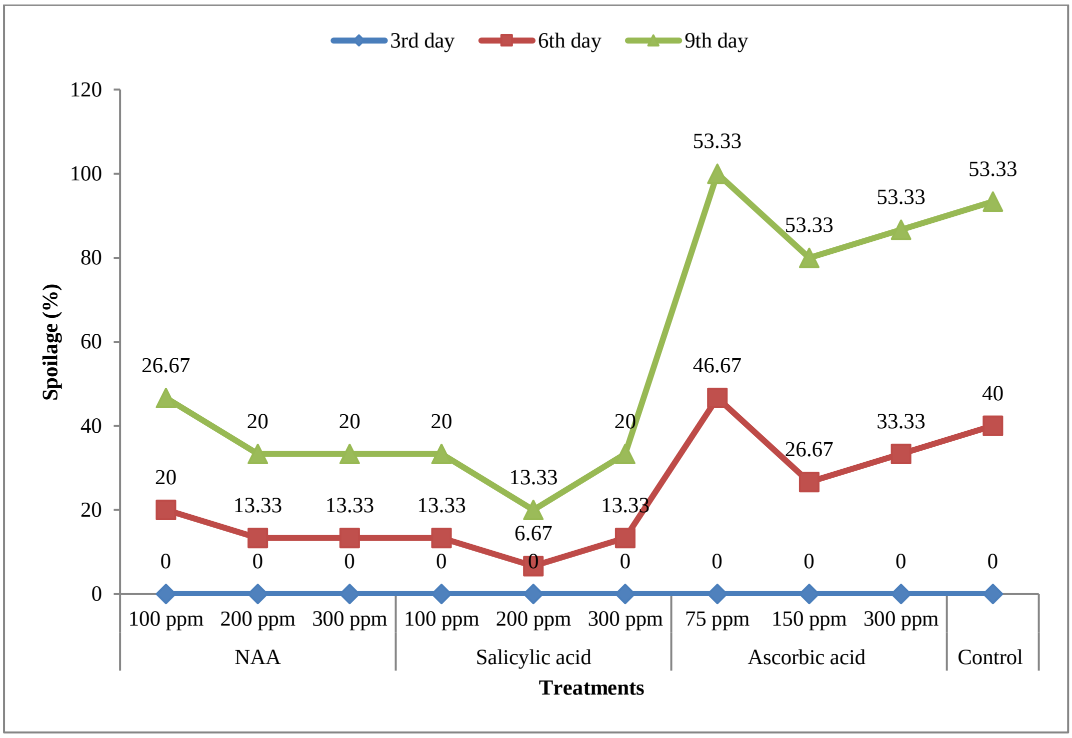

Fig. 20 Effect of post-harvest application of chemicals on spoilage (%) of guava under ambient storage (2016-17)

4.2.1.1.1.9 Spoilage percentage

The data on spoilage percentage for various chemical and storage days are presented in Table 29 and Fig. 19 and 20. Different treatments resulted into significant variances among themselves.

During first year of study, the spoilage percentage of guava fruit was increased as the storage advanced. However, the minimum average spoilage percentage (6.67) was observed in guava fruits treated with salicylic acid 200 ppm. No spoilage occurred up to 3rd day and it showed an inclined trend on 6th day, it was noted as 6.67 per cent whereas further increased values were recorded on 9th day i.e. 13.33 per cent. This treatment was followed by salicylic acid 300 ppm. Similarly, increasing trend in fruit spoilage with corresponding values 6.67 per cent on 6th day and 20.00 per cent on 9th day were observed in salicylic acid 300 ppm applications with average 8.89 per cent. But, the highest mean fruit spoilage percentage (22.22) was noted in control treatment.

In next year of study again, lowest values of spoilage were noted in salicylic acid 200 ppm. Inclining trend with respect to fruit spoilage percentage was recorded irrespective of various treatments and this trend continues till 9th day of ambient storage. Mean lowest fruit spoilage (4.49%) was recorded in SA 200 ppm. This treatment was followed by application of salicylic acid 300 ppm with mean value, 6.73 per cent. At the end of ambient storage period, the average percentage spoilage of guava among all the treatments found highest in control with value 13.44 per cent with significant difference.

The interaction between storage days and treatments was found to be significant during both years of study. Salicylic acid 200 ppm was observed the overall best treatment followed by salicylic acid 300 ppm. Significantly higher values were observed in control treatment during both years of the research work. Salicylic acid being a safe phenolic and natural compound known to generate various metabolic and physiological responses in fruit plants and act as latent bioagent in monitoring post-harvest loss of different horticultural crops and delay in ripening process through inhibition of ethylene biosynthesis (Asghari and Aghdam 2010). Tareen *et al* (2012) described that salicylic acid could be used commercially to keep fruits for up to one month without any spoilage in peach cv. ‘Flordaking’. Respiration process even after harvest leads to rotting of the fruits. Prasanna (2005) described that mango cv. Baneshan treated with benzyl adenine decreased spoilage.

Table 29. Effect of post-harvest treatments of chemicals on spoilage percentage of guava cv. Allahabad Safeda under ambient storage conditions

Treatment		Storage days (2015-16)				Storage days (2016-17)			
		3rd day	6th day	9th day	Mean	3rd day	6th day	9th Day	Mean
NAA	100 ppm	0.00	20.00	26.67	15.56	0.00	20.00	26.67	15.56
	200 ppm	0.00	13.33	20.00	11.11	0.00	13.33	20.00	11.11
	300 ppm	0.00	13.33	20.00	11.11	0.00	13.33	20.00	11.11
Salicylic acid	100 ppm	0.00	13.33	26.67	13.33	0.00	13.33	20.00	11.11
	200 ppm	0.00	6.67	13.33	6.67	0.00	6.67	13.33	6.67
	300 ppm	0.00	6.67	13.33	6.67	0.00	13.33	20.00	11.11
Ascorbic acid	75 ppm	0.00	20.00	26.67	15.56	0.00	46.67	53.33	33.33
	150 ppm	0.00	20.00	26.67	15.56	0.00	26.67	53.33	26.67
	300 ppm	0.00	26.67	46.67	24.44	0.00	33.33	53.33	28.89
Control		0.00	26.67	53.33	26.67	0.00	40.00	53.33	31.11
Mean		0.00	16.67	27.33		0.00	22.67	33.33	

Factors	C.D. (p≥0.05)	Factors	C.D. (p≥0.05)
Storage days (A)	1.22	Storage days (A)	1.26
Treatments (B)	2.24	Treatments (B)	2.31
Interaction (A X B)	3.88	Interaction (A XB)	4.01

4.2.1.2 Bio-chemical Characters of Fruits

4.2.1.2.1 Total soluble solids

The data pertaining to total soluble solids of guava fruit under ambient storage conditions has been presented in Table 30. It reveals that TSS content of the fruit decreased up to end of the storage at various intervals with post-harvest application of chemical treatments. NAA is a vital plant growth regulator of auxin assembly, which supports to reduce fruit drop, increases yield and superiority specially by enhancing TSS (Singh and Randhawa 2001).

During first year of study, different treatments varied significantly among themselves with respect to total soluble solids of Allahabad Safeda. Highest values (10.71%) of average TSS under ambient storage were obtained in NAA 200 ppm treatment. On 3^{rd} of ambient storage it was noted as 11.49 per cent but it showed declining trend after 3^{rd} day and found reduced values of 10.76 per cent and 9.89 per cent on 6^{th} and 9^{th} day respectively. It was followed by salicylic acid 200 ppm application and similar kind of decreasing trend was also observed in this treatment where the values decreased from 10.79 per cent (3^{rd} day) to 9.25 per cent (9^{th} day) with average TSS 10.05 per cent. While in control treatment much reduced values were recorded but with declining trend. TSS was reduced consistently on 3^{rd} day 6^{th} day and 9^{th} day with corresponding values of 8.19, 7.57, and 6.83 per cent, respectively.

The highest total soluble solids were also recorded in NAA 200 ppm treatment during second year. Reduced TSS values were noted on 3^{rd}, 6^{th} and 9^{th} day as 12.19 per cent, 11.55 per cent and 10.84 per cent, respectively but with declining trend. Next to this higher TSS was also recorded in SA 300 ppm where TSS reduced from 11.37 per cent (0 day) to 10.16 per cent (9^{th} day) with average of 10.77 per cent. Significantly lower values of TSS were recorded in control treatment with average of 8.71 per cent.

The interaction was found to be non-significant between storage days and treatments in both years. Selvan (2002) got similar results in guava var. Sardar. But the outcome of this study is in contrast to research conducted by Singh and Singh (1976) in ber cv. Banarasi Karaka.

Table 30. Effect of post-harvest treatments of chemicals on total soluble solids (%) of guava cv. Allahabad Safeda under ambient storage conditions

Treatment		Storage days (2015-16)				Storage days (2016-17)			
		3rd day	6th day	9th day	Mean	3rd day	6th day	9th day	Mean
NAA	100 ppm	10.29	9.62	8.79	9.79	10.13	9.58	8.99	9.57
	200 ppm	11.49	10.76	9.89	10.97	12.19	11.55	10.84	11.53
	300 ppm	11.24	10.55	9.69	10.74	11.12	10.51	9.83	10.49
Salicylic acid	100 ppm	10.33	9.68	8.88	9.84	10.37	9.82	9.25	9.81
	200 ppm	10.79	10.10	9.25	10.28	11.37	10.78	10.16	10.77
	300 ppm	10.56	9.89	9.05	10.06	10.15	9.58	8.99	9.57
Ascorbic acid	75ppm	9.62	8.98	8.23	9.15	9.28	8.77	8.22	8.76
	150 ppm	9.32	8.70	7.95	8.86	9.18	8.68	8.16	8.67
	300 ppm	8.54	7.92	7.17	8.07	9.16	8.68	8.17	8.67
Control		8.75	8.19	7.57	6.83	7.72	9.18	8.71	8.24
Mean		10.04	9.38	8.57	9.55	10.21	9.67	9.09	9.65
0 day mean		**10.20**				**0 day mean**		**10.40**	
Factors		**C.D. (p≥0.05)**				**Factors**		**C.D. (p≥0.05)**	
Storage days (A)		0.37				Storage days (A)		0.46	
Treatments (B)		0.68				Treatments (B)		0.84	
Interaction (A X B)		N S				Interaction (A XB)		N S	

4.2.1.2.2 Acidity

The data presented in Table 31 reveals that guava fruit firmness was significantly affected with post-harvest sprays of different chemicals and storage days. Post-harvest application of NAA, salicylic acid and ascorbic acid were resulted in lower fruit acidity as compared to control treatment. Fruit ripening is accompanied by several variations such as softening, advancement of color and reduction in total acidity.

Minimum acidity along with declining trend was observed in NAA 200 ppm under ambient storage conditions during the year of 2015-16. Mean values on day of storage of acidity was recorded 0.79 per cent. Likewise lower values were recorded on 3rd, 6th day and 9th day i.e. 0.63 per cent, 0.53 per cent, 0.42 per cent with average of 0.53 per cent. This treatment was followed by NAA 300 ppm application with average value of 0.57 per cent. Similarly a declining trend along with reduced values was noted in NAA 300 treatment. Maximum average value of acidity along with higher values was noted in control treatment with average of 0.82 per cent.

During second year of study, NAA 200 ppm application has also shown minimum acidity and declining trend. Highest values were obtained in control treatment where average acidity was recorded as 0.91 per cent.

The interaction between storage days and treatments was observed significant in 2nd year of study. Thus, with NAA treatment the titratable acidity was lessened which may be due to early ripening of fruits caused by its application, where acid might have been used during respiration activity or rapidly transformation into sugars of various kinds by different reactions involving reverse glycolytic pathways (Agnihotri *et al* 2013). Similar findings have been reported by Mandal *et al* (2012), Killadi *et al* (2007); Selvan and Bal (2005) and Singh *et al* (1998) in guava fruits.

4.2.1.2.3 Vitamin C

The data depicted in Table 32 and Fig. 29 showed that the vitamin C content of Allahabad Safeda guava fruit decreased gradually with the advancement of storage period. As the storage progressed vitamin C goes on decreasing till the end of storage.

Table 31. **Effect of post-harvest treatments of chemicals on acidity (%) of guava cv. Allahabad Safeda under ambient storage conditions**

Treatment		**Storage days (2015-16)**				**Storage days (2016-17)**			
		3rd day	**6th day**	**9th day**	**Mean**	**3rd day**	**6th day**	**9th day**	**Mean**
NAA	100 ppm	0.75	0.68	0.60	0.68	0.74	0.67	0.59	0.67
	200 ppm	0.63	0.53	0.42	0.53	0.63	0.54	0.44	0.54
	300 ppm	0.66	0.57	0.47	0.57	0.66	0.58	0.48	0.57
Salicylic acid	100 ppm	0.77	0.71	0.64	0.71	0.80	0.73	0.65	0.73
	200 ppm	0.66	0.58	0.49	0.58	0.69	0.61	0.51	0.60
	300 ppm	0.69	0.61	0.52	0.61	0.71	0.64	0.55	0.63
Ascorbic acid	75 ppm	0.78	0.73	0.66	0.72	0.84	0.78	0.71	0.78
	150 ppm	0.80	0.75	0.68	0.74	0.89	0.83	0.77	0.83
	300 ppm	0.82	0.78	0.72	0.77	0.91	0.86	0.81	0.86
Control		0.85	0.83	0.78	0.82	0.95	0.91	0.86	0.91
Mean		0.74	0.68	0.60	0.67	0.78	0.72	0.64	0.71

0 day Mean	**0.79**	**0 day Mean**	**0.82**
Factors	**C.D. ($p \geq 0.05$)**	**Factor**	**C.D. ($p \geq 0.05$)**
Storage days (A)	0.01	Storage days (A)	0.01
Treatments (B)	0.03	Treatments (B)	0.02
Interaction (A X B)	N S	Interaction (A XB)	N S

Table 32. Effect of post-harvest treatments of chemicals on vitamin C (mg/100 g) in guava fruits cv. Allahabad Safeda under ambient storage conditions

Treatment		Storage days (2015-16)				Storage days (2016-17)			
		3rd day	6th day	9th day	Mean	3rd day	6th day	9th day	Mean
NAA	100 ppm	203.35	177.68	161.77	194.07	204.19	181.49	166.82	197.66
	200 ppm	199.74	171.85	154.57	189.53	202.33	179.23	163.26	195.36
	300 ppm	196.69	167.57	148.46	185.83	198.82	173.63	156.04	190.65
Salicylic acid	100 ppm	184.33	151.06	125.90	170.48	193.02	165.13	144.94	183.49
	200 ppm	177.91	142.64	115.63	162.82	181.43	150.95	125.76	169.56
	300 ppm	189.97	158.77	136.28	177.57	195.29	168.32	150.43	186.57
Ascorbic acid	75ppm	172.67	134.78	107.26	156.39	170.31	137.79	109.66	156.97
	150 ppm	169.66	130.90	101.80	152.78	159.81	124.97	94.68	144.89
	300 ppm	166.83	127.83	98.33	149.96	154.56	119.46	87.54	139.28
Control		157.94	116.35	86.08	140.13	138.64	102.72	70.13	122.93
Mean		181.91	147.94	123.61	167.95	204.19	181.49	166.82	197.66

0 Days Mean	**218.35**	**0 Days Mean**	**217.80**
Factors	**C.D. (p≥0.05)**	**Factors**	**C.D. (p≥0.05)**
Storage days (A)	6.70	Storage days (A)	6.10
Treatments (B)	12.24	Treatments (B)	11.19
Interaction (A X B)	N S	Interaction (A XB)	N S

Highest mean values of vitamin C were recorded immediately after harvesting of the fruits (218.35 mg/100g) during first year of study. A declining trend was noted with the advancement of storage period. It was found highest in NAA 100 ppm treatment (average 194.07 mg/100g). Further declined values of 3rd day (203.35mg/100g), 6th day (177.68mg/100g) and 9th day (161.77mg/100g) under storage conditions also confirmed the same trend. It was followed by NAA 200 ppm with average value of 189.53 mg/100g. On the other hand, minimum vitamin C (140.13 mg/100g) was noted in control treatment with declining trend.

Next year highest values of vitamin C were also recorded in NAA 100 ppm treatment. Declined trend in vitamin C was also observed in this year. At end of storage period average of vitamin C was calculated as 197.66mg/100g in NAA 100 ppm treatment. Next to this, vitamin C content in NAA 200 ppm treatment also exhibited diminishing trend throughout 3rd, 6th and 9th day of storage. Least amount of vitamin C (122.93 mg/100g) was noted in control treatment. The interaction was found to be non-significant during both years with respect to storage days and treatments.

The vitamin C content varied meaningfully in all the treatments. In present study, vitamin C declined with advancement of storage days. The loss in ascorbic acid on the prolonged storage might be due to rapid conversion of L-ascorbic acid into dehydroascorbic acid in the presence of enzyme ascorbinase (Mapson 1970). These findings agree with those of given by Mandal *et al* (2012); Selvan and Bal (2005) in guava and Ahmed and Singh (2000) in mango.

4.2.1.2.4 Total sugars

The results on total sugars are presented in Table 33. The total sugars increased significantly during ambient storage. However, it was recorded that total sugars increased slow during initial stage of storage and decreased in its content afterwards.

During first year of study, maximum mean total sugars (8.36 %) were observed in fruits treated with NAA 200 ppm. After 0 day of storage the value of total sugars was 6.81 per cent whereas it increased during 3rd and 6th days and again decline was noted on 9th day. This treatment was followed by NAA 300 ppm with equivalent trend and average value 8.27 per cent. Similar trend and reduced values were recorded in control treatment on 0, 3rd, 6th and 9th day as 7.34 per cent, 7.39 per cent and 5.54 per cent, respectively with average of 6.64 per cent.

Table 33. Effect of post-harvest treatments of chemicals on total sugars (%) of guava cv. Allahabad Safeda under ambient storage conditions

Treatment		Storage days (2015-16)				Storage days (2016-17)			
		3rd day	6th day	9th day	Mean	3rd day	6th day	9th day	Mean
NAA	100 ppm	7.81	7.91	6.17	7.16	7.83	8.04	5.91	7.13
	200 ppm	8.98	9.13	7.45	8.36	8.35	8.60	6.63	7.70
	300 ppm	8.91	9.04	7.34	8.27	8.14	8.38	6.40	7.48
Salicylic acid	100 ppm	7.57	7.67	5.92	6.92	7.70	7.90	5.77	6.99
	200 ppm	7.99	8.11	6.40	7.35	8.03	8.26	6.16	7.34
	300 ppm	7.88	7.99	6.26	7.23	7.92	8.13	6.00	7.21
Ascorbic acid	75ppm	7.54	7.63	5.86	6.88	7.65	7.84	5.69	6.93
	150 ppm	7.45	7.52	5.73	6.78	7.6	7.77	5.60	6.87
	300 ppm	7.40	7.46	5.64	6.71	7.47	7.62	5.44	6.73
Control		7.34	7.39	5.54	6.64	7.41	7.53	5.32	6.66
Mean		7.89	7.99	6.23	7.23	7.81	8.01	5.89	7.10
0 day mean			6.81		0 Days Mean			6.70	

Factors	C.D. (p≥0.05)	Factors	C.D. (p≥0.05)
Storage days (A)	0.17	Storage days (A)	0.15
Treatments (B)	0.30	Treatments (B)	0.28
Interaction (A X B)	N S	Interaction (A XB)	N S

During 2016-17, the highest total sugar was noted in NAA 200 treatment with similar trend. This treatment was trailed by NAA 300 ppm with average of 7.48 per cent. While much lower total sugars were recorded in control treatment (6.66%).

Total sugars showed significantly difference at different storage periods. There was a steady improvement in total sugar content with advancement in storage duration up to 6 days. This increase was possibly due to dehydration, as in most of the treatments, fruits showed high PLW. Total sugars improved initially during storage and showed a declining trend with the advancement of the storage duration. Total sugars showed significantly different values at different storage periods. NAA 200 ppm was found to be best treatment followed by NAA 300 ppm. The interaction regarding total sugars (during 2015-16 and 2016-17) is found to be non-significant. These results corroborate well with Abubakar *et al* (2013) and Anawal *et al* (2016) in pomegranate and Chandra *et al* (2015) in aonla cv. NA-7.

4.2.2 Cold Storage Studies

4.2.2.1 Physical Characters of Fruits

4.2.2.1.4 Fruit colour

The data pertaining to guava fruit colour has been presented in Table 34. It has been observed that fruit colour in guava changed steadily with progression of cool storage.

During first year of study, salicylic acid treatments showed improved colour advancement. During harvesting average fruit colour in guava was light yellow green (YGG 145B and C). As the storage period advanced, skin colour changes were more visible at different intervals. In various treatments of salicylic acid, fruits changed their colour to light green (GG142A, B) during 7^{th} day of storage. This colour change continued and were recorded, light yellow green (YGG145A, B, D; YGG145B and YGG149B) during 14^{th} during 21^{st}day of storage.

During second year of study, the guava fruits were also found best regarding colour development in all concentrations of salicylic acid. Till 7^{th} day of cold storage the fruit colour was changed to light green (GG142A/B). But at the end of storage, skin colour was observed as light yellow green (YGG149B and YGG145B, C). Whereas in control treatment, the fruits had shown light yellow green/ medium yellow green/ yellow green (YGG145 A, YGG149B and YGG154 B) on 7^{th}, 14^{th} and 21^{st} day respectively.

Table 34. **Effect of post-harvest treatments of chemicals on fruit colour of guava cv. Allahabad Safeda under cold storage conditions**

Treatment		**Storage days(2015-16)**			**Storage days (2016-17)**		
		7th day	**14th day**	**21st day**	**7th day**	**14th day**	**21st day**
NAA	100 ppm	YGG145A	YGG149B	YGG145B	YGG145B	YGG149B	YGG145B
	200 ppm	YGG144D	YGG149C	YGG149C	YGG145A	YGG149C	YGG149C
	300 ppm	YGG144D	YGG149C	GG142A	YGG144D	YGG149C	GG142A
Salicylic acid	100 ppm	GG142A	YGG145B	YGG145B	GG142A	YGG145C	YGG145C
	200 ppm	GG142B	YGG145A	YGG145B	GG142B	YGG145A	YGG145B
	300 ppm	GG142A	YGG144D	YGG149B	GG142B	YGG144D	YGG149B
Ascorbic acid	75ppm	YGG149A	YGG154B	YGG154B	YGG149C	YGG154B	YGG154B
	150 ppm	YGG144D	YGG149A	YGG154B	YGG144D	YGG149A	YGG154B
	300 ppm	YGG149A	YGG154B	YGG154B	YGG149C	YGG154B	YGG154B
Control		YGG145B	YGG149A	YGG154B	YGG145A	YGG149B	YGG154B

0 day : YGG145B and C

HCC	:	**Visual Colour**
GG142A, B	:	Light green
YGG144D, 145A, B, C; 149B, C	:	Light yellow green
YGG149A, B	:	Medium yellow green
YGG 154 B	:	Yellow green

Treated fruits with salicylic acid exhibited delayed respiration rate. The change of skin colour from green to yellow in fruits is an indication of fruit ripening process. Salicylic acid was found to be better treatment with respect to skin colour development of the fruit on account of preventing the degradation of chlorophyll. Similarly, guava fruits treated with salicylic acid resulted in colour change and minimum weight loss and better firmness (Madhav *et al* 2016). Similar changes in fruit colour had been described by Singh (1998) in guava fruit.

4.2.2.1.5 Fruit firmness

The data presented in Table 35 and graphically explained in Fig. 21 and 22 reveals that the guava fruit firmness was significantly affected with post-harvest sprays of different chemicals and cold storage period. All the chemicals tried resulted in higher guava firmness as compared to control treatment.

During 2015-16, maximum fruit firmness, (16.76 lbs/cm^2) was observed in salicylic acid 200 ppm under cold storage conditions. On 7th day of storage firmness of guava fruit was recorded 17.25 lbs/cm^2. Corresponding lower values were recorded on 14th day and 21st day i.e. 16.46 lbs/cm^2, 15.48 lbs/cm^2. This treatment was followed by salicylic acid 300 ppm application with decreasing trend and corresponding values of 16.90 lbs/cm^2, 15.80 lbs/cm^2 and 14.56 lbs/cm^2, respectively at 7th, 14th and 21st days of cold storage with average of 16.19 lbs/cm^2. Minimum average value of fruit firmness (13.28 lbs/cm^2) was observed in control treatment.

During 2016-17, fruit firmness was also recorded the highest in SA 200 ppm. Lowest values of fruit firmness were obtained in control treatment where average firmness was recorded as 14.30 lbs/cm^2. Salicylic acid 200 ppm showed best results regarding fruit firmness followed by salicylic acid 300 ppm, but declining trend was also observed in both cases. Minimum average value and significantly lower values of fruit firmness were observed in untreated fruits under cold storage conditions. The interaction was found to be significant with respect to storage days and treatments in both years of research.

Table 35. Effect of post-harvest treatments of chemicals on fruit firmness (lbs/cm^2) of guava cv. Allahabad Safeda under cold storage conditions

Treatment		Storage days (2015-16)				Storage days (2016-17)			
		7th day	14th day	21st day	Mean	7th day	14th day	21st day	Mean
NAA	100 ppm	16.35	15.15	13.87	15.59	15.86	15.15	13.81	15.32
	200 ppm	16.40	15.21	13.95	15.65	15.92	15.24	13.90	15.39
	300 ppm	16.76	15.64	14.39	16.04	16.30	15.64	14.39	15.80
Salicylic acid	100 ppm	16.55	15.41	14.17	15.83	16.18	15.51	14.22	15.67
	200 ppm	17.25	16.46	15.48	16.76	16.52	15.88	14.95	16.09
	300 ppm	16.90	15.80	14.56	16.19	16.43	15.91	14.75	16.01
Ascorbic acid	75 ppm	15.61	14.38	12.78	14.76	15.66	14.91	13.53	15.10
	150 ppm	14.57	13.32	11.71	13.71	15.51	14.72	13.31	14.92
	300 ppm	14.33	13.05	11.42	13.46	15.24	14.43	13.00	14.64
Control		14.17	12.87	11.20	13.28	14.90	14.08	12.64	14.30
Mean		15.89	14.73	13.35	15.13	15.85	15.15	13.85	15.32
0 Days mean		**16.53**				**0 Days mean**		**16.44**	
Factors		**C.D. ($p \geq 0.05$)**				**Factor**		**C.D. ($p \geq 0.05$)**	
Storage days (A)		0.41				Storage days (A)		0.47	
Treatments (B)		0.75				Treatments (B)		0.85	
Interaction (A X B)		N S				Interaction (A XB)		N S	

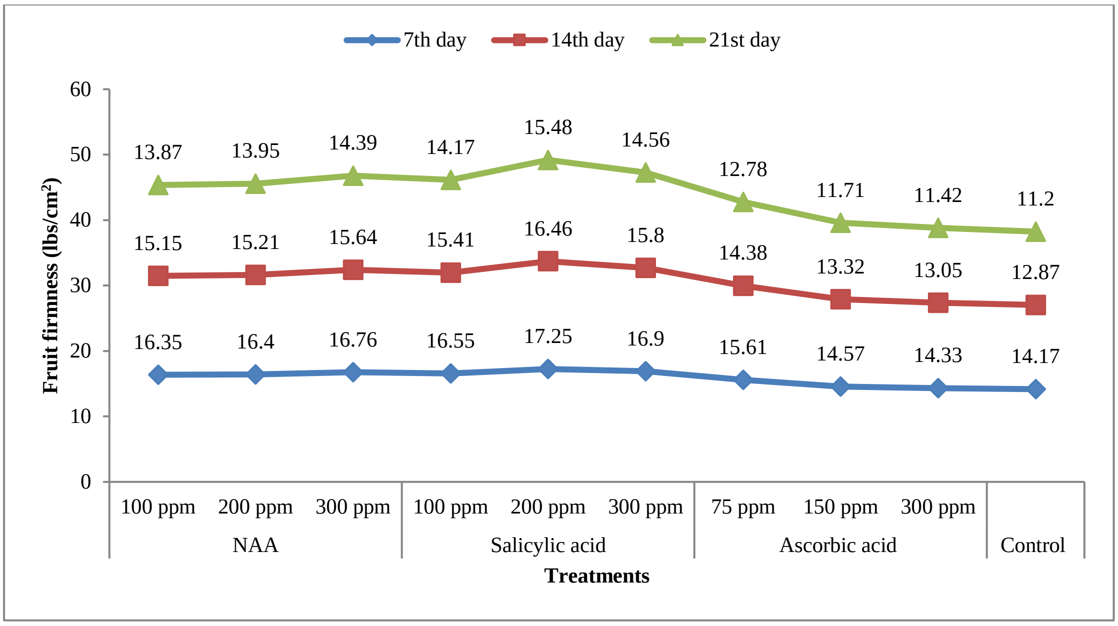

Fig. 21 Effect of post-harvest applications of chemicals on fruit firmness (lbs/cm^2) of guava under cold storage (2015-16)

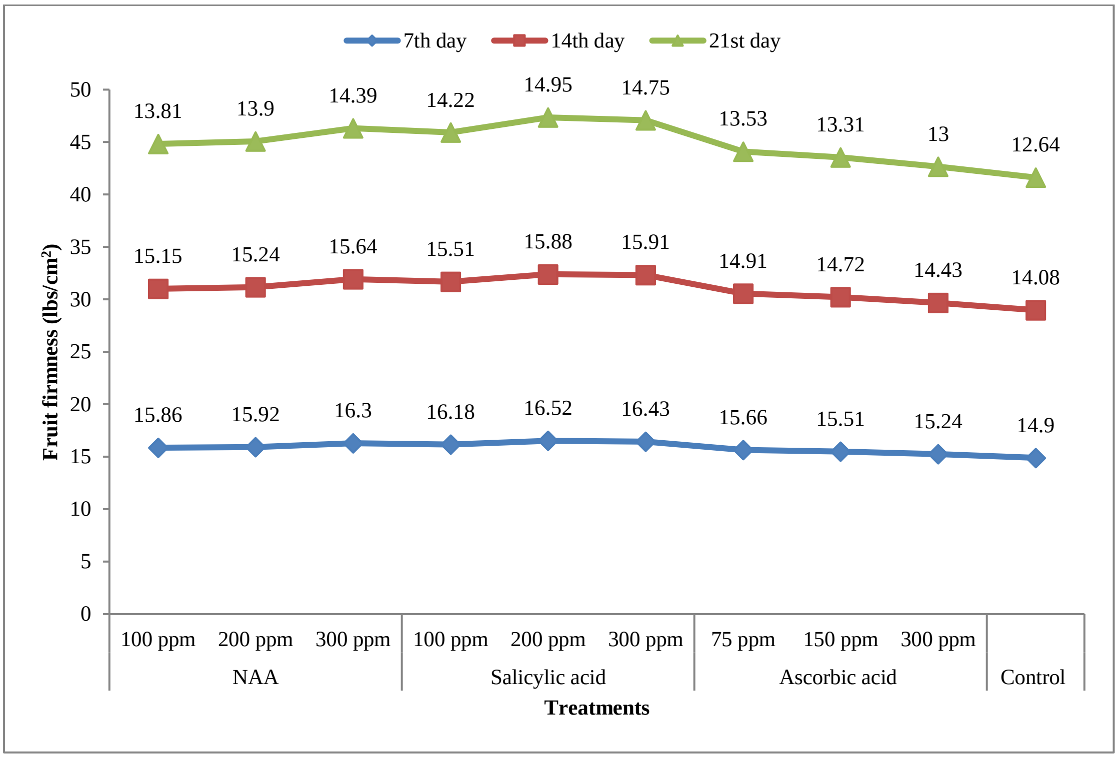

Fig. 22 Effect of post-harvest applications of chemicals on fruit firmness (lbs/cm^2) of guava under cold storage (2016-17)

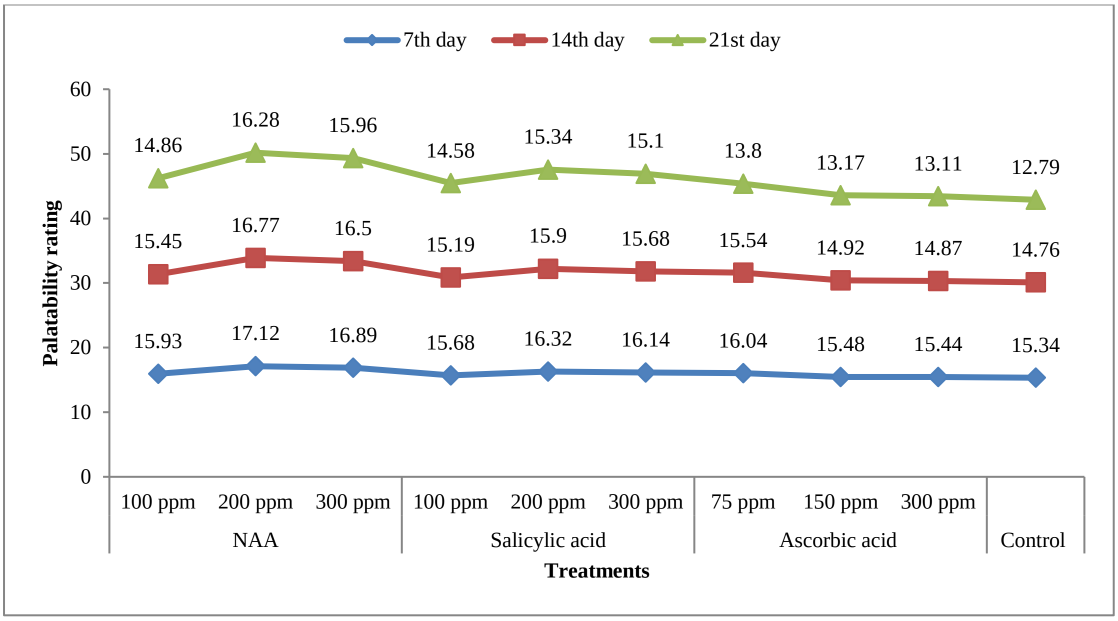

Fig. 23 Effect of post-harvest applications of chemicals on palatability rating (out of 20) of guava under cold storage (2015-16)

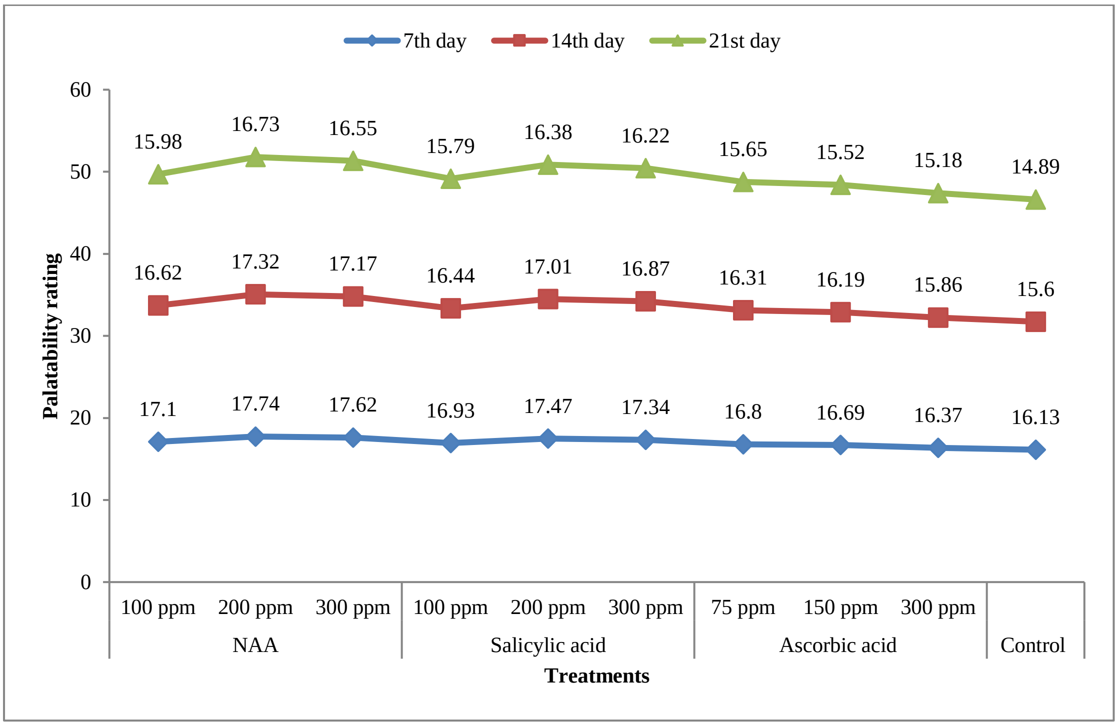

Fig. 24 Effect of post-harvest applications of chemicals on palatability rating (out of 20) of guava under cold storage (2016-17)

It was reported that peach fruits receiving various postharvest treatments of salicylic acid produced the firmest fruits, while the control trees (without receiving salicylic acid) had the soft fruits after 28 days of cold storage (Awad *et al* 2013). Salicylic acid prevents softening of the fruit as reported by Srivastava and Dwivedi (2000), Zhang *et al* (2003) and Wang *et al* (2006). They described that rapid softening of fruits during ripening was instantaneous with rapid reduction in endogenous salicylic acid of fruits. Salicylic acid affects cell puffiness which leads to advanced firmness of fruits (Zhang *et al* 2003 and Shafiee *et al* 2010). Figueroa *et al* (2012) reported that NAA declines the transcript level of cell wall debasing genes after cold storage in various fruits. Auxin could independently modify fruit ripening process by preventing the normal degradation of cell wall during cold storage.

4.2.2.1.6 Palatability rating

The data on palatability rating are presented in Table 36 and graphically presented in Fig. 23 and 24. Results shown decline in overall rating of guava fruits continuously and rapidly declined with progression of cold storage period in all the treatments. It has been proved that the loss of weight in fresh fruits is mainly due to the loss of water caused by transpiration and other related activities (Zhu *et al* 2008). The concentration of various volatile compounds rises with ripening of fruits and these compounds are responsible for refining flavor of fruit making it more delicious and valuable.

During first year, the average palatability rating among all the treatments was observed highest (16.72) in NAA 200 ppm at the end of cold storage period. As the storage advanced, palatability rating of guava fruit was decreased after 7th day to the value of 17.12. This trend of reduction was continuous and palatability rating was noted 16.77on 14th day and 16.28 on 21st day. It was followed by application of NAA 300 ppm and the mean palatability rating at the end of cold storage period was decreased and recorded as 16.45. Lower values with decreasing trend were recorded in control treatment. It declined in equivalent manner and recorded 12.79 after 21th days of storage. Mean value was calculated as 14.30.

During second year of study, with advancement of storage period, guava fruit palatability rating also revealed decreasing trend. At the end of cold storage period, the average palatability rating of guava fruit, among all the treatments found highest in NAA 200 ppm with average value 17.26. During 7th day of storage, it was observed as 17.74 and decreased further during 14th day and 21st day and recorded 17.32 and 16.73, respectively. It was followed by NAA 300 ppm treatment where palatability rating also showed continuous decreasing trend throughout 7th, 14th and 21st day of storage. On the other hand, declining trend and average minimum palatability rating i.e. 15.94 was recorded in control treatment.

Table 36. Effect of post-harvest treatments of chemicals on palatability rating score (out of 20.00) of guava cv. Allahabad Safeda under cold storage conditions

Treatment		**Storage days (2015-16)**				**Storage days (2016-17)**			
		7th day	**14th day**	**21st day**	**Mean**	**7th day**	**14th day**	**21st day**	**Mean**
NAA	100 ppm	15.93	15.45	14.86	15.41	17.1	16.62	15.98	16.57
	200 ppm	17.12	16.77	16.28	16.72	17.74	17.32	16.73	17.26
	300 ppm	16.89	16.50	15.96	16.45	17.62	17.17	16.55	17.11
Salicylic acid	100 ppm	15.68	15.19	14.58	15.15	16.93	16.44	15.79	16.39
	200 ppm	16.32	15.90	15.34	15.85	17.47	17.01	16.38	16.95
	300 ppm	16.14	15.68	15.10	15.64	17.34	16.87	16.22	16.81
Ascorbic acid	75 ppm	16.04	15.54	13.80	15.13	16.80	16.31	15.65	16.25
	150 ppm	15.48	14.92	13.17	14.52	16.69	16.19	15.52	16.13
	300 ppm	15.44	14.87	13.11	14.47	16.37	15.86	15.18	15.80
Control		15.34	14.76	12.79	14.30	16.13	15.60	14.89	15.54
Mean		16.04	15.56	14.50	15.37	17.02	16.54	15.89	16.48
0 day mean		**16.47**				**0 day mean**		**17.05**	
Factors		**C.D. (p≥0.05)**				**Factors**		**C.D. (p≥0.05)**	
Storage days (A)		0.17				Storage days (A)		0.18	
Treatments (B)		0.31				Treatments (B)		0.34	
Interaction (A X B)		0.53				Interaction (A XB)		N S	

Significantly lower values were noted in control treatment during both 2015-16 and 2016-17. The interaction among storage days and treatments was found to be significant during 2015-16 and non-significant during 2016-17. Singh *et al* (2018) also obtained the highest average palatability rating (16.33 out of 20) when guava fruits were treated with NAA @ 400 ppm at 7th days of storage which was closely followed by 16/20 in control treatment. Gupta and Jawandha (2010) reported in peach fruits cv. 'Early Grande' that fruits harvested at proper stage of maturity sustained maximum palatability rating after 21 + 3 days of storage. It was reported in ber fruit that incline in organoleptic rating up to 14th day under cold storage condition may be due to slow rate of biochemical events resulting from reduced transpiration and respiration activities under cold storage condition (Bal 1982).

4.2.2.1.8 Physiological loss in weight

The data pertaining to physiological loss in weight of winter guava has been presented in Table 37 and Fig. 25 and 26. Various chemical applications resulted into significant differences among themselves.

During 2015-16, PLW of fruits was increased with progress of cold storage period. However, the lowest weight loss (1.03%) was observed in guava fruits treated with 200 ppm salicylic acid. On 7th day loss in weight of the fruit was 0.30 per cent and it showed an inclined trend and at 14th day, it was noted as 0.96 per cent whereas further higher values were recorded on 21st day i.e. 1.84 per cent. But the average values recorded in case of salicylic acid 300 ppm (1.06 %) were at par with salicylic acid 200 ppm application. On the contrary, the highest mean PLW (1.83 %) was noted in control treatment.

Throughout 2016-17, inclining trend with respect to PLW was recorded irrespective of various treatments and this trend continued till 21st day of cold storage. Lowest weight loss (1.13%) is noted in case of salicylic acid 200 ppm. At 7th day of storage it was observed as 0.35 per cent and increased further during 14th day and 21st day to the value of 1.10 per cent and 1.93 per cent, respectively. Similar inclining trend and at par results were recorded in application of salicylic acid 300 ppm with average of 1.14 per cent. At the end of cold storage period, the average physiological weight loss of guava fruit among all the treatments found highest in control with average value 1.65 per cent.

There was increase in physiological loss in weight as the storage period progressed. Cold storage can effectively slow down respiration process and unpleasant changes in guava fruit. Much less spoilage percentage was noted in salicylic acid 200 and 300 ppm. But NAA 300 ppm also gave better results regarding PLW. Significantly lower values had been observed in control treatment during both years. Significant interaction was observed between storage days and treatments during both the years.

Table 37. Effect of post-harvest treatments of chemicals on physiological loss in weight (%) of guava cv. Allahabad Safeda, guava fruits under cold storage conditions

Treatment		**Storage days (2015-16)**				**Storage days (2016-17)**			
		7th day	**14th day**	**21st day**	**Mean**	**7th day**	**14th day**	**21st day**	**Mean**
NAA	100 ppm	0.52	1.27	2.47	1.42	0.54	1.29	2.47	1.43
	200 ppm	0.46	1.20	2.38	1.35	0.49	1.23	2.36	1.36
	300 ppm	0.36	1.12	2.02	1.17	0.36	1.14	2.03	1.18
Salicylic acid	100 ppm	0.42	1.15	2.25	1.27	0.45	1.17	2.22	1.28
	200 ppm	0.30	0.96	1.84	1.03	0.35	1.10	1.93	1.13
	300 ppm	0.33	0.98	1.87	1.06	0.33	1.12	1.97	1.14
Ascorbic acid	75 ppm	0.54	1.29	2.51	1.45	0.57	1.34	2.57	1.49
	150 ppm	0.57	1.32	2.56	1.48	0.61	1.37	2.60	1.53
	300 ppm	0.58	1.33	2.63	1.51	0.63	1.39	2.71	1.58
Control		0.65	1.67	3.18	1.83	0.64	1.51	2.80	1.65
Mean		0.47	1.23	2.37	1.36	0.50	1.27	2.37	1.38

Factors	**C.D. (p≥0.05)**	**Factors**	**C.D. (p≥0.05)**
Storage days (A)	0.11	Storage days (A)	0.15
Treatments (B)	0.19	Treatments (B)	0.25
Interaction (A X B)	0.33	Interaction (A XB)	0.38

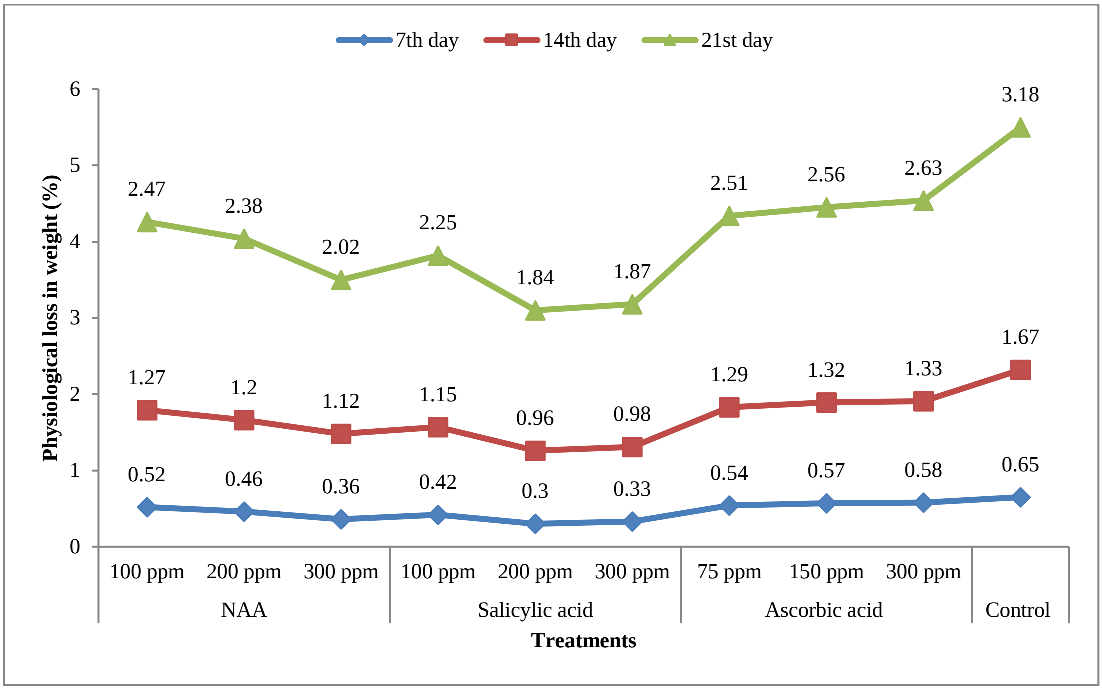

Fig. 25 Effect of post-harvest application of chemicals on physiological loss in weight (%) of guava under cold storage (2015-16)

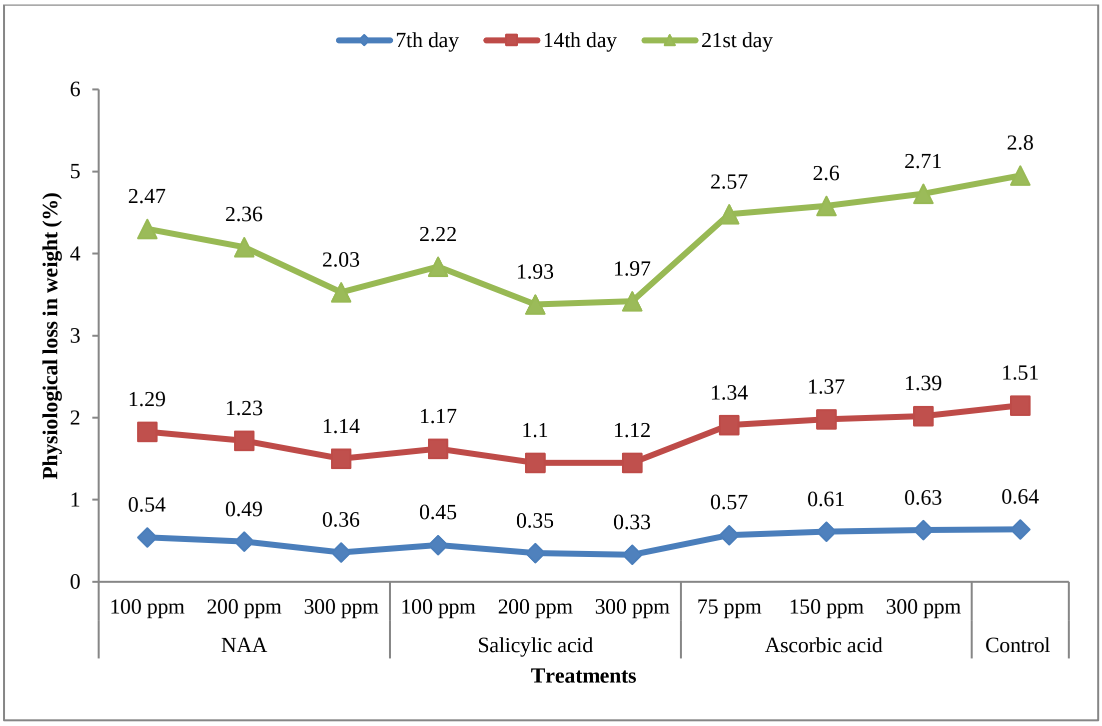

Fig. 26 Effect of post-harvest application of chemicals on physiological loss in weight (%) of guava under cold storage (2016-17)

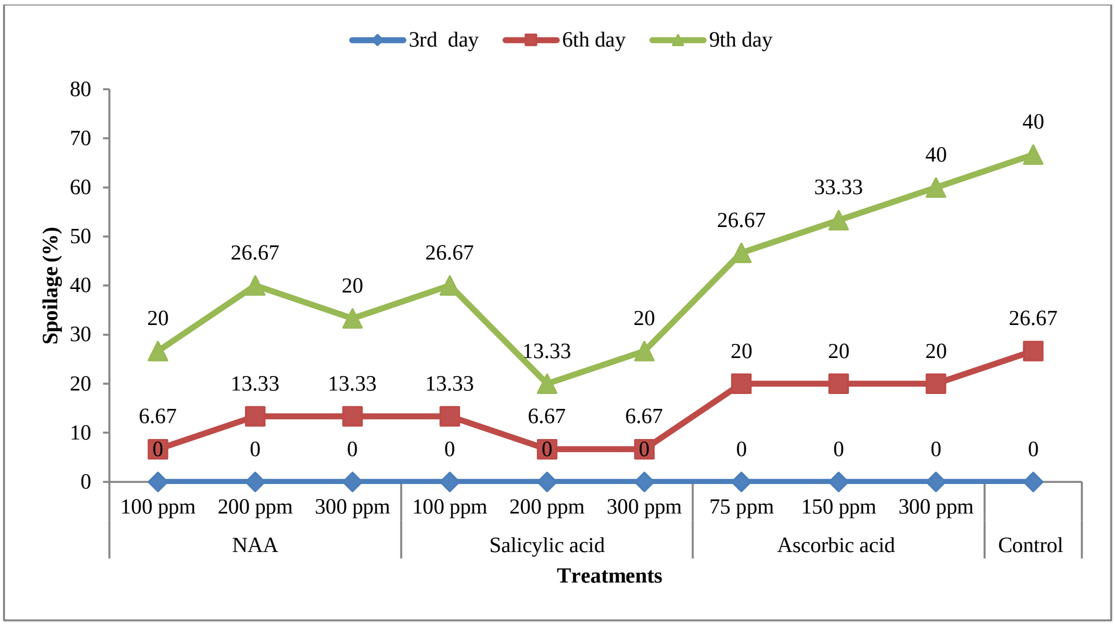

Fig. 27 Effect of post-harvest application of chemicals on spoilage (%) of guava under cold storage (2015-16)

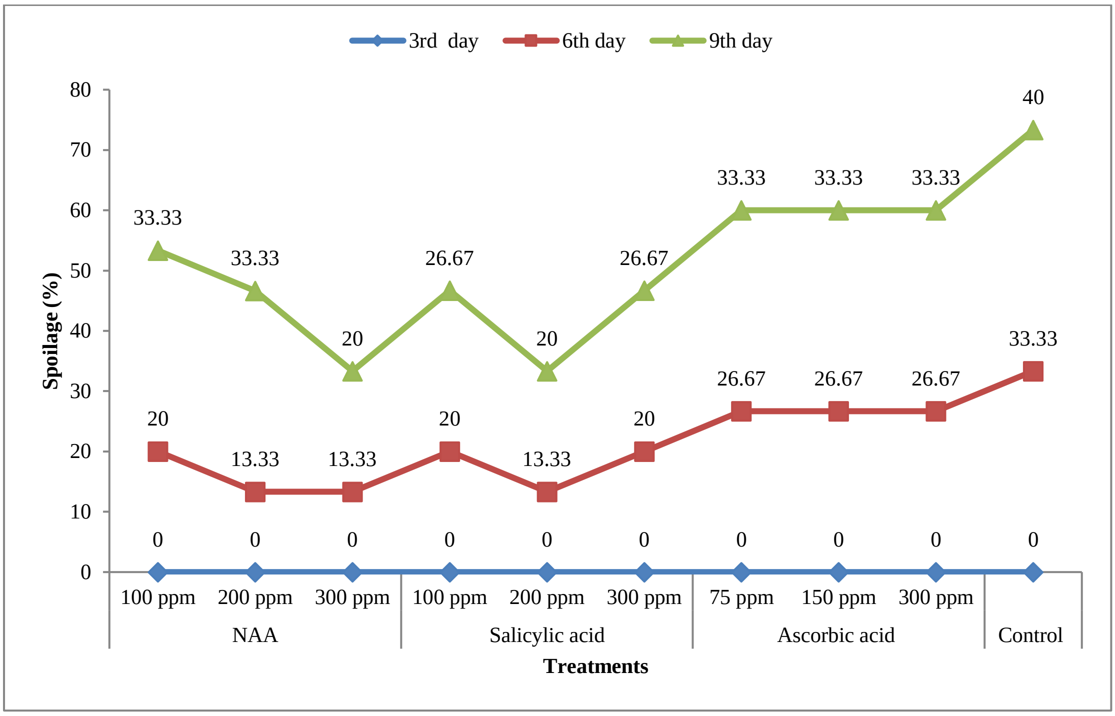

Fig. 28 Effect of post-harvest application of chemicals on spoilage (%) of guava under cold storage (2016-17)

Physiological loss in weight increased gradually in all treatments at cold storage throughout the storage period has also been reported in guava fruits (Mandal *et al* 2012). PLW rate was slow in the initial stages but faster as the storage period advanced. The mean lowest PLW was recorded in NAA within the specified storage period while, mean maximum PLW was recorded in controlled fruits. The fruits treated with NAA showed lower PLW. Increased loss in weight in different fruits of following storage may also be due to variations in rind stomatal density as well as surface (Singh *et al* 2005). Awad (2013) in peach, Bal *et al* (1978) in Umran ber; Abbasi *et al* (2010) and Brar *et al* (2014) in peach reported that reduction in PLW during storage could be attributed to the low rates of respiration and transpiration of fruits. These results are in synchronization with those of submitted by Wongmetha and Ke (2012) during cold storage studies of mango fruit.

4.2.2.1.9 Spoilage percentage

The data on spoilage of fruits during storage are presented in Table 38 and Fig. 27 and 28. Post-harvest applications of various chemical applications and cold storage resulted into significant variances among themselves.

During 2015-16, it was observed that as the cold storage progressed, the spoilage percentage of fruits was increased. However, the lowest mean spoilage percentage, 6.67 was observed in guava fruits treated with salicylic acid 200 ppm. Onward 7th day, it showed an inclined trend and at 14th day, it was noted as 6.67 whereas further increased values were recorded on 21st day i.e.13.33. Likewise salicylic acid 200 ppm, increasing trend and spoilage with corresponding values 6.67 on 14th day and 13.33 on 21st day and mean value of 6.67 were observed in salicylic acid 300 ppm. On the other hand, the highest mean fruit spoilage (22.22) was noted in untreated fruits. Here also fruit spoilage showed an inclining trend with values 26.67 on 14th day and 40.00 on 21st day of storage.

Throughout 2016-17, inclining trend with respect to fruit spoilage was recorded irrespective of various treatments and this trend continued till 21st day of cold storage. Mean lowest fruit spoilage (6.67) was noted in case of salicylic acid 200 ppm. Values of spoilage were nil up to 7th day of cold storage and increased further during 14th day and 21st day to the tune of 13.33. Equivalent values were noted in salicylic acid 300 ppm with same mean value i.e. 11.11. At the end of cold storage period, the average fruit spoilage of guava, among all the treatments found highest in control with value 31.11% with significant variations. The interaction between storage days and treatments and interaction was found to be significant in both year of the study. Significantly higher values were observed in control treatment during both years of the research work.

Table 38. **Effect of post-harvest treatments of chemicals on spoilage (%) of guava cv. Allahabad Safeda under cold storage conditions**

Treatment		Storage days (2015-16)				Storage days (2016-17)			
		3rd day	6th day	9th day	Mean	3rd day	6th day	9th day	Mean
NAA	100 ppm	0.00	6.67	20.00	8.89	0.00	20.00	33.33	17.78
	200 ppm	0.00	13.33	26.67	13.33	0.00	13.33	33.33	15.56
	300 ppm	0.00	13.33	20.00	11.11	0.00	13.33	20.00	11.11
Salicylic acid	100 ppm	0.00	13.33	26.67	13.33	0.00	20.00	26.67	15.56
	200 ppm	0.00	6.67	13.33	6.67	0.00	13.33	20.00	11.11
	300 ppm	0.00	6.67	20.00	8.89	0.00	20.00	26.67	15.56
Ascorbic acid	75 ppm	0.00	20.00	26.67	15.56	0.00	26.67	33.33	20.00
	150 ppm	0.00	20.00	33.33	17.78	0.00	26.67	33.33	20.00
	300 ppm	0.00	20.00	40.00	20.00	0.00	26.67	33.33	20.00
Control		0.00	26.67	40.00	22.22	0.00	33.33	40.00	24.44
Mean		0.00	14.67	26.67	13.77	0.00	21.33	30.00	17.11

Factors	**C.D. ($p \geq 0.05$)**	**Factors**	**C.D. ($p \geq 0.05$)**
Storage days (A)	1.53	Storage days (A)	1.09
Treatments (B)	2.79	Treatments (B)	1.98
Interaction (A X B)	4.83	Interaction (AXB)	3.43

Salicylic acid is used for postponement in ripening process of fruits. NAA treatment encompasses the shelf-life and reduced the spoilage and enhanced fruit quality by postponing the onset of senescence process during storage in case of guava (Selvan and Bal 2005). Mandal *et al* (2012) described that the spoilage of guava fruits increased continuously with the advancement of storage period. The fruits treated with NAA exhibited least spoilage. NAA useful role might be effective due to hindrance of senescence and low temperature effect inside the cold storage which makes difficult for decaying organism to survive and growing conditions.

4.2.2.2 Bio-chemical characters of Fruits

4.2.2.2.1 Total soluble solids

The data pertaining to total soluble solids of guava fruit under cold storage conditions has been presented in Table 39. It reveals that TSS content of the fruit decreased up to end of the storage with post-harvest application of chemical treatments and at various intervals.

During first year of study, different treatments varied significantly among themselves with respect to total soluble solids of Allahabad Safeda. Highest values of average TSS under ambient storage were obtained in NAA 200 ppm treatment with average of 11.07 per cent. TSS was noted as 11.85 per cent on 7^{th} day of storage, but it showed declining trend after that and found reduced values 11.17 per cent and 10.19 per cent on 14^{th} and 21^{st} day, respectively. Similar kind of decreasing trend was also observed in 300 ppm NAA where the values decreased from 11.38 per cent (7^{th} day) to 9.75 per cent (21^{st} day) with average TSS 10.62 per cent. While in control treatment much reduced and significantly lower values were recorded but with declining trend. TSS reduced to the tune of 9.38 per cent on 7^{th} day, 8.84 per cent on 14^{th} day and 8.05 per cent on 21^{st} day, correspondingly with average value of 8.76 per cent.

Throughout 2016-17, the highest total soluble solids were recorded in NAA 200 ppm treatment. Reduced TSS values were noted on 7^{th}, 14^{th} and 21^{st} day as 12.13 per cent, 11.35 per cent and 10.37 per cent, respectively but with declining trend. It was followed by NAA 300 ppm where TSS reduced from 11.84 per cent (7^{th} day) to 10.01 per cent (21^{th} day) with average of 10.98 per cent. Significantly lower values of TSS were recorded in control treatment with average of 9.18 per cent.

Table 39. **Effect of post-harvest treatments of chemicals on total soluble solids (%) of guava cv. Allahabad Safeda under cold storage conditions**

Treatment		Storage days (2015-16)				Storage days (2016-17)			
		7th day	14th day	21st Day	Mean	7th day	14th day	21st day	Mean
NAA	100 ppm	10.51	9.91	9.05	9.82	11.04	10.34	9.38	10.25
	200 ppm	11.85	11.17	10.19	11.07	12.13	11.35	10.37	11.28
	300 ppm	11.38	10.72	9.75	10.62	11.84	11.08	10.01	10.98
Salicylic acid	100 ppm	10.32	9.74	8.90	9.65	10.82	10.14	9.10	10.02
	200 ppm	11.17	10.53	9.58	10.43	11.51	10.77	9.72	10.67
	300 ppm	10.66	10.04	9.15	9.95	11.26	10.54	9.55	10.45
Ascorbic acid	75ppm	10.16	9.59	8.75	9.50	10.66	9.99	9.05	9.90
	150 ppm	9.97	9.40	8.57	9.31	10.53	9.86	8.93	9.77
	300 ppm	9.72	9.15	8.35	9.07	10.24	9.47	8.57	9.43
Control		9.38	8.84	8.05	8.76	9.90	9.26	8.37	9.18
Mean		10.51	9.91	9.03	9.82	10.99	10.28	9.30	10.19
0 day mean		10.93			**0 day mean**		10.21		
Factors		**C.D. (p≥0.05)**				**Factor**		**C.D. (p≥0.05)**	
Storage days (A)		0.24				Storage days (A)		0.26	
Treatments (B)		0.44				Treatments (B)		0.48	
Interaction (A X B)		N S				Interaction (A XB)		N S	

TSS content of the fruit decreased up to end with post-harvest application but slow and steady during the cold storage period. Maximum values of TSS during cold storage period were observed in NAA 200 ppm treatment followed by NAA 300 ppm applications. While in control treatment much reduced and significantly lower values were recorded along with declining trend. The interaction was found to be significant regarding storage days and treatments in both years. Similar results were reported by Selvan and Bal (2005) in guava var. Sardar. But Gautam *et al* (2012) in mango and Mahajan and Dhatt (2004) in pear reported variable results.

4.2.2.2.2 Acidity

The data presented in Table 40 shows that the acidity of Allahabad Safeda guava fruit decreased progressively with the advancement of cold storage period.

During 2015-16, minimum acidity was observed in NAA 200 ppm under cold storage conditions. Lower values were recorded on 7th, 14th day and 21st day i.e. 0.65 per cent, 0.60 per cent, 0.53 per cent, respectively. This treatment was followed by NAA 300 ppm application with average value of 0.59 per cent. Maximum average values of acidity along with higher values were noted in control treatment with average of 0.72 per cent.

During second year of study, NAA 200 ppm application has also shown minimum acidity. In this treatment mean was calculated as 0.60% and guava acidity had shown declining trend. The interaction between storage days and treatments was found to be significant only during 2016-17.NAA 200 ppm was observed the best treatment followed by NAA 300 ppm treatment in lowering the acid content of the fruit. Significantly higher values of fruit acidity were observed in control treatment.

Mandal *et al* (2012); Selvan and Bal (2005) and Killadi *et al* (2007) in guava fruits also proved similar results. Bal *et al* (1982, 1978 and 2010) verified the same results with NAA in ber. Banik *et al* (1988) specified that various treatments had no adverse effects on acidity in ber fruits.

Table 40. **Effect of post-harvest treatments of chemicals on acidity (%) of guava cv. Allahabad Safeda under cold storage conditions**

Treatment		**Storage days (2015-16)**				**Storage days (2016-17)**			
		7th day	**14th day**	**21st day**	**Mean**	**7th day**	**14th day**	**21st day**	**Mean**
NAA	100 ppm	0.70	0.67	0.59	0.65	0.77	0.73	0.65	0.72
	200 ppm	0.65	0.60	0.53	0.59	0.68	0.61	0.51	0.60
	300 ppm	0.65	0.60	0.53	0.59	0.70	0.63	0.54	0.62
Salicylic acid	100 ppm	0.71	0.68	0.61	0.67	0.79	0.75	0.67	0.74
	200 ppm	0.67	0.63	0.56	0.62	0.74	0.68	0.59	0.67
	300 ppm	0.70	0.65	0.59	0.65	0.76	0.71	0.61	0.69
Ascorbic acid	75 ppm	0.71	0.68	0.60	0.66	0.82	0.78	0.71	0.77
	150 ppm	0.72	0.68	0.62	0.67	0.83	0.8	0.74	0.79
	300 ppm	0.74	0.70	0.64	0.69	0.86	0.84	0.79	0.83
Control		0.76	0.73	0.68	0.72	0.88	0.85	0.82	0.85
Mean		0.70	0.66	0.60	0.65	0.78	0.74	0.66	0.73
0 Day Mean		**0.72**				**0 Day Mean**		**0.82**	
Factors		**C.D. (p≥0.05)**				**Factors**		**C.D. (p≥0.05)**	
Storage days (A)		0.01				Storage days (A)		0.01	
Treatments (B)		0.01				Treatments (B)		0.01	
Interaction (A X B)		N S				Interaction (A XB)		0.01	

4.2.2.2.3 Vitamin C

The data presented in Table 41 shows that the vitamin C content of Allahabad Safeda guava fruit decreased gradually with the advancement of storage period. The perusal of results shows that vitamin C content was at higher end during the start of cold storage. As the storage progressed it goes on decreasing till the end of storage.

During 2015-16-year, highest values of vitamin C were recorded immediately after harvesting of the fruits. A declining trend was noted with the advancement of cold storage. It was found highest in NAA 100 ppm treatment (average 193.31 mg/100g). Further declined values of 7th day (211.43 mg/100g), 14th day (191.87 mg/100g) and 21st day (176.63 mg/100g) under cold storage conditions also confirmed the identical trend. It was followed by NAA 200 ppm with average value of 185.68 mg/100g. On the other hand, minimum vitamin C was noted in control treatment to the tune of 125.32 mg/100g with decreasing trend.

Throughout 2016-17, highest values of vitamin C were recorded in NAA 100 ppm treatment with average, 213.27 mg/100g. Likewise 2015-16, decline trend was also observed this year. It was followed by NAA 200 ppm treatment, where vitamin C of fruits also exhibited diminishing trend throughout 7th, 14th and 21st day to the tune of 201.99 mg/100g, 183.79 mg/100g and 168.70 mg/100g, respectively, with average of 201.99 mg/100g. Least amount of vitamin C was noted in control treatment and average was 158.25mg/100g with declining trend. The interaction was found non-significant during both years with respect to storage days and treatments.

Similar observations were reported by Teaotia *et al* (1972) in guava cv. Allahabad Safeda cultivar. On the contrary, Singh (1998) described that vitamin C content of Allahabad Safeda guava fruits increased during first 10 days of cold storage and then decreased. Singh and Chauhan (1982) also described that there was decline in tendency of ascorbic acid in guava fruits cv. Sardar (L-49).

4.2.2.2.4 Total sugars

The data regarding the total sugars were presented in Table 42. It was recorded that total sugars increased during initial stages of cold but a decreasing trend was noted at the end of storage period in all the treatments.

Table 41. Effect of post-harvest treatments of chemicals on vitamin C (mg/100 g) of guava cv. Allahabad Safeda under cold storage conditions

Treatment		Storage days (2015-16)				Storage days (2016-17)			
		7th day	14th day	21st day	Mean	7th day	14th day	21st day	Mean
NAA	100 ppm	211.43	191.87	176.63	193.31	213.27	197.79	184.49	198.52
	200 ppm	206.07	184.48	166.48	185.68	201.99	183.79	168.70	184.83
	300 ppm	195.24	172.14	152.03	173.14	195.50	175.58	158.23	176.44
Salicylic acid	100 ppm	188.44	163.32	140.71	164.16	180.54	157.42	138.75	158.90
	200 ppm	181.93	155.14	130.80	155.95	177.54	152.41	129.79	153.25
	300 ppm	192.61	169.56	148.64	170.27	190.14	168.84	148.70	169.23
Ascorbic acid	75 ppm	181.13	153.74	127.71	154.19	174.15	148.00	124.51	148.89
	150 ppm	172.89	144.76	116.18	144.61	165.42	137.83	112.00	138.42
	300 ppm	166.56	135.99	106.13	136.23	164.30	136.32	110.39	137.00
Control		157.45	124.87	93.64	125.32	158.25	128.15	99.88	128.76
Mean		185.37	159.59	135.89	160.29	213.27	197.79	184.49	198.52

0 Days Mean	**212.90**	**0 Days Mean**	**215.35**
Factors	**C.D. (p≥0.05)**	**Factors**	**C.D. (p≥0.05)**
Storage days (A)	9.36	Storage days (A)	8.63
Treatments (B)	17.08	Treatments (B)	15.75
Interaction (A X B)	N S	Interaction (A XB)	N S

Table 42. **Effect of post-harvest treatments of chemicals on total sugars (%) of guava cv. Allahabad Safeda under cold storage conditions**

Treatment		Storage days (2015-16)				Storage days (2016-17)			
		7th day	14th day	21st day	Mean	7th day	14th day	21st day	Mean
NAA	100 ppm	7.94	8.10	7.37	7.53	6.59	6.81	6.14	6.47
	200 ppm	8.28	8.49	7.82	7.89	7.27	7.55	6.80	7.14
	300 ppm	8.23	8.43	7.78	7.85	7.16	7.42	6.69	7.03
Salicylic acid	100 ppm	7.90	8.05	7.30	7.48	6.52	6.72	6.07	6.40
	200 ppm	8.20	8.38	7.68	7.80	7.11	7.36	6.65	6.98
	300 ppm	8.10	8.27	7.55	7.69	6.78	7.02	6.33	6.66
Ascorbic acid	75 ppm	7.84	8.00	7.23	7.42	6.39	6.57	5.95	6.27
	150 ppm	7.10	7.25	6.47	6.68	6.31	6.48	5.88	6.19
	300 ppm	7.07	7.21	6.42	6.64	6.24	6.40	5.79	6.12
Control		6.31	6.43	5.63	5.87	6.03	6.18	5.59	5.92
Mean		7.70	7.86	7.13	7.28	6.64	6.85	6.19	6.52
0 day mean		**6.45**				**0 day mean**		**6.38**	
Factors		**C.D. (p≥0.05)**				**Factors**		**C.D. (p≥0.05)**	
Storage days (A)		0.14				Storage days (A)		0.13	
Treatments (B)		0.26				Treatments (B)		0.23	
Interaction (A X B)		N S				Interaction (A XB)		N S	

During first year of study, maximum mean total sugars (7.89 %) were observed in fruits treated with NAA 200 ppm. After 0 day of storage the average value was 6.45 per cent but it increased after 14th days of storage to the value of 8.49 per cent. It declined (7.82 %) on 21st day. This treatment was followed by NAA 300 ppm. Similar trend and reduced values were recorded in control treatment on 7th, 14th and 21st day as 6.31 per cent, 6.43 per cent and 5.63 per cent, respectively with average of 5.87 per cent.

During 2016-17, the highest total sugars were also noted in NAA 200 treatment with similar trend. Total sugars were recorded 6.38 per cent at time of storage and it inclined to 7.55 per cent (14th day) and then again declined during 21st day i.e. 6.80 per cent. This treatment was trailed by NAA 300 ppm with average value of 7.03 per cent. While much lower total sugars were recorded in control treatment (5.92%).

Increase in total sugars might be due to dehydration, as in most of the treatments fruits showed high PLW during storage period. The interaction regarding total sugars (during 2015-16 and 2016-17) was found to be non-significant. Yadav *et al* (2001) and Jayachandran *et al* (2005) in guava; Katoch (1981) and Kaundal *et al* (2000) in plum storage found that total sugars increased firstly during storage and then gradually declined. Yeshayahu *et al* (2001) in mandarin and Greenberg *et al* (2006) in 'Nova' mandarin also reported same results.

4.3 Effect of Pre-harvest Spray of Ethephon on Ripening and Quality of Guava cv. Allahabad Safeda.

Various horticultural products can be exposed to ethrel in an alkaline medium to promote their ripening (Mohamed and Abu-Goukh 2003). They reported that ethylene released from ethrel was much effective in prompting fruit ripening in fruits than dipping them in aqueous solution of ethrel.

4.3.1.1 Physical Characters of Fruits

4.3.1.1.4 Fruit colour

The impact of pre-harvest ethephon treatment on guava fruits cv. Allahabad Safeda at ambient temperature is outlined in Table 43. The loss of green colour is an apparent sign of ripening in guava fruits. During study, fruits at harvest stage were recorded to be light yellow green in colour.

Throughout first year, highest colour changes were noted in ethephon 500 ppm and 1000 ppm where fruit colour changes to creamish yellow orange (YOG150A and 154A). El-Rayes (2000) described that ethrel treatment increased markedly skin colour, skin carotenoids and fruit juice. In addition, ethephon application reduced peel chlorophyll and juice acidity. The higher the concentration of ethephon applied, the lower the chlorophyll content in fruit rind and the higher the carotenoids in "Washington Navel" and" Amoon" oranges.

Table 43. Effect of ethephon on fruit colour of guava fruits cv. Allahabad Safeda

Treatment	Storage days (2015-16)				Storage days (2016-17)			
	0 day	2nd day	4th Day	6th day	0 day	2nd day	4th day	6th day
Ethephon 250 ppm	YGG145B	YGG145B	YGG144A	YGG145B	YGG144A	YGG144D	YGG145B	YGG154A
Ethephon 500 ppm	YGG145A	YGG144D	YGG154A	YGG145B	YGG144A	YGG144D	YGG144D	YG10A
Ethephon 750 ppm	YGG145A	YGG144D	YOG150A	YOG150A	YGG154A	YGG154D	YGG145B	YG12C
Ethephon 1000 ppm	YGG144A	YGG144A	YOG 154 A	YOG154A	YGG144C	YGG144D	YOG 154 A	YOG150A
Control	YGG144A	YGG144D	YGG145B	YG9C	YGG145A	YGG145A	YGG154B	YG12B

HCC	**: Visual Colour**
YG9C	: Light yellow
YG10A,12C	: Creamish yellow
YG12B	:Light yellow
YGG144A, B, C, D, 145A, B	: Light yellow green :
YGG154A, B, D	: Yellow green
YOG150A, 154 A	: Creamish yellow orange

As the storage advanced, the colour changes were very fast. After 6th day the fruit skin colour was creamish orange yellow (YGG145B, YOG150A and YOG 154 A) in ethephon 500 ppm to ethephon 1000 ppm. However, fruits in control treatment changed their colour to light yellow (YG 9C).

During second year of study, similar changes were recorded in all ethephon treatments. It was noted that fruits attained maturity colour immediately in storage. Highest colour changes were seen in ethephon 500 ppm treatment where fruit colour changes from Light yellow green (YGG144A) to creamish yellow (YG10A). On the contrary normal colour development was seen in control treatment.

It may be summarized that fruit colour changed very quickly with pre-harvest application of ethephon particularly with ethephon 750 ppm and 1000 ppm. Colour development was very early and the fruit size in not fully developed which may cause reduction in yield. But ethephon 250 ppm and 500 ppm gave satisfactory results regarding shelf life and total yield of the crop. Kaur (2017) proved that ethrel application had significantly influenced flesh colour and overall acceptability scores. Ethrel enhanced ripening in mango by stimulating flesh and skin color from green to yellow due to carotenoids synthesis. Improvement in carotenoids is related with the climacteric increase in respiration process that is familiarized by ethylene action (Saltveit 1999). Mohamed and Goukh (2003) reported that colour development induced by exogenously applied ethylene releasing compounds has been understood to be through a reduction in chlorophyll concentration and increase in carotenoid pigments. Ethrel was reported to hasten chlorophyll destruction in many fruits, including mango (Ashwani *et al* 1995;Barmore 1974), banana (Rao *et al* 1971) and orange (Azab 1994). Jayawickrama *et al* (2001) observed that sensory evaluation scores for flesh colour and over all accept ability were significantly higher in ethrel treated papaya fruits as compared to control.

4.3.1.1.5 Fruit firmness

The data on firmness of fruits is depicted in Table 44 and graphically explained in Fig. 29 and 30. The fruit firmness was significantly influenced with applications of different concentrations of ethephon in contrast to control. Firmness values showed a significant reduction during ripening reflected the rapid softening of fruit pulp. The softening of the fruit with ethrel treatment may be explained through its action on cell wall hydrolysis and fluctuations in complex constituents to simpler ones, which happens during ripening under the control of ethylene (Jain and Dashora 2010).

Table 44. Effect of ethephon on fruit firmness (lbs/cm^2) of guava fruits cv. Allahabad Safeda

Treatment	Storage days (2015-16)					Storage days (2016-17)				
	0Day	2nd day	4th day	6th day	Mean	0day	2nd day	4th day	6th day	Mean
Ethephon 250 ppm	16.84	14.74	12.69	11.78	14.01	16.30	14.47	12.72	11.51	13.75
Ethephon 500 ppm	16.32	14.21	12.14	11.17	13.46	16.40	14.33	12.46	11.69	13.72
Ethephon 750 ppm	16.20	13.61	11.15	10.05	12.75	16.82	13.48	11.33	10.48	13.03
Ethephon 1000 ppm	15.94	13.19	10.89	9.51	12.38	16.50	13.15	10.99	10.12	12.69
Control	17.00	15.02	13.32	12.41	14.44	16.60	14.55	12.69	11.93	13.94
Mean	16.46	14.15	12.04	10.98	13.41	16.52	14.45	12.76	11.15	13.72
Factors	**C.D. (p≥0.05)**					**Factors**			**C.D. (p≥0.05)**	
Storage days (A)	0.61					Storage days (A)			0.57	
Treatments (B)	0.68					Treatments (B)			0.63	
Interaction (A X B)	1.36					Interaction (A X B)			1.27	

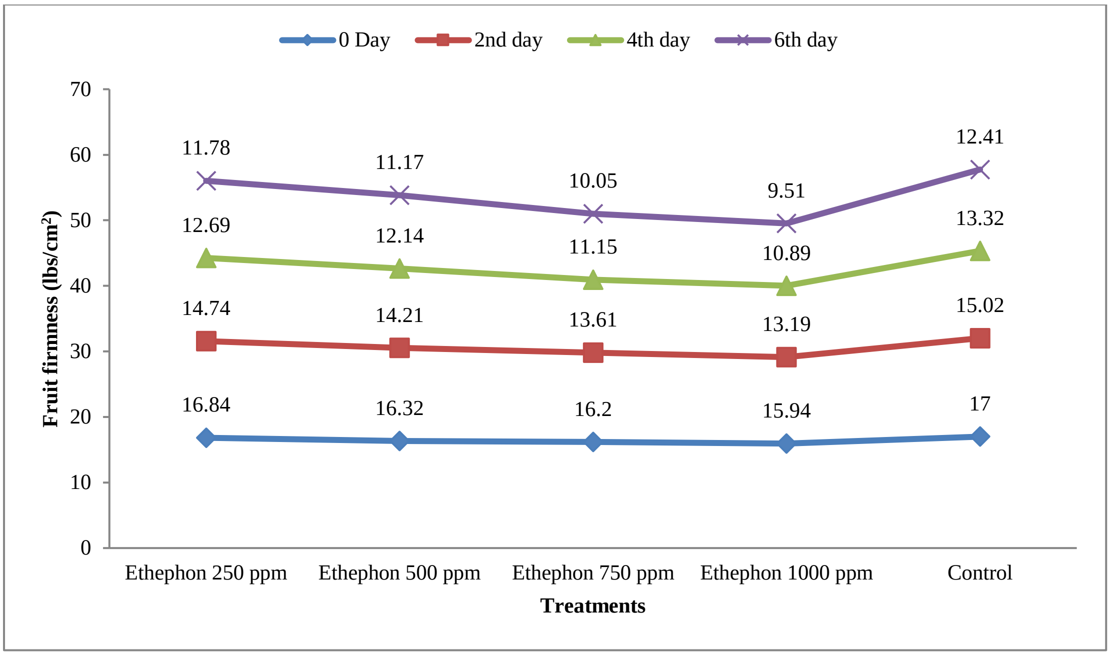

Fig. 29 Effect of ethephon on fruit firmness (lbs/cm^2) of guava under ambient storage (2015-16)

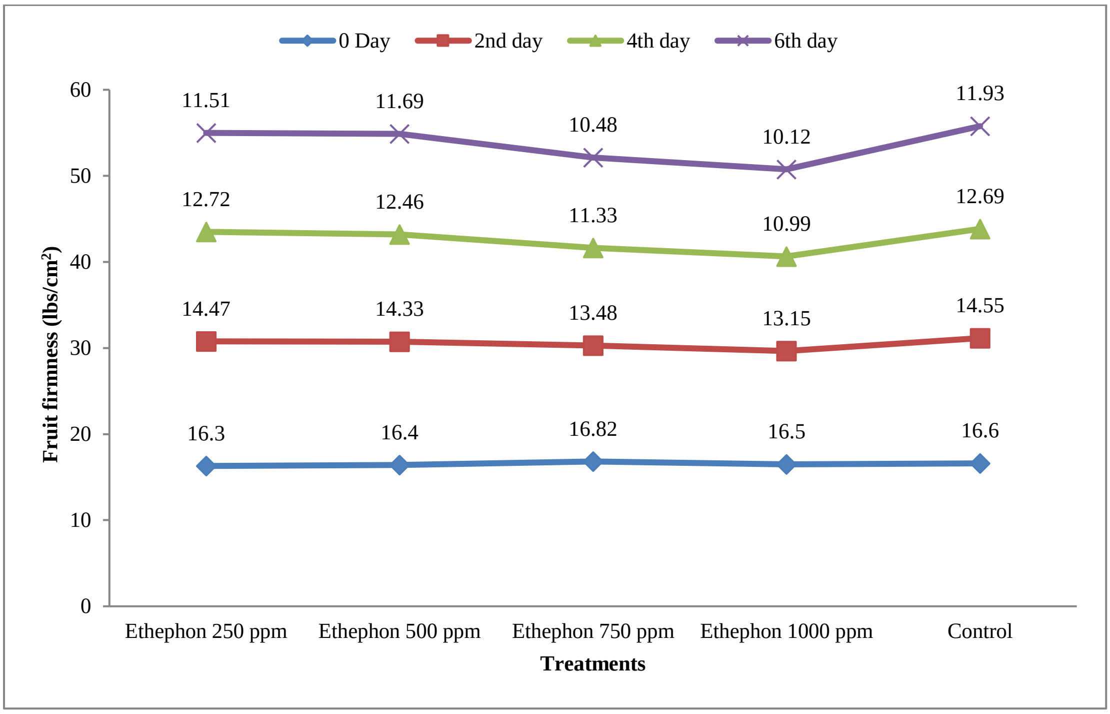

Fig. 30 Effect of ethephon on fruit firmness (lbs/cm^2) of guava under ambient storage (2016-17)

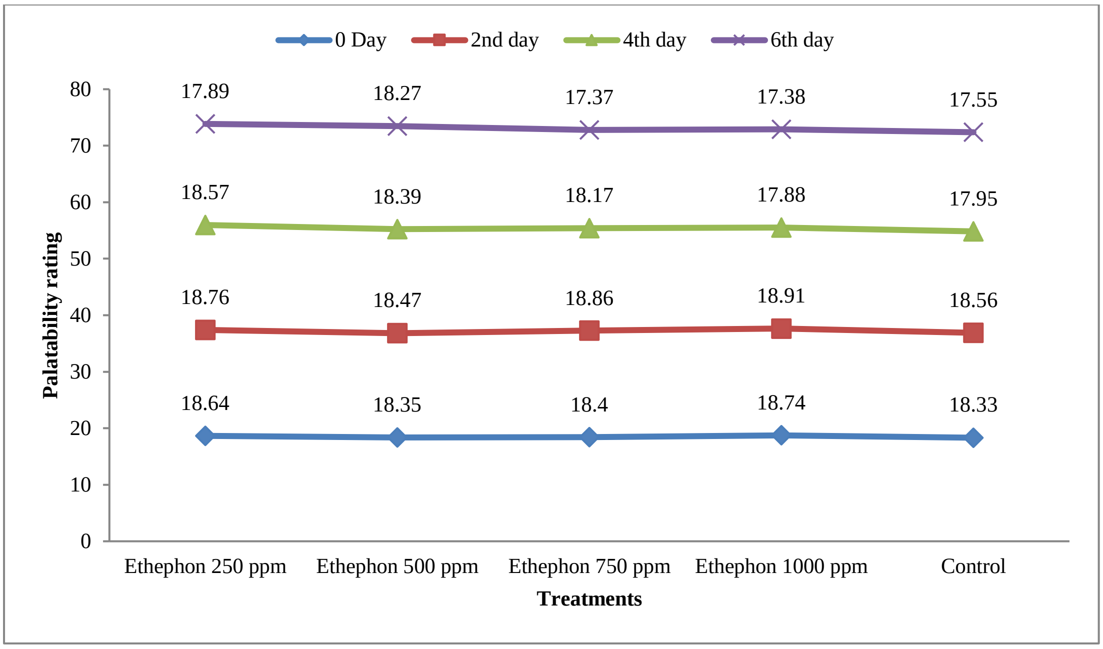

Fig. 31 Effect of ethephon on palatability rating (out of 20) of guava under ambient storage (2015-16)

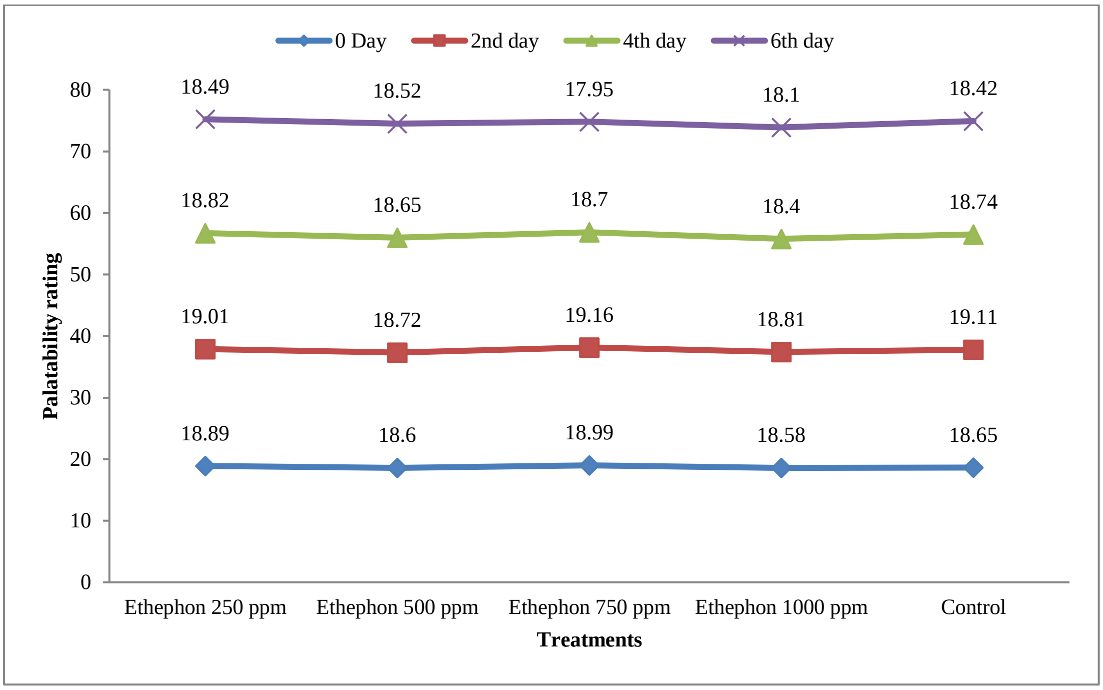

Fig. 32 Effect of ethephon on palatability rating (out of 20) of guava under ambient storage (2016-17)

During first year, it was observed that as the concentration of ethephon increased, the fruit firmness continuously declined. Maximum fruit firmness (14.44 lbs/cm^2) was experienced in control treatment. Among various treatments of ethephon maximum firmness was retained by ethephon 250 ppm (14.01 lbs/cm^2) whereas it was noted the highest during harvest day (16.84 lbs/cm^2). It showed declining trend towards end of storage period with corresponding values of 14.74 lbs/cm^2, 12.69 lbs/cm^2 and 11.78 lbs/cm^2 on 2nd day, 4th day and 6th day, respectively with average value of 13.46 lbs/cm^2.Next to this, better firmness was retained by ethephon 500 ppm with average value of 13.46lbs/cm^2. Minimum fruit firmness (12.38 lbs/cm^2) was noted in ethephon concentration of 1000 ppm.

During second year, fruit firmness was recorded highest in control treatment (13.94 lbs/cm^2) followed by in ethephon 250 ppm (13.75 lbs/cm^2). Declining trend and least values of fruit firmness were observed in ethephon 1000 ppm treatment (12.69 lbs/cm^2). The alteration in fruit firmness was also accredited to variation in the turgor of the cells and in the composition of cell wall pectin's and lipo protein membrane adjoining the cells. It might be due to decomposition of soluble pectin substances by action of endopolyglacturonase enzyme (Martin-Cabrejas *et al* 1994).

Among various treatments of ethephon maximum firmness was retained by ethephon 250. Guava fruit firmness declined continuously with various treatments of ethephon. Better fruit firmness was also recorded in control. It also showed declining trend towards end of storage period. The resembling results were observed by Nour and Goukh (2010) in guava and Kulkarni *et al* (2011) in banana var. Robusta. Dhat *et al* (2005) revealed that firmness of Asian pear decreased in control treatment at ambient temperature, but the fruits did not improve quality parameters properly. The results of current study are in conformity with the findings with Mahajan *et al* (2010) in banana.

4.3.1.1.6 Palatability rating

The data pertaining to palatability rating of guava fruits cv. Allahabad Safedaat ambient temperature as influenced by pre-harvest treatments of ethephon is presented in Table 45 and depicted in Fig. 31 and 32. The organoleptic rating related characters like colour and taste were improved in apple with application of ethrel as it increased phenylalanine-ammonia lyase enzyme activity in treated fruits, which seemed to be the influential factor (Singh *et al* 2002).

Table 45. Effect of ethephon on palatability rating (out of 20.00) of guava fruits cv. Allahabad Safeda

Treatment	Storage days (2015-16)					Storage days (2016-17)				
	0 day	2nd day	4th day	6th day	Mean	0day	2nd day	4th day	6th day	Mean
Ethephon 250 ppm	18.64	18.76	18.57	17.89	18.47	18.89	19.01	18.82	18.49	18.80
Ethephon 500 ppm	18.35	18.47	18.39	18.27	18.37	18.60	18.72	18.65	18.52	18.62
Ethephon 750 ppm	18.40	18.86	18.17	17.37	18.20	18.99	19.16	18.70	17.95	18.70
Ethephon 1000 ppm	18.74	18.91	17.88	17.38	18.23	18.58	18.81	18.40	18.10	18.47
Control	18.33	18.56	17.95	17.55	18.10	18.65	19.11	18.74	18.42	18.73
Mean	18.49	18.71	18.19	17.69	18.27	18.74	18.96	18.66	18.30	18.67

Factors	C.D. ($p \geq 0.05$)	Factors	C.D. ($p \geq 0.05$)
Storage days (A)	0.10	Storage days (A)	0.11
Treatments (B)	0.11	Treatments (B)	N S
Interaction (A X B)	0.23	Interaction (A X B)	0.23

During first year of study, maximum palatability rating was experienced in ethephon 250 ppm with mean value of 18.47. Palatability rating was the highest during harvesting day but as the storage period advanced, palatability rating increased up to 2nd day having values 18.76. Thereafter decreasing trend was observed, and it reduced to 18.57 on 4th day and 17.89 on 6th day. Next to this, higher rating was also recorded in ethephon 500 ppm with average value 18.37. Significantly lower palatability rating was noted in control treatment (18.10).

During 2016-17, similar trend and highest fruit palatability rating was recorded in ethephon 250 ppm (18.80). Palatability increased up to 2nd day and then declines to the value of 18.49 on 6th day. This was followed by ethephon 500 ppm with average of 18.62. Least values of palatability rating were noted in ethrel 1000 ppm having value18.47.

The change in fruit color during ripening process may be due to the synthesis of carotenoids and other chemicals complemented with loss of chlorophyll. It may be concluded that mean highest palatability rating was recorded in ethephon 250 ppm followed by ethephon 500 ppm. On the contrary, lowest average palatability rating was noted in control treatment. Correspondingly, during initial stages of storage, the values of firmness were minimum, then increased and declined thereafter in all the treatments with progression of storage period. Yadav *et al* (2001) recorded similar observations that various fruits in which ethrel were applied resulted in the highest organoleptic score. The maximum organoleptic score in ethrel treated plants may be because ethrel as a ripening hormone reduces the fruit pressure, which is an index of fruit softness or hardness. Ethrel abruptly improved the activity of phenylalanine-ammonialyase in treated fruits, which seems to be an influential factor of color advancement. Dhillon and Mahajan (2011) recorded that increase in organoleptic rating mainly related to improvement in TSS and decrease in acidity.

4.3.1.1.8 Physiological loss in weight

Data pertaining to the influence of different levels of ethephon on physiological loss in weight of guava fruits is presented in Table 46 and Fig 33 and 34. It was observed from the data that there was significant variation in physiological loss of weight of guava fruits due to ethephon treatment as well as storage duration. As the storage period advanced the physiological loss in weight also increased.

Physiological loss in weight is one of the most important physical characters, which determines postharvest losses besides lowering the quality of fruits. The higher physiological loss in weight lower is the quality of fruit and vice versa. This is accredited to the general loss of water or related substances and partial desiccation of the fruits during storage period (Waskar and Gaikwad 2005).

The minimum weight loss among ethephon treatments was observed in ethephon 250 ppm (3.18%) whereas in control the loss occurred to the tune of 2.80 per cent during first year of study. In ethephon 250 ppm, the loss showed inclined trend with advancement of storage. During 2nd, 4th and 6th day, loss had corresponding values of 1.94 per cent, 3.07 per cent and 4.51 per cent, respectively. Above all, the loss was slow and steady in control treatment. The weight loss values were lowest in the initial stages of the storage period but showed increasing trend after 2nd day and similar pattern continue up to final day of storage. On the other hand, maximum PLW of the fruit was recorded in ethephon 1000 ppm (3.64%) followed by ethephon 750 ppm (3.59%).

During second year, similar continuous increasing trend and minimum value of PLW were recorded in ethephon 250 ppm with average of 3.16 per cent. Maximum PLW occurred in ethephon 1000 ppm (3.50%) while in control treatment it was 2.70 per cent. Finally, it could be concluded that weight loss increased as the concentration of ethephon increased in various treatments.

Among the various ethephon treatments, ethephon 250 ppm showed minimum loss whereas loss was quite high in ethephon 1000 ppm. The interaction between storage days and treatments was calculated non-significant in first year. However, it was recorded significant during second year. Constant respiration and transpiration processes have caused in weight loss during ripening. It was reported that the loss in weight of fruit during storage period at ambient temperature increased with the enrichment of storage days in pear (Dhillon *et al* 2005). Siddqui and Dhua (2009) in mango cv. Himsagar supported the fact that ethrel application caused more weight loss than other treatment. It may be due to progressive respiration with advanced concentration of ethrel treatment. Bal (2006) in ber and Mahajan *et al* (2010) in banana fruits proved similar results that are in conformity with present findings. Kaur and Kaur (2017) in guava also proved that the physiological loss in weight was significantly improved with the increase in ethrel chemical concentrations.

4.3.1.1.9 Spoilage percentage

The data relating to spoilage of guava fruits at ambient temperature as influenced by different ethephon treatments is presented in Table 47 and depicted in Fig.35 and 36.

It has been indicated from the data of 2015-16 that fruit spoilage was nil up to 2nd day of storage in all the treatments and showed increasing trend with advancement of storage period. Minimum spoilage percentage was recorded in ethephon 250 ppm with average of 15.56 per cent other than control (11.11). The spoilage percentage showed increasing trend on 4thday (20.00) and thereafter further increase was seen to the tune of 26.67 per cent towards

6th day storage in 250 ppm ethephon. At the end of storage, the highest average values of spoilage average were recorded in ethephon 1000 ppm (28.89).

During 2016-17, minimum spoilage percentage (11.11) was also recorded in ethephon 250 ppm and control treatment. While the highest fruit spoilage was observed in ethephon 1000 ppm with average value of 22.22 which was at par with ethephon 750 ppm. The interaction was found to be significant regarding storage days and treatments during both the years. A considerable loss was recorded in fruits due to decay caused by various fungi and characteristic biochemical changes such as desiccation, shriveling and other processes.

The results are in line with the outcomes reported by Bal (2006) in ber, Mahajan *et al* (2004) in guava and Praveena (2011) in sapota cv. Kalipatti. Harika (2012) submitted the same results that fruit spoilage was maximum at high concentration of ethrel i.e. 2000 ppm. Spoilage of the fruits is directly linked to the rate of respiration process which leads to decline of fruits. This tendency of augmented spoilage with improved ripeness is similar to that reported by Gupta and Jawandha (2010) for peach fruit.

Table 46. Effect of ethephon on PLW (%) of guava fruits cv. Allahabad Safeda

Treatment	Storage days (2015-16)					Storage days (2016-17)		
	2nd day	4th day	6th day	Mean	2nd day	4th day	6th day	Mean
Ethephon 250 ppm	1.94	3.07	4.51	3.18	1.82	2.96	4.71	3.16
Ethephon 500 ppm	1.97	3.11	4.54	3.21	1.84	3.02	4.82	3.22
Ethephon 750 ppm	2.21	3.48	5.07	3.59	2.07	3.15	5.00	3.41
Ethephon 1000 ppm	2.22	3.54	5.16	3.64	2.10	3.21	5.19	3.50
Control	1.85	2.88	3.67	2.80	1.75	2.77	3.59	2.70
Mean	1.94	3.07	4.51		1.91	3.02	4.66	
Factors	**C.D. ($p \geq 0.05$)**				**Factors**			**C.D. ($p \geq 0.05$)**
Storage days (A)	0.26				Storage days (A)			0.24
Treatments (B)	0.34				Treatments (B)			0.31
Interaction (A X B)	N.S.				Interaction (A X B)			0.54

Table 47. Effect of ethephon on fruit spoilage (%) of guava fruits cv. Allahabad Safeda

Treatment	Storage days (2015-16)				Storage days (2016-17)			
	2nd day	4th day	6th day	Mean	2nd day	4th day	6th day	Mean
Ethephon 250 ppm	0.00	20.00	26.67	15.56	0.00	13.33	20.00	11.11
Ethephon 500 ppm	0.00	20.00	40.67	20.22	0.00	20.00	26.67	15.56
Ethephon 750 ppm	0.00	26.67	40.00	22.22	0.00	20.00	40.67	20.22
Ethephon 1000 ppm	0.00	33.33	50.33	27.89	0.00	26.67	40.00	22.22
Control	0.00	13.33	30.00	14.44	0.00	13.33	28.00	13.78
Mean	0.00	22.67	37.53	20.07	0.00	13.33	20.00	11.11
Factors	**C.D. (p≥0.05)**				**Factors**		**C.D. (p≥0.05)**	
Storage days (A)	1.14				Storage days (A)		1.12	
Treatments (B)	1.48				Treatments (B)		1.45	
Interaction (A X B)	2.56				Interaction (A X B)		2.52	

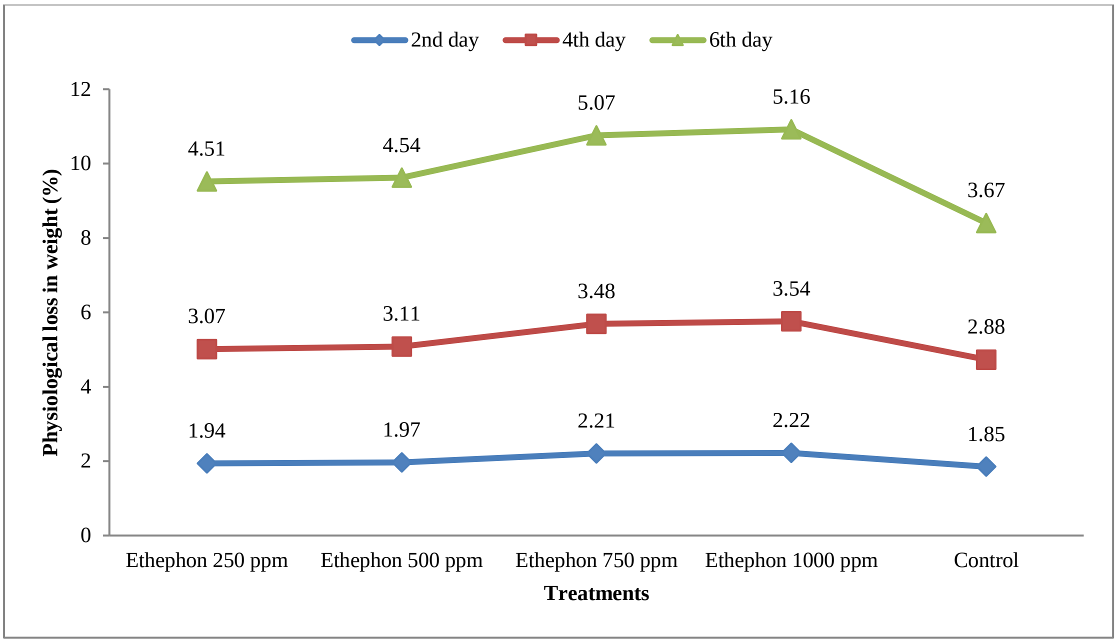

Fig. 33 Effect of ethephon on physiological loss in weight (%) of guava under ambient storage (2015-16)

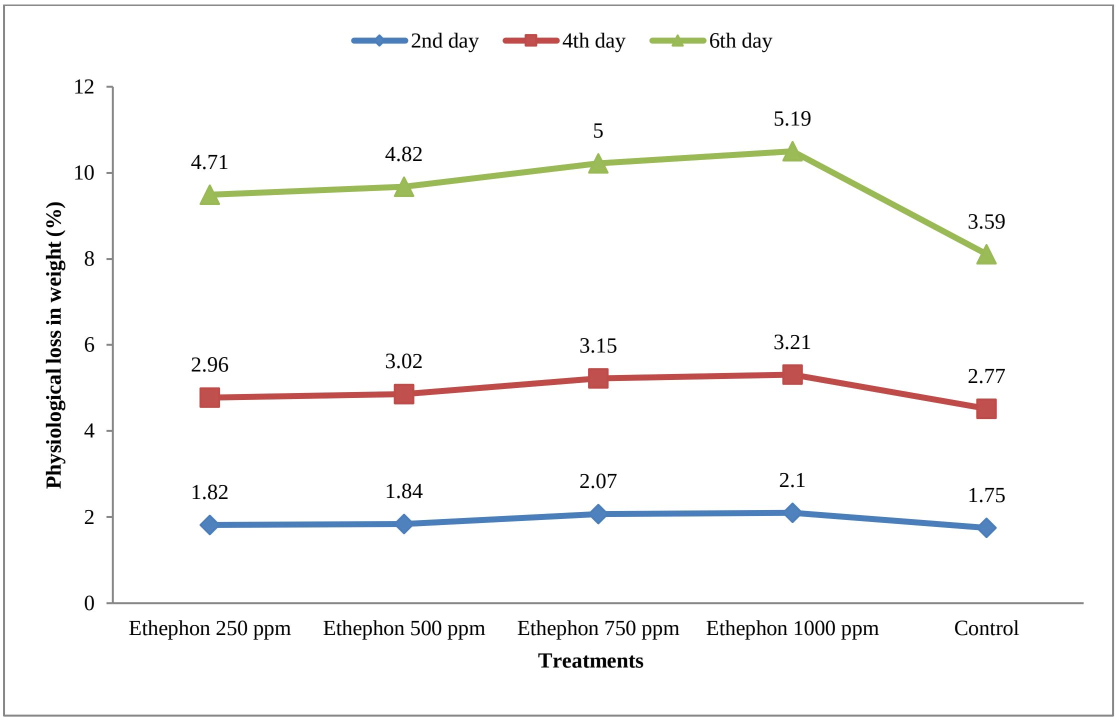

Fig.34 Effect of ethephon on physiological loss in weight (%) of guava under ambient storage (2016-17)

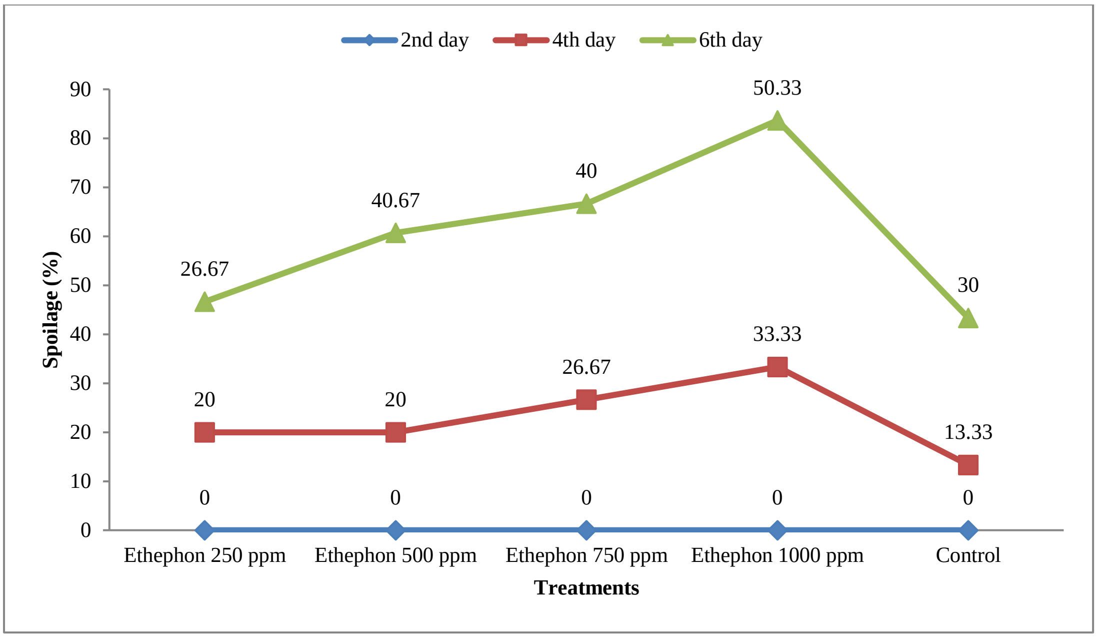

Fig. 35 Effect of ethephon on spoilage (%) of guava under ambient storage (2015-16)

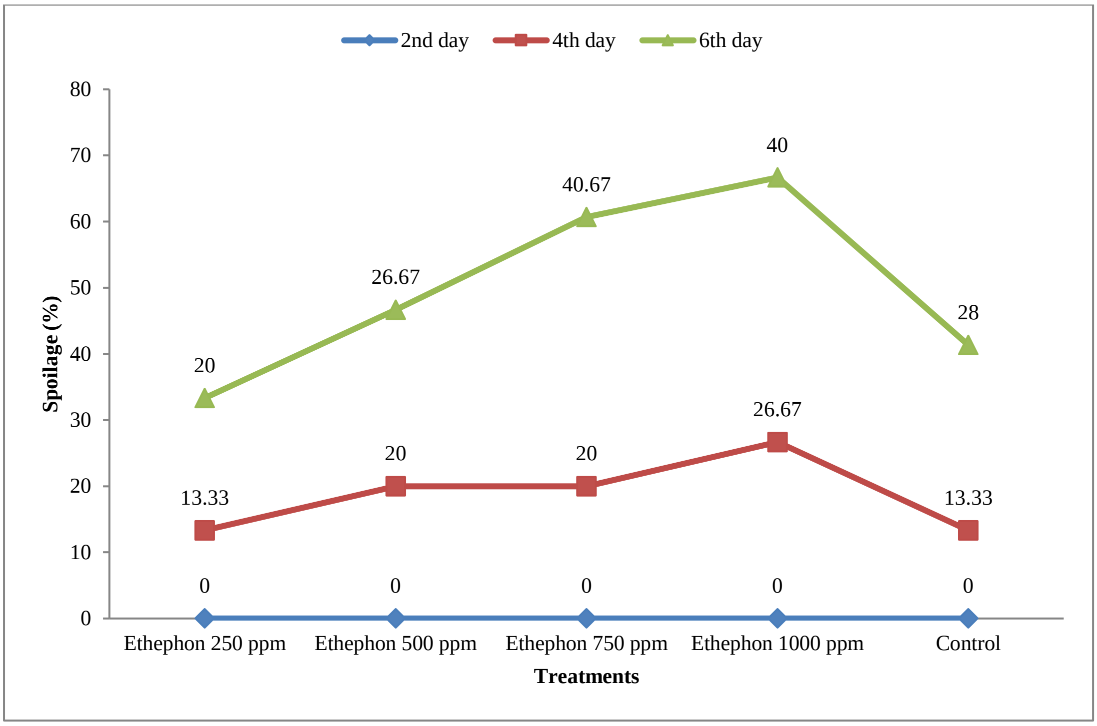

Fig. 36 Effect of ethephon on spoilage (%) of guava under ambient storage (2016-17)

4.3.1.2 Bio-chemical Characters of Fruits

4.3.1.2.1 Total soluble solids

The data pertaining to TSS of guava fruits as influenced by various concentrations of ethephon treatments is displayed in Table 48 and graphically explained in Fig. 43.

The highest average value of TSS (10.54%) with increasing trend was recorded in ethephon 1000 ppm during first year of study. Treated fruits of guava showed lower valves of TSS during initial stages of storage period. As the days of storage progressed the values of TSS increased. But the values of TSS increased up to of 2nd(10.50%)and 4thdays (10.65%). Thereafter a declining trend was recorded on 6th day (10.61%). This treatment was followed by ethephon 750 ppm with same declining trend and average of TSS was recorded 10.43 per cent.

During second year of study, same trend and the highest average TSS (10.29%) was noted in ethephon 1000 ppm whereas it showed increasing trend during 2nd(10.25%)and 4th day(10.37%) of ambient storage. Thereafter, it declined to 10.34 per cent on 6th day. Simultaneously, it was trailed by ethephon 750 ppm with average TSS of 10.12 per cent. On the contrary, the lowest average TSS was noted in control treatment (9.99%).

It was inferred from the results that treated fruits of guava had lower valves of TSS during initial stages of storage period. Ethephon 1000 ppm was considered as the best treatment with respect to TSS.TSS in fruit pulp during ripening increased with ethephon doses lower to higher concentration during storage. This treatment was followed by ethephon 750 ppm with same declining trend. Significant interaction was found between storage days and treatments during course of study. Increase in TSS due to improvement in soluble solids content and soluble sugars caused by hydrolysis of polysaccharides like cellulose, starch and pectin substances into simpler materials. Improvement in TSS due to application of ethrel might be due to its action on changing complex substances into simpler sugars through higher respiration process during ripening of winter guava (Yadav *et al* 2001). Dhillon and Mahajan (2011) in pear proved that TSS in fruit pulp during ripening increased with ethrel doses lower to higher concentration during storage. The reduction in TSS level after 8 days of storage for ripening at ambient storage might be due to the inter conversion of sugars into volatile organic acids. Bal *et al* (1992) in papaya fruits reported highest total soluble solids with application of ethephon.

Table 48. Effect of ethephon on total soluble solids (TSS %) of guava fruits cv. Allahabad Safeda

Treatment	Storage days (2015-16)					Storage days (2016-17)				
	0 day	2nd day	4th day	6th day	Mean	0day	2nd day	4th day	6th day	Mean
Ethephon 250 ppm	10.04	10.20	10.30	10.24	10.20	9.95	10.05	10.17	9.97	10.04
Ethephon 500 ppm	9.87	10.20	10.40	10.38	10.21	9.82	10.15	10.28	10.15	10.10
Ethephon 750 ppm	10.28	10.41	10.54	10.50	10.43	10.18	10.45	10.51	9.35	10.12
Ethephon 1000 ppm	10.39	10.50	10.65	10.61	10.54	10.20	10.25	10.37	10.34	10.29
Control	9.69	9.53	10.59	9.75	9.89	9.45	9.95	10.35	10.20	9.99
Mean	10.05	10.17	10.50	10.30	10.25	9.86	10.14	10.30	10.00	10.08
Factors	**C.D. ($p \geq 0.05$)**					**Factors**			**C.D. ($p \geq 0.05$)**	
Storage days (A)	0.10					Storage days (A)			0.10	
Treatments (B)	0.11					Treatments (B)			0.12	
Interaction (A X B)	0.23					Interaction (A X B)			0.24	

Table 49. Effect of ethephon on acidity (%) of guava fruits cv. Allahabad Safeda

Treatment	Storage days (2015-16)						Storage days (2016-17)			
	0day	2nd day	4th day	6th day	Mean	0day	2nd day	4th day	6th day	Mean
Ethephon 250 ppm	0.82	0.79	0.77	0.75	0.78	0.82	0.78	0.76	0.75	0.78
Ethephon 500 ppm	0.80	0.76	0.74	0.71	0.75	0.81	0.77	0.75	0.72	0.76
Ethephon 750 ppm	0.78	0.76	0.74	0.69	0.74	0.78	0.76	0.74	0.66	0.74
Ethephon 1000 ppm	0.81	0.79	0.70	0.64	0.74	0.82	0.79	0.72	0.66	0.75
Control	0.86	0.81	0.75	0.69	0.78	0.85	0.82	0.75	0.69	0.78
Mean	0.81	0.78	0.74	0.70	0.76	0.82	0.78	0.74	0.70	0.76
Factors	**C.D. (p≥0.05)**					**Factors**		**C.D. (p≥0.05)**		
Storage days (A)	0.01					Storage days (A)		0.01		
Treatments (B)	0.01					Treatments (B)		0.01		
Interaction (A X B)	0.02					Interaction (A X B)		0.03		

4.3.1.2.2 Acidity

The data related to titrable acidity of guava fruits at ambient temperature as affected by various ethephon treatments is presented in Table 49. A declining trend in acid content of fruits was observed in all ethephon treatments. Treated fruits have higher values during first stage of storage but as the storage progressed it continued to decline towards end. Comparable results were also described by Mahajan *et al* (2008) in guava fruits, who noted a reduction in acid content during ripening process and storage. Due to ethephon application, there is an increase in the membrane permeability which permits the acid stored in cell vacuole to repair at faster rate, and it resulted in the reduction of acidity. Reduction in acidity occurs due to faster degradation of organic acids into simple sugars and utilization of acids during respiration activities.

During year 2015-16, lowest acidity was recorded in ethephon 750 ppm and 1000 ppm (0.74%) with decreasing trend during 2nd, 4thand 6th day of storage. These treatments were trailed by ethephon 500 ppm with average acidity value of 0.75 per cent. Whereas in control fruit acidity was somewhat higher with average value of 0.78 per cent.

During second year of study, ethephon 750 ppm treatment had shown the lowest average value (0.74%) during ambient storage. Likewise 2015-16, the values declined up to 4th day and 6th day of storage. Almost near value of acidity was estimated in fruits treated with ethephon 500 ppm. Whereas in control treatment higher values were recorded to the tune of 0.78 per cent. Significant interaction was observed between storage days and treatments during both the years of observations.

This reduction might be due to the exploitation of organic acids at a quicker rate in the respiration activity during ripening. Above acid process might have been activated with the exogenous application of ethephon. The conversion of organic acids into soluble sugars and long chain polysaccharides may also result in reduction of acids (Lelievre *et al* 1997). Alike results were also described by Mahajan *et al* (2008) in guava fruits, who recorded a decrease in acid content during ripening process and storage. The results attained in present research study are in conformity with the annotations of Sakhale *et al* (2006) and Deepa and Preetha (2014) in mango fruits. Similar observations were also submitted by Singh *et al* (2012) in papaya. The decrease in titratable acidity with ethrel treatment may be due to its action on the profligate conversion of organic acids and starch into reducing and non-reducing sugars and their derivatives through higher respiration and carbon assimilation activity during rapid ripening process (Yadav *et al* 2001).

4.3.1.2.3 Vitamin C

The data on vitamin C of guava fruits as influenced by various post-harvest ethephon treatments is presented in Table 50 and described in Fig. 45. Vitamin C of guava declined during storage in all treatments of ethephon.

Table 50. Effect of ethephon on vitamin C (mg/100 gm) of guava fruits cv. Allahabad Safeda

Treatment	Storage days (2015-16)					Storage days (2016-17)				
	0 day	2nd day	4th day	6th day	Mean	0 day	2nd day	4th day	6th day	Mean
Ethephon 250 ppm	210.94	176.69	148.89	129.00	166.38	229.53	177.25	128.58	84.09	154.86
Ethephon 500 ppm	226.61	176.64	143.29	119.11	166.41	238.34	185.54	136.00	91.17	162.76
Ethephon 750 ppm	225.19	177.99	145.81	122.27	167.82	245.29	191.31	140.34	94.45	167.85
Ethephon 1000 ppm	219.57	181.38	149.71	127.14	169.45	247.24	193.99	143.83	98.59	170.91
Control	220.34	170.22	136.04	111.31	159.48	225.61	175.50	129.01	86.25	154.09
Mean	220.53	176.58	144.75	121.77	220.53	237.20	184.71	135.55	90.91	162.10

Factors	C.D. (p≥0.05)	Factors	C.D. (p≥0.05)
Storage days (A)	3.56	Storage days (A)	3.12
Treatments (B)	3.18	Treatments (B)	2.80
Interaction (A X B)	7.12	Interaction (A X B)	6.25

During first year of study, maximum vitamin C was retained in ethephon 1000 ppm treatment with average 169.45 mg/100 g of guava. These values were 219.57 mg/100g, 181.38 mg/100g, 149.71 mg/100g and 127.14 mg/100g on 0, 2^{nd}, 4^{th} and on 6^{th} day of storage, respectively. Continuously reduction was seen in vitamin C content in all the storage intervals. This treatment was followed by ethephon 750 ppm with equivalent declining trend and has average value of vitamin C as 167.82 mg/100g. On the contrary, lowest vitamin C was registered in control treatment (159.48 mg/100g).

During 2016-17, the highest vitamin C was also retained in ethephon 1000 ppm treatment with falling trend at each storage interval with average of 170.91 mg/100g. A reduction in ascorbic acid content with the subsequent prolongation of storage might be due to rapid oxidation phenomenon of organic acid in later storage. This treatment was followed by ethephon 750 ppm where average vitamin C was recorded as 167.85 mg/100g. Least values of vitamin C were observed in control treatment (154.09 mg/100g). The interaction between storage days and treatments was found to be significant.

Yadav *et al* (2001) resolved that spray of ethrel in guava was resulted significantly higher in organoleptic rating, ascorbic acid and reduced fruit pressure over control treatment. It may be accredited to softening of fruit with ethrel action of cell wall hydrolysis and fluctuations of complex substance to simples as carried out in ripening process which is under control of ethylene. Matching observations during ripening were described by Suryanarayana and Goud (1984) in sapota. Reduced ascorbic acid content of ethrel treated sapota fruits may be due to the hastening of ripening process under the influence of ethylene (Tsomu 2013). Sandhu *et al* (1989) and Bal *et al* (1992) in ber showed a declining trend in ascorbic acid content significantly irrespective of the treatments applied during storage. Similar observations were also recorded by Sakhale *et al* (2006) and Doke *et al* (2018) in mango.

4.3.1.2.4 Total sugars

The data pertaining to total sugars of guava fruits at ambient temperature as influenced by different ethrel treatment is presented in Table 51 and depicted in Fig. 46. Treated fruits have exhibited lowest values of total sugars in initial stage of storage period but as the storage period proceeded the continuous and gradual increase is seen in values of all the treatments.

During first year of study increasing trend was recorded regarding total sugars of fruits irrespective of ethephon treatment. However, the highest total sugars were observed in ethephon 1000 ppm with average of 6.34 per cent. The values of total sugars 6.14 per cent, 6.29 per cent, 6.50 per cent and 6.42 per cent correspondingly on 0, 2^{nd}, 4th and 6^{th} days of storage were recorded.

Table 51. Effect of ethephon on total sugars (%) of guava fruits cv. Allahabad Safeda

Treatment	Storage days (2015-16)					Storage days (2016-17)				
	0day	2nd day	4th day	6th day	Mean	0day	2nd day	4th day	6th day	Mean
Ethephon 250 ppm	5.97	6.20	6.38	6.32	6.22	6.18	6.26	6.40	6.35	6.30
Ethephon 500 ppm	5.96	6.24	6.39	6.34	6.23	6.29	6.46	6.56	6.48	6.45
Ethephon 750 ppm	6.10	6.33	6.45	6.37	6.31	6.15	6.44	6.68	6.58	6.46
Ethephon 1000 ppm	6.14	6.29	6.50	6.42	6.34	6.31	6.54	6.58	6.49	6.48
Control	5.67	5.83	5.88	5.81	5.80	5.98	6.14	6.28	6.19	6.15
Mean	5.97	6.18	6.32	6.25	6.18	6.18	6.37	6.50	6.42	6.37

Factors	C.D. (p≥0.05)	Factors	C.D. (p≥0.05)
Storage days (A)	0.11	Storage days (A)	0.12
Treatments (B)	0.12	Treatments (B)	0.13
Interaction (A X B)	N S	Interaction (A X B)	N S

It was clear from the data that values were minimum on 0 day but showed increasing trend during 2nd and 4th day of storage. After that declining trend with lower value was recorded. This treatment was followed by ethephon 750 and 500 ppm with identical trend but with little lower values of average 6.31 per cent and 6.23 per cent total sugars, respectively. Whereas the values were significantly lower in control to the tune of 5.80 per cent.

During 2016-17, the highest values were also registered in ethephon 1000 ppm with 6.48 per cent average at the end of ambient storage followed by ethephon 750 ppm (6.46%). Significantly lowered value and matching trend had been recorded in various treatments of ethephon. On the other hand, significantly lowest values were observed in control treatment to the tune of 6.15 per cent. The interaction was found non-significant between storage days and treatments during the course of study.

Increase in sugar content in ethephon treated plants might be due to the quick ripening of fruits and enhanced activities of hydrolytic enzymes, which is connected with advanced metabolic changes in fruits, leading to the alteration of complex polysaccharides and organic acids into simple sugars through advanced respiration and carbon integration activity. Dhillon and Mahajan (2011) described that sugars increased initially (up to 8 days) and reduced thereafter under in all the fruit ripening treatments. All the ethephon treatments resulted in enhancement of sugars in the fruit over control in pear fruit. Vijaylakshmi and Srinivasan (2000) in mango have recorded similar results. Bal (1992), (2006) in papaya and ber fruits also reported similar results. Kacha *et al* (2014) recorded that the total sugars were expressively improved with ethrel treatment. It might be happened due to the ethrel indorsed hydrolysis of starch into sugars in phalsa. Present results are supported by Singh *et al* (2012) in papaya and Sakhale *et al* (2006) and Patel *et al* (2015) in mango fruit.

Chapter V

SUMMARY AND CONCLUSION

The present investigations on "**Effect of pre- and post- treatments on ripening and storage life of winter season guava (*Psidium guajava* L.) cv. Allahabad Safeda"** were carried out in Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara during 2015-16 and 2016-17. The summary of the results obtained is presented below:

5.1 Effect of Pre-harvest Treatments on Shelf life of Guava in Allahabad Safeda under Ambient and Cold Storage Conditions

5.1.1 Ambient Storage Studies

Fruit size of guava was accessed after treatment with NAA, salicylic acid and ascorbic acid under ambient storage conditions in contrast to control.

NAA 100 ppm was considered as the best treatment in increasing fruit size. However, significantly lower fruit size was recorded in control treatment. A declining trend during storage has been noted in all the treatments.

Fruit weight declined considerably in all the treatments during storage. Fruit weight kept on decreasing with progress in storage duration. During initial stage of storage fruit weight was highest while lowest at the end of the storage period. Maximum guava fruit weight was achieved with salicylic acid 200 ppm treatment.

Best colour development was observed in salicylic acid 200 ppm. Fruits in control treatment changed their colour to light yellow. In salicylic acid fruits were of light-yellow green or medium yellow green.

Specific gravity of guava fruit increased during the storage. NAA 200 ppm resulted in maximum specific gravity of the fruits.

A steady decline of fruit firmness was observed with the increase in storage duration under all the treatments. Maximum fruit firmness was retained with the application of salicylic acid 200 ppm while control treatment had shown significantly lower values.

Palatability rating of the fruits increased firstly and then decreased as the storage period progressed. Highest palatability was retained by NAA 200 ppm treatment throughout the study while lower values were observed in control treatment.

Seed weight continuously decreased during storage period. During study maximum seed weight was retained with application of NAA 100 ppm. Lowest mean seed weight of guava was recorded in untreated fruits.

Total soluble solids of guava fruit improved gradually with the advancement of storage period. Highest value of TSS during ambient storage period was recorded in NAA 200 ppm treatment followed by NAA 300 ppm. Bottommost values of guava TSS were recorded in controlled fruits.

Acidity in guava fruits declined during storage period. NAA 200 ppm application was proved to be best as it sustained lowest acidity followed by NAA 300 ppm treatment. Highest acidity values were recorded in control treatment.

Higher values of vitamin C content were estimated during the initial phase of storage. As the storage progressed it declined till the end of storage irrespective of treatment. Maximum vitamin C was recorded in fruits which were sprayed with NAA 200 ppm followed by NAA 300 ppm while least vitamin C was observed in case of untreated fruits.

It was noted that total sugars in guava fruits increased during storage period. Total sugars were experienced highest in NAA 200 ppm followed by NAA 300 ppm treatment while bottommost values had been verified in control.

5.1.2 Cold Storage Studies

NAA 100 ppm was the finest treatment in relation to increase in fruit size. On the contrary, significantly lower values along with decreasing trend were recorded in untreated fruits.

As the storage advanced the values of fruit weight kept on declining. The values of fruit weight were at their highest during primary stages while lowest during 9th day of cold storage. Maximum guava fruit weight was obtained in salicylic acid 200 treatment while lower fruit weight had been registered in control treatment.

Specific gravity of guava fruit increased as the fruit matures. It may be concluded that best treatment was NAA 200 ppm followed by NAA 300 ppm treatment. A declined trend with respect to specific gravity of fruits was recorded irrespective of various treatments and this trend continues till 21st day of cold storage.

Best development was found in all concentrations of salicylic acid while control fruits had shown faster loss of green colour in storage thereby resulted in excessive and early ripening.

Maximum fruit firmness was retained in salicylic acid 200 ppm followed by salicylic acid 300 ppm while control fruits had shown faster loss of firmness in storage thereby resulted in excessive softening and shriveling of guava and showed significantly lower values.

Throughout storage duration the palatability kept on decreasing. It had been observed that palatability had higher values during initial stages of cold storage. NAA 200 ppm treatment was the premium treatment followed by NAA 300 ppm. Here also lowest values were experienced in control treatment. With the advancement of storage, guava fruit palatability rating showed decreasing trend.

Higher seed weight was recorded during initial phases of storage period than end of the storage. Throughout cold storage a decreasing trend was accessed. NAA 100 ppm was the unrivaled treatment followed by NAA 200 ppm whereas control treatment displayed lowest values throughout the course of study.

A reduction in TSS content was observed under storage in all the treatments; however, its content was sustained to an appreciable level irrespective of the treatments. Maximum TSS was recorded in NAA 200 ppm treatment followed by NAA 300 ppm treatment. Total soluble solids of guava fruits improved gradually with the advancement of storage period. Control treatment had lowermost values of TSS.

Acidity declined during storage period under cold conditions, but decline was very gradual. NAA 200 ppm application was found to best treatment as it continued with lowest acidity values while next to it is NAA 300 ppm treatment. Highest values of acidity were experienced in control treatment.

Vitamin C content was estimated higher during the start of storage. A declining trend was noted as the storage advanced regardless of various treatments. Minimum vitamin C was observed in control treatment whereas, uppermost values of vitamin C were recorded in treatment NAA 200 ppm followed by NAA 300 ppm.

Increase in total sugars was recorded up to 7th day of storage and subsequently increase was slightly sharp up to 14 days and after that a declining trend was noted. Total sugars were assessed the highest in NAA 200 treatment followed by NAA 300 ppm application while control treatment experienced lowest values.

5.2 Effect of Post-harvest Treatments on Shelf life of Guava cv. Allahabad Safeda under Ambient and Cold Storage Conditions

5.2.1 Ambient Storage Studies

Fruit colour changed gradually with advancement of ambient storage period. Salicylic acid 200 ppm has showed better coloured development of fruits. Fruits in control treatment changed their colour to light yellow green/creamish yellow and normal ripening pace was noted.

Maximum fruit firmness along with declining trend was observed in salicylic acid 200 ppm followed by salicylic acid 300 ppm. On the other hand, minimum average value of fruit firmness and significantly lower figures were observed in control.

Decline in taste and appearance of guava fruits continuously and rapidly declined with advancement of ambient storage period in all the treatments. Palatability rating had higher values during initial stages than end of the storage. NAA 200 ppm treatment was the best treatment followed by NAA 300 ppm and decreasing trend continued more towards end of storage.

Salicylic acid 200 ppm was very useful treatment in minimizing physiological weight loss of guava fruits. Next to this, PLW was also noted lowest in salicylic acid 300 ppm. At the end of ambient storage period, the average weight loss of guava fruit among all the treatments found highest in control.

Under ambient storage conditions, minimum spoilage was noted under post-harvest treatment of salicylic acid 200 ppm. This treatment was followed by application of salicylic acid 300 ppm. Significantly higher values had been observed in control treatment during both years of the study.

TSS content of the fruit decreased up to end of the storage at various intervals. Maximum TSS was recorded in NAA 200 treatment. Next to this higher TSS was also recorded in SA 300 ppm. TSS content was sustained to an appreciable level irrespective of the treatments. While in control treatment much reduced values were recorded but with declining trend.

Minimum acidity was recorded in case of NAA 200 ppm. Likewise, declining trend in accordingly with reduced values was noted in NAA 300 treatment. Maximum average value of acidity was noted in control.

Higher vitamin C content was recorded during the early stage of ambient storage. A declining trend was noted as the period advanced towards the end of storage regardless of various treatments. Highest vitamin C were recorded in treatment NAA 100 ppm followed by NAA 200 ppm whereas minimum vitamin C was observed in case of control treatment with declining trend.

Total sugars improved initially during storage and showed a declining trend with the advancement of the storage duration. Total sugars showed significantly different values at unlike storage periods. NAA 200 ppm was found to be best treatment followed by NAA 300 ppm. Significantly lowered values had been accomplished in untreated fruits.

5.2.2 Cold Storage Studies

Fruit colour changed steadily with advancement of cold storage. Salicylic acid 200 ppm showed better colour development while at time of harvesting the fruits were of light-yellow green skin colour. As the storage period advanced, skin colour changes were more visible at different storage intervals and were recorded light yellow green during 14th during 21stday of storage

Salicylic acid 200 ppm showed better fruit firmness followed by salicylic acid 300 ppm, but declining trend was also observed in both cases. Minimum average value and significantly lower values of fruit firmness were observed in untreated fruits under cold storage conditions.

Average palatability rating among all the treatments was observed highest in NAA 200 ppm treatment at the end of cold storage period followed by salicylic acid 300 ppm. Declining trend and significantly lower values of average minimum palatability ratings were recorded in control treatment. Higher palatability ratings were recorded during initial stages of storage period than end of the storage.

There was increase in physiological loss in weight as the storage period progressed. Cold storage can effectively slow down respiration process and unpleasant changes in guava fruit. Much less spoilage percentage was noted in salicylic acid 200 and 300 ppm. But NAA 300 ppm also gave better results regarding PLW. Significantly lower values were recorded in control treatment.

Much less spoilage percentage was noted in salicylic acid 200 ppm followed by salicylic acid 300 ppm. Values of spoilage were nil up to 7th day of cold storage and increased as the storage progressed. While significantly higher spoilage percentage was recorded in control treatment.

TSS content of the fruit decreased up to end of storage period. Maximum values of TSS during cold storage period were established in NAA 200 ppm treatment followed by

NAA 300 ppm applications. While in control treatment much reduced and significantly lower values of TSS were recorded along with declining trend.

NAA 200 ppm was observed as the best treatment followed by NAA 300 ppm treatment having lower acidity content in the fruit. Significantly higher values of fruit acidity were observed in control treatment.

Vitamin C content was at higher side during initial stages of cold storage. NAA 100 ppm exhibited best results concerning retaining of vitamin C trailed by NAA 200 ppm. Least amount of vitamin C was registered with declining trend under controlled conditions.

Maximum mean total sugars were estimated in fruits treated with NAA 200 ppm followed by in NAA 300 ppm and salicylic acid 200 ppm. Significantly lowered total sugar had been accomplished in untreated fruits.

5.3 Effect of Pre-harvest sprays of Ethephon on Ripening and Quality of Guava cv. Allahabad Safeda

5.3.1Ambient Storage Studies

The fruit colour changed very quickly with pre-harvest application of ethephon particularly in ethephon 750 ppm and 1000 ppm. Colour development was very rapid and the fruit size in not fully developed which may cause reduction in yield. But ethephon 250 ppm and 500 ppm gave satisfactory results regarding shelf life and total yield of the crop.

Fruit firmness declined continuously with various treatments of ethephon. Better fruit firmness was also recorded in control. But among different treatments, ethephon 250 ppm had shown satisfactory results. It also showed declining trend towards end of storage period. During initial stages of storage, firmness was minimum then increased and thereafter declined in all the treatments with storage advancement.

Highest palatability rating among all the treatments of ethephon was noted in ethephon250 ppm treatment at the end of storage period followed by ethephon500 ppm. Increasing and thereafter declining trend with significantly lower values of average minimum palatability rating were recorded in control treatment. It had been perceived that palatability had higher rating during initial stages of storage period than end of the storage.

Physiological weight loss increased as the concentration of ethephon increased in various treatments. Ethephon 250 ppm showed minimum average PLW and showed inclined trend with advancement of storage. The weight loss values were lowest in the initial stages of the storage period but maximum PLW along with increasing trend was recorded in ethephon 1000 ppm.

Minimum spoilage percentage was recorded in ethephon 250 ppm whereas loss was quite high in ethephon 1000 ppm. The weight loss values were lowest in the initial stages of the storage period but showed increased values with progression of storage period. A considerable loss was recorded in fruits due to decay caused by various fungi and characteristic biochemical changes such as desiccation, shriveling and other processes.

TSS was recorded lower in treated fruits during initial stages of storage period. Ethephon 1000 ppm was considered as the best treatment with respect to have higher TSS. As the dose of ethephon had increased from lower to higher concentration, increased TSS had been recorded. This treatment was followed by ethephon 750 ppm with equivalent declining trend.

Ethephon 1000 and 750 ppm were found to be the best treatment in lowering of fruit acidity. It was trailed by ethephon 500 ppm application. Higher values of acidity percentage were recorded in case of ethephon 250 ppm.

Vitamin C content of fruit flesh was recorded maximum in case of ethephon 1000 ppm treatment followed by in ethephon 750 ppm. While lowest values had been registered in ethephon 250 ppm during period of study. Continuously reduction was seen in vitamin C content in all the storage intervals.

Total sugars were recorded higher with ethephon 1000 ppm followed by ethephon 750 ppm. Lowest values of total sugars were recorded in ethephon 250 ppm but next to control.

Among the different pre-harvest treatments tested, NAA 200 ppm showed promising results in terms of maintaining fruit size, total soluble solids, acidity, vitamin C and total sugars under ambient and cold conditions. More fruit weight, reduction in PLW and less spoilage was recorded in salicylic acid 200 ppm under ambient and cold storage with post-harvest applications. Better firmness, high palatability with less spoilage and PLW was observed in ethephon 250 ppm. Attractive fruit colour with ethephon 500 ppm and improved biochemical characters like acidity, total sugars with ethephon 750 ppm and total soluble solids and vitamin C were obtained with ethephon 1000 ppm. It was concluded that during cold storage the guava fruits maintained better quality up to two weeks in comparison to ambient storage.

LITERATURE CITED

A.O.A.C (2010) Official Methods of Analysis. 18th Edition, Revision 3, Association of Official Analytical Chemists, Washington DC.

Abbas MF, Al-Niami JH and Al-Sareh EA (1994) The effect of ethephon on the ripening of fruits of jujube. *J. Hort. Sci.,* **69:465**–466

Abbasi NA, Tareen MJ, Hafiz IA (2012) Post-harvest application of salicylic acid enhanced antioxidant enzyme activity and maintained quality of peach cv. Flordaking' fruit during storage. *Scientia Hort.,* **142:** 221-28

Abbasi N, Hafeez S, Tareen M J, Hewett EW, Johnston JW and Gunson F (2010) Salicylic acid prolongs shelf life and improves quality of 'Maria Delicia' peach fruit. *Acta Hort.,* **880:** 91-97

Abubakar AR, Ashraf N and Ashraf M (2013) Influence of plant bio stimulants on physio-chemical characteristics of pomegranate cv. Kandhari Kabuli. *Journal of Cell and Tissue Research*, **13**(3): 3949

Adel MI and Nejatian MA (2017) Effect of salicylic acid and chelated magnesium sulfate on fruit quality improvement (physical characteristics) in pear (cv. Louise Bonne). *Majallah-i Ulum-i Bāghbānī,* **30** (1): 133-140

Agnihotri A, Tiwari R and Singh OP (2013) Effect of crop regulators on growth, yield and quality of guava. *Annals of Plant and Soil Research,* **15**: 54-7

Agrawal S and Dikshit SN (2010) Studies on the effect of plant growth regulators on qualitative characters of sapota cv. Cricket Ball. *Indian J. Hort.,* **67**: 177–80

Ahmed MN (1998) Studies on the Effect of post-harvest application of Polyamines and Antioxidants on Shelf Life of Mango (*Mangifera indica* L.) cv. Baneshan. Doctoral dissertation, ANGRAU ACH, Horticulture.

Ahmed MS and Singh S (2000) Studies on extension of storage life of Amrapali mango. *Orissa Journal of Horticulture,* **28**; 73-76

Ahmed W, Tahir FM, Rajwana IA, Raza SA and Asad HU (2012) Comparative evaluation of plant growth regulators for preventing premature fruit drop and improving fruit quality parameters in 'Dusehri' mango. *International Journal of Fruit Science*, **12**(4): 372-389

Akhtar A, Abbasi NA and Hussain A (2010) Effect of calcium chloride treatments on quality characteristics of loquat fruit during storage. *Pak J. Bot.,* **42**(1): 181-188

Al-Atroushy SM and Abdul-Qader SM (2015) Effect of potassium and ascorbic acid on growth, yield, and quality of olive cv. Khadrawi. *International Journal for Sciences and Technology*, **10** (1): 19-23

Ali, S, Masud T, Abbasi KS, Mahmood T and Hussain I (2013) Influence of CaCl sub on biochemical composition, antioxidant and enzymatic 2 activity of apricot at ambient storage. *Pakistan Journal of Nutrition*, **12**(5): 476

Al-Khawaga AS (2014) Impact of vitamins B and C, glutamic acid and silicon on fruiting of superior grapevines world rural observ. *6*, 57-62 'Allahabad Safeda' guava. *Indian J. Hort.*, **45** (1-2): 45-50

Al-Saif H and Mohammed A (2011) Effect of plant growth regulators on fruit growth and quality development of syzygium samarangense (water apple/wax apple). Doctoral dissertation, University of Malaya.

Amanullah Sikandar, Mateen Sajid, Muhammad Bilal Qamar and Ahmad Saeed (2017) Post-harvest treatment of salicylic acid on guava to enhance the shelf life at ambient temperature. *Int. J. Bio. Sci.*, **10** (3): 92-106

Amarante CVTD, Drehmer AMF, Souza FD and Francescatto P (2005) Pre-harvest spraying with gibberellic acid (GA_3) and aminoethoxyvinilglycine (AVG) delays fruit maturity and reduces fruit losses on peaches. *Revista Brasileira de Fruticultura*, **27**(1):1-5

Amoros A, Zapata P, Pretel MT, Botella MA, Almansa MS and Serrano M (2004) Role of naphthalene acetic acid and phenothiol treatments on increasing fruit size and advancing fruit maturity in loquat. *Scientia Hort.*, **101**(4): 387-398

Anawal, VV, Narayanaswamy P and Ekabote SD (2016) Effects of plant growth regulators on fruit set and yield of pomegranate (*Punica granatum* L.) cv. Bhagwa. *Indian Horticulture Journal*, **6**(2), 171-174

Apelbaum A, Shiow Y, Wang A, Burgon, Baker JE and Lieberman M (1981) Inhibition of the conversion of 1 Amino cyclopropane-1-corboxylic acid to ethylene by structural analog inhibitors of electron transfer uncouplers of oxidative phosphorylation and free radial scavengers. *Plant Physiology*, **67**: 74-79

Arora Rachna and Singh S (2014) Effect of growth regulators on quality of ber (*Zizyphus mauritiana* L.) cv. Umran. *Agri. Sci. Digest.*, **34** (2):102 – 106

Asgharia M and Aghdam MS (2010) Impact of salicylic acid on post-harvest physiology of horticultural crops. *Trends Food Sci. Tech.*, **21:** 502-09.

Ashwani K, Dhawan SS and Kumar A (1995) Effect of post-harvest treatments on the enhancement of ripening of “Dashehari" mango. *Haryana J. Hort. Sci.*, **24** (2): 109±15

Augusti M, EL-Otmani M, Aznar M, Juan M. and Almela M. (1995) Effect of 3,5,6 trichloro-2-pyridyloxyacetic acid on fruit size at maturity. *J. Hort. Sci.*, **70**: 855-862

Augustin MA and Azizah O (1988) Post-harvest storage of guava (*Psidium guajava* var. Taiwan). *Pertanika,* **11** (l): 45-50

Awad RM (2013) Effect of post-harvest salicylic acid treatments on fruit quality of peach cv. Flordaprince during cold storage. *Australian Journal of Basic and Applied Sciences*, **7**(7): 920-927

Azab S and Ismail A (1994) Effect of ethrel on colour development and juice quality of sweet oranges and grapefruits. *Qatar University Journal of Science*, **14** (2):293±7

Bal (2006) Effect of pre-harvest spray of growth regulators on ambient storage of ber. *International J. Agri. Sci.*,**2** (1): 9-12

Bal JS (1982) Study on biochemical changes during room and refrigerated storage of ber. *Prog. Hort.*, **14:** 158-61

Bal JS (1997) Fruit Growing (First Edition). Kalyani Publishers, New Delhi.

Bal JS (2006) Effect of pre-harvest spray of growth regulators on ambient storage of ber. *International J. Agri. Sci.*, **2** (1): 9-12

Bal JS (2014) Fruit Growing (Third Edition). Kalyani Publishers, New Delhi

Bal JS (2018) Fruit Science Culture and Technology vol. 1. Basic Aspects and Practices. New India Publishing Agency, New Delhi

Bal JS and Randhawa JS (2007) Extension Bulletin. Punjab Agricultural University, Ludhiana.

Bal JS and Singh P (1978) Developmental physiology of ber (*Zizyphus mauritiana* Lamk.) var. Umran I physical changes. *Indian Food Packer,* **32** (3): 59-61

Bal JS, Kahlon P S, Jawanda JS and Sandhu SS (1992) Effect of pre-harvest spray on growth regulators at turning stage on the maturity of ber fruits (*Ziziphus mauritiana* Lamk.). *Acta Hort.*,**321**:318–325

Bal JS, Randhawa JS and Boora R S (2010) Studies on post-harvest life of ber fruits treated with growth regulators and stored with different packages at cool temperature. National seminar on impact of climatic changes on fruit crops held at PAU, Ludhiana, Pp:333-38

Bal JS, Randhawa JS and Singh S N (1988) Effect of NAA on fruit characters and quality of ber cv. Umran. *Haryana J. Hort. Sci.,* **17** (1-2): 20-23

Bal JS, Singh MP, Minhas PPS and Bindra AS (1990) Effect of ethephon on ripening and quality of papaya. *Acta Hort.*, 296: 119-122

Bal JS, Singh SN, Randhawa JS and Jawanda JS (1984) Effect of growth regulators on fruit drop, size and quality of ber (*Zizyphus mauritiana* Lamk.) *Indian J. Hort.,* **41**: 182-185

Bal JS, Singh SN, Randhawa JS and Sharma SC (1982) Effect of naphthalene acetic acid and Trichlorophenoxy acetic acid on fruit drop, size quality of ber. *Prog. Hort.,* **14** (2-3): 148-151

Bal, JS, Singh MP, Minhas, PPS and Bindra AS (1992) Effect of ethephon on ripening and quality of papaya. *Acta Hort*., **296**: 119-122

Bandhopadhyay A and Sen SK (1995) Studies on the physico-chemical changes associated with storage life of ber cv. 'Gola'. *Indian Agriculturist,* **39** (1):67-70

Banik D, Hore JK and Sen SK (1988) Studies on storage life of ber (*Zizyphus maurtiana* Lamk.). *Haryana J. Hort. Sci.,* **17**: 49-55.

Baninaiem E, Mirzaali and Astjerdi AM, Rastegar S and Abbaszade K (2016) Effect of pre- and post-harvest Salicylic acid treatment on quality characteristics of tomato during cold storage. *Advances in Horticultural Science*, **30** (3): 183-192

Baraya CP (1997) Effect of pre-harvest application of plant growth regulators and bio-stimulants on the post-harvest shelf-life of guava cv. 'Lucknow-49'. M.Sc. (Ag.) Hort. Thesis, RAU, Bikaner.

Barmore CR (1974) Ripening mangoes with ethylene and ethephon. *Proc. of Florida State Horticultural Society*, **87**: 331−334

Basak A, Rozpara E and Grzyb Z (1998) Use of bio-regulators to reduce sweet cherry tree growth and to improve fruit quality. *Acta Hort.,* **468**: 719–723.

Baskran A and Sathiamurty (2008) Effect of retardants on quality of papaya (*Carica papaya* Linn.) cv. CO 2. *The Asian journal of Horticulture,* **3**(2):313-314

Batlang U (2008) Benzyladenine plus gibberellins (GA_{4+7}) increase fruit size and yield in greenhouse-grown hot pepper (*Capsicum annuum* L). *J. Biol. Sci.,* **8**(3): 659-662.

Baviskar MR, Wasker DP and Kaulgud SN (1995) Effect of various post-harvest treatments on shelf life and quality of ber fruit. *Indian J. Hort.,* **52** (1): 37-45

Bhalerao BP, UT Deasi, SD Masalkar and Choudheri SM (1994) Effect of calcium salt, auxin, cytokinin and polyethylene packaging on shelf life of guava. *J.Maharastra Agri. Univ.,* **19** (3): 390-392

Bhat Ramesh Kumar (2000) Crop regulation in guava (*Psidium guaiava* L.) cv. Allahabad Safeda. Thesis submitted to The Faculty of Post Graduate Studies, Sher-E-Kashmir University of agriculture Sciences and Technology, Jammu.

Bhati BS and Yadav PK (2003) Effect of foliar application of urea and NAA on quality of ber (*Zizyphus mauritiana* Lamk.) cv. Gola. *Haryana J. Hort. Sci.,* **32(**1-2): 32-33

Bhatia BS and Yadav RK (2005) Effect of foliar spray of urea and NAA on fruit yield and quality of ber (*Zizyphus mauritiana* Lamk.). In "National Seminar on Commercialization of Horticulture in Nontraditional Areas" held at CIAH, Bikaner.

Bindhyachal R (2011) Response of foliar spray of boron and plant growth regulators on growth, yield and quality of guava (*Psidium guajava* L.) cv. Arka Amulya. Thesis submitted to Birsa Agricultural University Ranchi (Jharkhand).

Bisen S, Thakur RS and Tembhare D (2014) Effect of calcium nitrate and gibberellic acid application on growth, fruit quality and post-harvest behavior of guava fruit. *The Ecoscan*, **6**: 55-62

Biswas B, Ghosh SK, Ghosh B and Mitra SK (1988) Effect of growth substances on fruit weight, size and quality of guava cv. L-49. *Indian Agriculturist*, **32**(4): 245-248

Biten court De Souza AL, Quintao Scalon SDP, Chitarra MIF and Chitarra AB (1999) Post-harvest application of $CaCl_2$ in Strawberry fruits (*Fragaria ananassa* Dutch cv. Sequoia): Evaluation of fruit quality and post-harvest life. *Cienc Eagrotec Lavras*, **23**: 841-848

Blankenship SM and Dole JM (2003) 1-Methylcyclopropene: a review. *Post-harvest Biology and Technology*, **28** (1): 1−25

Brackmann A, Thewes FR, Anese, RDO, Linke Junior W and Schultz EE (2015) Aminoethoxyvinylglycine: isolated and combined with other growth regulators on quality of 'Brookfield'apples after storage. *Scientia Agricola*, **72** (3): 221-228

Brahmachari VS, Naresh Kumar and Kumar R (1997) Effect of foliar feeding of calcium, potassium and growth substances on yield and quality of guava (*Psidium guajava* L.). *Haryana J. Hort. Sci.*, **26** (3/4): 169-173

Brahmachari VS, Mandal AK, Kumar R and Rani R (1996) Effect of growth substances on flowering and fruiting characters of Sardar guava (*Psidium guajava* L.). *Hort. J.,* **9** (1): 1-7

Brar JS, Dhaliwal HS and Bal JS (2012) Influence of paclobutrazol and ethephon on fruit quality of 'Allahabad Safeda' guava. *Hort.Flora Research Spectrum*, **1**(2): 135-138

Brar JS, Gupta N and Gill MS (2014) Effect of pre and post-harvest treatments of salicylic acid on quality characteristics of peach (*Prunus persica* L.) fruits during storage. *Prog. Hort.*, **46**:217-21

Cai C, Chen K, Xu W, Zhang W, Li X and Ferguson I (2006) Effect of 1-MCP on post-harvest quality of loquat fruit. *Post-harvest Biol. Technol.*, **40** (2):155-162

Cao J K, Yan JQ, Zhao YM and Jiang WB (2013) Effects of four pre-harvest foliar sprays with - aminobutyric acid or salicylic acid on the incidence of post -harvest disease and induced defense responses in jujube (*Zizyphus jujuba* Mill.) fruit after storage. *J. Hort. Sci. Biotech.,* **88:** 338-44

Chahal S and Bal JS (2004) Quality of GA, NAA and wax treated ber (*Zizyphus mauritiana* Lamk.) fruits after storing them in cold storage for different duration. *Haryana J. Hort. Sci.,* **33** (3-4):240-42

Chamkha M, Cathala B, Cheynier V, Douillard R (2003) Phenolic composition of champagnes from Chardonnay and Pinot Noir vintages. *J. Agr. Food Chem.,* **51**:3179–3184

Champa WH, Gill MIS, Mahajan BVC and Arora NK (2014) Pre-harvest salicylic acid treatments to improve quality and post-harvest life of table grapes (*Vitis vinifera* L.) cv. Flame Seedless. *Journal of Food Science and Technology*, **52**(6): 3607-3616

Chandra R and Singh KK (2015) Foliar application of zinc sulphate, magnesium sulphate and copper sulphate on the yield and quality of aonla (*Emblica officinallis* Gaerth L.) cv. NA-7 under Garhwal Himalaya. *Himalaya Journal of Medicinal Plants Studies*, **3**(5): 42-45

Chang SS (1989) The effect of plant growth regulators on flowering and fruit quality in loquat. *Taiwan Agriculture Bimonthly,* **25**(3): 69-80

Chaudhary AS, Singh Moti and Singh GN (1992) Effect of plant growth regulators on quality of loquat fruits cv. Tanaka Japan. *Prog. Hort.,* **24**: 22-22

Chauhan KS and Gupta AK (1985) Effect of foliar application of urea on the fruit drop and physico-chemical composition of ber (*Ziziphus mauritiana* Lamk.) fruits under arid conditions. *Haryana J. Hort. Sci.,* **14**:9–11

Cleland CF (1995) Plant hormones physiology, biochemistry and molecular biology. P. J. Davies, (Ed.) 2nd Edition, Kluwer Academic Publishers, The Netherlands.

Crisosto CH, Crisosto GM and Metheney P (2003) Consumer acceptance of 'Brooks and 'Bing' cherries is mainly dependent on fruit SSC and visual skin color. *Post-harvest Bio. Technol.,* **28**: 159-167

Cruz - Castillo, JG Woolley, DJ and Lawes GS (1999) Effect of CPPU and other plant growth regulators on fruit development in kiwi fruit. *Acta Hort.,* **498:173-**178

Dashora, LK (2001) Influence of pre- and post-harvest application of plant growth regulators on physico-chemical changes and shelf-life of guava fruits (*Psidium guajava* L.) cv. Lucknow-49. Doctoral dissertation, Maharana Pratap University of Agriculture and Technology, Udaipur.

Dastjerdi A, Moradi N, Rezazadeh E and Heidari M (2014) Effect of salicylic acid and storage time on quality of mango fruits (*Mangifera indica* L.). *The Plant Production,* **37**(1):27-36.

Debnath A (2010) Effect of growth regulators on flowering, fruit set, yield and quality in phalsa (*Grewia sub-inaequalis* DC.). Thesis submitted to Andhra Pradesh Horticultural University.

Deepa J and Preetha P (2014) Influence of exposure time, temperature and ethylene concentration on the ripening of mango fruits. *Trends in Biosciences*, **7**(20): 3260-3267

Deepthi VP and Sekhar RC (2015) Post-harvest physiological and biochemical changes in guava (cv. Lucknow-49) fruits harvested at two stages of maturity during low temperature storage. *International Journal of Processing and Post-harvest Technology*, **6**(2): 128-143

Dhanani MM (1984) Effect of urea and various growth regulators on growth, yield and quality of guava cv. L-49. M.Sc. (Ag.) Thesis, GAU, Navsari.

Dhatt AS, Mahajan BVC, Bhatt AR (2005) Effect of pre and post harvest calcium treatments on storage life of Asian pear. *Acta Hort.*,**696**: 497-501

Dhillon WS and Mahajan BVC (2011) Ethylene and ethephon induced fruit ripening in pear. *Journal of Stored Products and Postharvest Research*, **2**(3): 45-51

Dhillon WS, Mahajan BVC, Dhatt AS and Sandhu AS (2005) Waxing and storage studies in soft-pear cv. Punjab Beauty. *Acta Hort.,* **696**: 485-492

Dhoot LR, Desai UT and Rana DA (1984) Studies on the shelf-life of guava fruits with polythene packaging and chemical treatment. *J. Maharashtra Agri. Uni.,* **9** (2): 185-8

Ding ZS, Tian SP, Zheng XL, Zhou ZW and Xu Y (2007) Responses of reactive oxygen metabolism and quality in mango fruit to exogenous oxalic acid or salicylic acid under chilling temperature. *Stress Physiol. Plant*, **130:** 112–121

Doke ND, Dhemre JK and Khalate SM (2018) Role of ethylene on ripening of Kesar mango fruits. *International Journal of Chemical Studies*, **6**(2): 170-174

Dubey AK, Singh DB and Dubey N (2002) Crop regulation in guava (*Psidium guajava* L) cv. Allahabad Safeda. *Prog. Hort.,* **34** (2): 200-203

Dutta P and Banik AK (2007) Effect of foliar feeding of nutrients and plant growth regulators on physicochemical quality of Sardar guava grown in West Bengal. *Acta Hort.,* **335**(6): 407-411

Dutta P, Banik AK, Raychoudhury R and Dhua RS (1991) Influence of ethylene absorbents on shelf life of guava fruits. *Indian J. Hort.*, **48** (3): 213-216

Echeverria E and Valich J (1989) Enzymes of sugar and acid metabolism in stored 'Valencia 'oranges. *J. Amer. Soc. Hort. Sci.,* **114:445**–449

El-hilali F, Ait-Oubahou A, Remah1 A and Akhayat O (2003) Chilling injury and peroxidase activity changes in “Fortune” mandarin fruit during low temperature storage. *Bulgarian Journal of Plant Physiology,* **29**: 44–54

El-Rayes, DA (2000) Enhancement of color development and fruit ripening of "Washington Navel" and" Amoon" oranges by Ethrel pre-harvest application. *Assiut Journal of Agricultural Sciences,* **31**(2), 71-87

El-Razek EA, Abd-Allah ASE and Saleh MMS (2013) Foliar spray of some nutrient elements and antioxidants for improving yield and fruit quality of Hindi mango trees. *Middle East Journal of Scientific Research*, **14**(10): 1257-1262

El-Sherif AA, Saeed WT and Nouman VF (2000) Effect of foliar application of potassium and zinc on behaviour of Montakhab El-Kanater guava trees. *Bulletin of Faculty of Agriculture University of Cairo,* **51**(1):73-84

Farag KM and Kassem, HA (2000) Effect of naphthalene acetic acid, calcium, phosphorus, or potassium on fruit quality, abscission and the shelf life of guava fruits. *Emirates Journal of Food and Agriculture*, **12** (1): 1-19

Fattahi J, Fifall R and Babri M (2010) Post-harvest quality of kiwifruit (*Actinidia deliciosa* cv. Hayward) affected by pre-storage application of salicylic acid. *South West J. Hort. Biol. Environ.,* **1**:175-86

Figueroa CR, Opazo MC, Vera P, Arriagada O, Díaz M and Moya-León MA (2012) Effect of post-harvest treatment of calcium and auxin on cell wall composition and expression of cell wall-modifying genes in the Chilean strawberry (*Fragaria chiloensis*) fruit. *Food Chemistry*, **132**(4): 2014-2022

Gaidi BR and Bohra SP (2003) Effect of plant growth regulators on pigment composition, photosynthesis and some biochemical aspects in ber (*Zizyphus mauritiana* cv. Tikadi). *South Ind. J.,* **51**: (1/6):129-133

Garasiya VR, Patel NM, Bhadauria HS, Verma LR, Rathore BS and Vaghela PO (2013) Effect of NAA, GA_3, CCC and 2, 4-D on the quality parameters of winter season guava (*Psidium guajava* L.) cv. L-49. *Research on Crops,* **13** (2): 768-769

Garg RC, Ram HB and Singh SK (1978) A note on the effect of certain growth regulators on the ripening and storage behavior of guava cv. 'L-49.' *Prog. Hort.,* **9** (4): 48-51

Gaspar JW, Couto FAA, Salomao LCC, Finger FL and Cardoso AA (1997) Effect of low temperature and plastic films on post-harvest life of guava (*Psidium guajava* L.). *Acta Hort.,* **452**:107-114

Gaur GS (1996) Studies on crop regulation of guava. *Recent Hort.,* **3** (1): 21-23

Gautam US, Singh R, Tiwari N, Gurjar PS and Kumar A (2012) Effect of integrated nutrient management in mango cv. Sunderja. *Indian J. Hort.,* **69** (2): 151-155

Ghazi I, El-Banna and Weaver Robert J (1979) Effect of ethephon and gibberellin on maturation of ungirdled Thompson Seedless grape. Amer *J. Enol. Vitic.,* **30**(1): 11-13

Ghazzawy HS (2013) Effect of some applications with growth regulators to improve fruit physical, chemical characteristics and storage ability of Barhee date palm cultivar. *Int. Res. J. Plant Sci.,* **4** (7): 208-213

Ghosh SN, Bera B, Roy S, Kundu A and Roy SKD (2009) Effect of nutrients and plant growth regulators on fruit retention, yield and physicochemical characteristics in aonla cv. 'NA-10'. *Hort. Sci.,* **4** (2): 164-166

Gill KBS, Dhaliwal HS, Mahajan BVC (2014) Effect of post-harvest treatment of ascorbic acid on shelf life and quality of guava (*Psidium guajava* L.) cv. Allahabad Safeda. *Int. J. Agri. Sci. Veter. Med.,* **2**(1): 130–141

Gill KS and Bal JS (2013) Impact of application of growth regulators on Indian jujube. *Acta Hort.,* **993**:119-124

Gill KS, Dhaliwal HS, Mahajan BVC, Paliyath G and Boora RS (2016) Enhancing postharvest shelf life and quality of guava (*Psidium guajava* L.) cv. Allahabad Safeda by pre-harvest application of hexanal containing aqueous formulation. *Post-harvest Biology and Technology*, **112:** 224-232

Gill PPS and Bal JS (2010) Effect of pre-harvest applications of nutrient and growth regulators on quality of Sardar guava. *Haryana J. Hort. Sci.,* **39**(3/4): 193-194

Gill PPS and Bal JS (2016) Effect of growth regulator and nutrients spray on control of fruit drop, fruit size and quality of ber under sub-montane zone of Punjab. *Journal of Horticultural Science*, **4**(2): 161-163.

Godara NR, S Rajbir and Dahiya SS (2001) Response of foliar application of growth regulators and nutrients in ber (*Z. mauritiana* Lamk.) cv. Umaran. *Haryana J. Hort. Sci.,* **30**(3/4):161-163

Greenberg Kaplan I, Fainzack M, Egozi Y and Giladi B (2006) Effect of auxins sprays on yield, fruit size, fruit splitting and the incidence of creasing of 'Nova' mandarin. *Acta Hort.,* **727:** 249-254

Gupta N and Jawandha SK (2010) Influence of maturity stage on fruit quality during storage of' early grande' peaches. *Notulae Scientia Biologicae*, **2**(3): 96-99

Gupta OP, Chauhan KS and Daulta BS (1983) Effect of ethrel on the storage life of citrus fruits. *J.Res.,* HAU, **13**: 458-463

Gupta OP, Siddiqui S and Chauhan KS (1987) Evaluation of various calcium compounds for increasing the shelf life of ber. *Indian J. Agri Sci.,* **21** (2): 65-70

Gupta VK, Mukherjee D (1980) Effect of morphactin on the storage behavior of guava fruits. *J. Amer. Soc. Hort. Sci.,* **105** (1): 115-119

Haard NF and Salunkhe DK (1975) Symposium on post-harvest biology and handling of fruits and vegetables. The AVI Publishing Co. Inc.

Hajilou J and Fakhimrezaei S (2013) Effects of post-harvest calcium chloride or Salicylic acid treatments on the shelf-life and quality of apricot fruit. *The Journal of Horticultural Science and Biotechnology,* **88** (5):600-601

Han T, Wang Y, Li L and Ge X (2003) Effect of exogenous salicylic acid on post-harvest physiology of peaches. *Acta Hort.,* 628: 583–589

Harhash MM and Al-Obeed RS (2007) Effect of naphthalene acetic acid on yield and fruit quality of Barhee and Shahl date palm cultivars. *Assiut J. Agri. Sci.,* **38**(2): 63-73

Harika M (2012) Studies on pre and post-harvest treatments on ripening in sapota (*Manilkara achras* (Mill) Fosberg) *cv.* Kalipatti (Doctoral dissertation, Dr YSR Horticultural University). Rajendranagar.

Hazarika TK, Sangma D Balsri, Mandal D, Nautiyal BP and Shukla A C (2016) Effect of plant growth regulators on growth, yield and quality of tissue cultured papaya (*Carica papaya*) cv. Red Lady. *Indian Journal of Agricultural Sciences,* **86** (3): 404–8

Hiteshkumar Raval Vatsal (2014) Effect of plant growth regulators on flowering, fruit set, fruit yield and quality of red guava (*Psidium guajava* L.). Thesis submitted to College of Agriculture, Anand Agricultural University, Anand, Gujarat.

Hong K, Xie J, Zhang L, Sun D and Gong D (2012) Effects of chitosan coating on postharvest life and quality of guava (*Psidium guajava* L.) fruit during cold storage. *Scientia Hort.,* **144**: 172-178

Ibrahim HIM, Ahmed FF, Akl AM MA, and Rizk MNS (2013) improving yield quantitively and qualitatively of Zaghloul date palms by using some antioxidants. *Stem Cell,* **4**(2): 35-40

Ingle HV, Rathod NG and Patil DR (2001) Effect of growth regulators and mulching on yield and quality of Nagpur mandarin. *Ann. J. Plant Phys.,* **15** (1): 85-88

Iqbal M, Khan MQ, Rehman K and Munir M (2009) Effect of foliar application of NAA on fruit drop, yield and physico-chemical characteristics of guava (*Psidium guajava* L.) red flesh cultivar. *J. Agri. Sci.,* **47**(3): 259-269

Ismail Omayma Ml, Abd El-Moniem AA, Abd-Allah ASE and El-Naggar MAA (2010) Influence of some post-harvest treatments on guava fruits. *Agri. Biol. J. N. Am.*, **1**(6): 1309-1318

Jagadeesh SL and Rokhade AK (1998) Effects of post-harvest treatments on keeping quality of guava (*Psidium guava* L.) fruits cv. Sardar-1. *Karnataka J. Agri. Sci.,* **11**(4): 1003-1008

Jahromi Aboutalebi Abdolhossein and Ramazani Malihe (2015) Effect of chitosan and salicylic acid on qualitative properties of Indian ziziphus (*Ziziphus mauritiana* Lamk. cv. 'Seb'). *Indian Journal of Fundamental and Applied Life Sciences*, **5**(1)*:* 113-116

Jain MC and Dashora LK (2010) Effect of different plant bio regulators in relation to fruit quality and yield of guava (*Psidium guajava* L) cv. Sardar. *Prog. Hort.*, **42**(1): 50-53

Jain MC and Dashora LK (2011) Effect of plant growth regulator son physic-chemical characters and yield of guava cv. Sardar under high density planting system. *Indian J. Hort.,* **68**: 259–61

Jain RK, Chitkara SD and Chauhan KS (1981) Studies of physico-chemical characters of ber (*Zizyphus mauritiana* Lamk.) fruits cv. Umran in cold storage. *Haryana J. Hort. Sci.*, **10**: 141-46

Jawanda JS, Bal JS, Josan JS and Mann SS (1980) Studies on storage of ber fruit II cool temperature. *Punjab Hort. J.,* **20** (3/4): 56-61

Jawandha SK, Gupta N and Randhawa JS (2012) Effect of post-harvest treatments on enzyme activity and quality of cold stored ber fruit. *Not. Sci. Biol.,* **4**:86-89

Jayachandran KS, Srihari D and Reddy YN (2005) Changes in post-harvest quantity of guava fruits affected by pre-harvest application of growth regulators. *Agri. Sci. Digest,* **25** (3): 210 – 212

Jayachandran KS, Srihari D and Reddy YN (2007) Post-harvest application of selected antioxidants to improve the shelf life of guava fruit. *Acta Hort.*,**735**: 627–632

Jayawickrama F, Wijeratnam RSW and Perera S (2001) The effect of selected ripening agents on organoleptic and physico-chemical properties of papaya. *Acta Hort.*, **533:** 275-281

Jeet Ram (2004) Studies on the effect of phosphorus, zinc and foliar spray of nutrients and growth regulators on ber (*Ziziphus mauritiana* Lamk.) cv. Umran. Doctoral dissertation, Chaudhary Charan Singh Haryana Agricultural University, Hisar.

Joshi GD, Prabhudesai VG and Salvi MJ (1986) Physico-chemical characteristics of karonda (*Carissa carandas* L.) fruits. *Maharashtra J. Hort.*, **3** (1): 39-44

Kacha HL, Giriraj Jat and Patel SK (2014) Performance of various plant growth regulators on yield and quality of phalsa (*Grewia asiatica* L). *Hort. Flora Research Spectrum*, **3**(3): 292-294

Kader AA (1992) Post-harvest technology of horticultural crops (2*nd* Edition) UC Publication 3311. University of California, Division of Agriculture and Natural Resources, Oakland, California

Kale VS, Kale PB and Adpawar RW (1999) Effect of plant growth regulators on fruit yield and quality of ber cv. Umran (*Zigyphus mauritina* Lamk). *Annals of Plant Physiol.*, **13** (1): 69-72

Karlidag H, Yildirim E and Turan M (2009) Salicylic acid ameliorates the adverse effect of salt stress on strawberry. *Sci. Agri. Piracicaba. Braz.*, **66**(2):180-187

Karole B and Tiwari R (2016) Effect of pre-harvest spray of growth regulators and urea on growth, yield and quality of ber under malwa plateau conditions. *Annals of Plant and Soil Res.*, **18**(1): 18-22

Kaseem HA, Al-Obeed RS, Ahmed MA and Omar AKH (2011) Productivity, fruit quality and profitability of jujube trees improvement by pre-harvest application of agrochemicals. *Middle-East J. Sc. Res.*, **9**:628-37

Katiyar PN, Singh JP and Singh PC (2009) Effect of nutrients and plant growth regulators on physico-chemical parameters and yield of guava (*Psidium guajava* L.) fruit cv. Allahabad Safeda. *Internat. J. Agri. Sci.*, **5** (1): 173-174

Katiyar PN, Singh JP, Singh PC and Gangwar APS (2008) Effect of pre-harvest application of plant growth regulators on post-harvest quality of organically grown guava (*Psidium guajava* L.) fruits. *Asian Journal of Horticulture*, **3** (2): 330-332

Katoch SK (1981) Effect of pre-harvest application of some growth regulators, nutrients and fungicides on storage behaviour of plum. M.Sc., Thesis, Dr Yashwant Singh Parmar University of Horticultural and Forestry, Solan, Himachal Pradesh.

Katyal R (1987) Studies on the effect of growth regulators on fruit set, fruit retention, fruit quality and yield in ber (*Ziziphus mauritiana* Lamk.) cv. Kaithli. M.Sc. Thesis, Haryana Agricultural University, Hisar.

Kaundal GS, Mushtaq K, Minhas PPS and Bal JS (2000) Effect of growth regulators, nutrient and wax emulsion on the storage behaviour of plum (*Prunus salicina* Lindal.). *J. Res. PAU*, **37**: 48-55

Kaur A (2008) Storage behaviour of plum (*Prunus salicina* Lindl.) fruits cv. Satluj Purple in response to various chemicals Thesis submitted to Punjab Agricultural University, Ludhiana.

Kaur P (2016) Shelf life enhancement studies in Guava (*Psidium guajava* L.) cv. Shweta. M.Sc. Thesis submitted, PAU, Ludhiana.

Kaur S (2009) Effect of chemicals on storage life and quality of ber cv. Umran. M.Sc. Thesis submitted to Punjab Agricultural University, Ludhiana

Kaur S (2017) Effect of different treatments of ethrel on ripening behaviour and post-harvest quality of mango (*Mangifera indica* L.) during storage. *Journal of Applied and Natural Science*, **9**(1): 85-93

Kaur S and Bal JS (2014) Influence of pedicel retention and ascorbic acid on post-harvest life of ber in cold chamber. *Acta Hort.,* **1116:125-**30

Kaur S and Kaur A (2017) Effect of growth regulators on yield and quality of winter guava cv. Allahabad Safeda. *Int. J. of Adv. Res.,* **5** (9): 98-103

Kays SJ and Van Nostrand Reinhold (1991) Post-harvest physiology of perishable plant products. New York: Van No strand Reinhold. ISBN 0-442-23912-2. pp. 532.

Khademi Z and Ershadi A (2013) Postharvest application of salicylic acid improves storability of peach (*Prunus persica* cv. Elberta) fruits. *International Journal of Agriculture and Crop Sciences,* **5**(6): 651-655

Kher R, Bhat S and Wali VK (2005) Effect of foliar application of GA_3, NAA and CCC on physico-chemical characteristics of guava cv. Sardar. *Haryana J. Hort. Sci.*, **34** (1/2): 31-32

Killadi B, Singh MD, Singh BP and Singh RA (2007) Shelf -life evaluation of guava (*Psidium guajava* L.) cultivars. *Acta Hort.*, **735** : 603-607

Kishan R and Godara NR (1992) Effect of post-harvest treatment of different chemicals on shelf-life of Gola ber (*Zizyphus mauritiana* Lamk.) fruits. *Int. J. Trop. Agri*., **10**: 288-92

Klein BP, Perry AK (1982) Ascorbic acid and vitamin A activity in selected vegetables from different geographical areas of the United States. *J. Food Sci.,* **47**: 941–945

Koruna Kumara, Mankar Abhay and Singh Jayant (2007) Effect of growth substances on yield and quality of mango cv. langra. *The Orissa Journal of Horticulture*, **35** (1) 67-70

Kulkarni SG, Kudachikar VB and Prakash MK (2011) Studies on physico-chemical changes during artificial ripening of banana (*Musa* sp.) variety ‘Robusta’. *Journal of Food Science and Technology*, **48**(6): 730-734

Kumar D, Rajput CBS and Singh SP (1994) Effect of calcium chloride and bavistin on the post-harvest life of jujube fruits (*Zizyphus mauritiana* Lamk.) cv. Banarasi Pewandi. *Prog. Hort.,* **26** (1-2): 72-76

Kumar P and Singh S (1993) Effect of GA_3 and Ethrel on ripening and quality of mango cv. Amrapali. *The Hort. J.,* **6**(1): 19-24

Kumar R, Lal Shanti and Tiwari JP (2010) Influence of zinc sulphate and boric acid spray on vegetative growth and yield of winter season guava (*Psidium guajava* L.) cv. Pant Prabhat. *Pantnagar. J. Res.,* **8**(1): 135-138

Kumar Rajesh Tiwari and Kumawat BR (2013) Quantitative and qualitative enhancement in guava (*Psidium guajava* L.) cv. Chittidar through foliar feeding. *International Journal of Agricultural Sciences,* **9** (1): 177-181

Kumar SP, Singh C, Verma AK and Jain BP (1998) Effect of potassium, nitrogen and gibberellic acid on yield attributed of guava (*Psidium guajava* L). *J. Res. Birsa Agri. Univ.,* **10**: 52-55

Kumar MA and Reddy YN (2008) Preliminary investigations on the effect of foliar spray of chemicals on flowering and fruiting characters of mango cv. Baneshan. *Res. J. Agri. and Biol. Sci.,* **7** (2): 150-156

Kundu S and Mitra SK (1997) Regulation of cropping in guava. *Ind. J. Hort.*, **54** (2): 139-145

Ladaniya MS, Singh S and Mahalle B (2005) Sub-optimum low temperature storage of "Nagpur" mandarin as influenced by wax coating and intermittent warming. *Indian J. Hort.*; **62**(1): 1-7

Lal N and Das RP (2017) Effect of Plant Growth Regulators on Yield and Quality of Guava (*Psidium guajava* L.) cv. Allahabad Safeda. *Int. J. Curr. Microbiol. App. Sci.,* **6**(5): 857-863

LeClere S, Scmelz EA and Chourey PS (2003) Cell wall invertase deficient miniature kernels have altered phytohormone levels. *Phytochem.,* **69** (3): 692-699

Lelievre JM, Tichit L, Dao P, Fillion L, Nam YW, Pech JL and Latche A (1997) Effects of chilling on the expression of ethylene biosynthetic gene in ' Passe-crassane' pear (*Pyrus communis*) fruits. *Plant Mol. Biol.,* **33**: 847-855

Leopold AC (1964) Plant Growth and Development Mc Graw Hill Publication, New York.

Limin Ye and Fenfen Xu **(**2011) Storage effects of salicylic acid on post-harvest chestnut Chinese. *Journal of Bio. process Engineering,* **9 :**57-60

Lo'ay AA and El Khateeb AY (2011) Delaying guava ripening by exogenous salicylic acid. *J. Plant Prod., Mans. Univ.,* **2**: 715-724

Loewus FA and Loewus MW (1987) Biosynthesis and metabolism of ascorbic acid in plant. *Crit. Rev. Plant Sci.,* **5**:101–119

Lolaei A Kaviani, B Rezaei MA, Raad MK and Mohammadipour R (2012) Effect of pre- and post-harvest treatment of Salicylic acid on ripening of fruit and overall quality of strawberry (*Fragaria ananasa* Duch cv. Camarosa) fruit. *Ann. Biol. Res.*, **3**(10): 4680-4684

Looney NE (1998) Plant bio regulators in fruit production: an overview and outlook. *Journal-Korean Society for Horticultural Science,* **39**:125-128

Lougheed ES, Murr DP and Miller SR (1979) Effect of calcium and daminozide on ethylene production and softening of apple fruits. *Inorganic Plant Nutrition,* **35**:43-44

Lu X, Sun D, Li Y, Shi W, Sun G (2011) Pre- and post-harvest salicylic acid treatments alleviate internal browning and maintain quality of winter pineapple fruit. *Scientia Hort.*, **130**: 97–101

Madhav JV, Sethi S, Sharma RR and Rudra SG (2016) Impact of Salicylic acid on the physiological and quality attributes of guava (*Psidium guajava* L.) fruits during storage at low temperature. *The Indian Journal of Agricultural Sciences*, **86**(9): 2390-2397

Madhav Venu Janagam, Shruti Sethi, Sharma RR and Nagaraja A (2018) Impact of salicylic acid treatments on storage quality of guava fruits cv. Lalit during storage. *Int. J. Curr. Micro. Boil. App. Sci.,* **7**(9): 2390-2397

Madrid M (2011) Reducing post-harvest losses and improving fruit quality worldwide: The One-Billion-Dollar Untapped Business Opportunity, Fruit Profits and 2011. Available online: http://fruitprofitscom.

Mahajan BVC, Dhatt AS, and Sandhu KS (2004) Effect of post-harvest application of ethephon and calcium carbide on the ripening behaviour and quality of guava fruits. *Prog. Hort.*, **36**(2): 259-265

Mahajan BVC, Kaur T, Gill MIS, Dhaliwal HS and Ghuman BS (2010) Studies on optimization of ripening techniques for banana. *J. Food Sci. Technol.,* **47**: 315-319

Mahajan BVC, Sharma SR and Dhall RK (2009) Optimization of storage temperature for maintaining the quality of guava. *J. Food Sci. Technol.*, **46**: 604-605

Mahajan BVC, Singh G, Dhatt AS (2008) Studies on ripening behaviour and quality of winter guava with ethylene gas and ethephon treatments. *J. Food Sci. Technol.,* **45**: 81-84

Mahajan BVC, and Dhatt AS (2004) Studies on post-harvest calcium chloride application on storage behaviour and quality of Asian pear during cold storage. *J. Food Agri*. Environ., **2**(3-4): 157-159

Mandal G, Dhaliwal HS and Mahajan BVC (2012) Effect of pre-harvest application of NAA and potassium nitrate on storage quality of winter guava (*Psidium guajava* L.). *Indian Journal of Agricultural Sciences*, **82**(11): 985–89

Manoj KS and Upendra ND (2000) Delayed ripening of banana fruit by salicylic acid. *Plant Sci.,* **158:** 87-96

Manthe BM Schulz and H Schnabl (1992) Effects of salicylic acid on growth and stomatal movements of *Vicia faba* L.: evidence for salicylic acid metabolization. *J. Chem. Ecol.*, **18**: 1525-1539

Mapson LW (1970) Vitamins in fruits stability of (In) Biochemistry of fruits and their products.Hulme, AC (ed) Academic press, London **1**(12): 376-377

Martin-Cabrejas MA, Waldran KW, Selvendaran RR, Parket ML and Maotes GK (1994) Ripening related changes in cell wall of 'Spanish' pear. *Physiol. Pl.,* **91**: 671-679

Martinez AT, Ruiz-Duenas FJ, Martinez MJ, Del Rio JC and Gutierrez A (2009) Enzymatic delignification of plant cell wall: from nature to mill. *Current Opinion in Biotechnology,* **20**(3): 348–357

Martinsson M, Kwast A, Cieslinski G and Treder W (2006) Impact of production systems and fertilizer application on yield and quality of strawberries. *Acta Hort.,* **708**: 59–64

Marzouk HA and Kassem HA (2011) Improving yield, quality, and shelf life of Thompson seedless grapevine by pre-harvest foliar applications. *Scientia Hort.,* **130**(2): 425-430

Masalkar SD and Wavhal KN (1991) Effect of various growth regulators on physico-chemical properties of ber cv. Umran. *Maharashtra Journal of Horticulture:* **5***:*37–40

McGuire G Raymond (1997) Market quality of guavas after hot-water quarantine treatment and application of carnauba wax coating. *HortScience,* **32**(2):271-274

Meena VS, Nambi E, Kashyap P and Meena KK (2013) Naphthalene acetic acid and ferrous sulphate induced changes in physico-chemical composition and shelf-life of ber. *Indian J. Hort.,* **70**(1): 37-42

Mirdehghan SH and Ghotbi F (2014) Effects of salicylic acid, jasmonic acid, and calcium chloride on reducing chilling injury of pomegranate (*Punica granatum* L.) fruit. *Journal of Agricultural Science and Technology*, **16**(1): 163-173

Mohabe Omprasad (2015) Effect of foliar spray of NAA and nutrients on fruit quality and yield parameters of guava (*Psidium guajava* L.) cv. Dharidarwd. Thesis submitted to Department of Fruit Science, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior College of Horticulture, Mandsaur (MP).

Mohamed E, Hamdoun EA, Elamin OM and Mahmoud HI (2016) Effects of ethrel, packaging and waxing on quality and shelf life of guava (*Psidium guajava* L.) fruits. *Gezira Journal of Agricultural Science,* **14**(1): 75-92

Mohamed HE and Abu-Goukh AB (2003) Effect of ethrel in aqueous solution and ethylene released from ethrel on mango fruit ripening. *The Journal of Horticultural Science and Biotechnology,* **78**(4): 568-573

Mohamed MAA, El-Mehrat, HG and Salem ASE (2012) Effect of post-harvest treatments with salicylic acid and chito-care on navel orange fruits quality and storability compared with the commercial post-harvest fungicide treatment. *J. Plant Prod.,* **3:**3069-82

Nabil WA, Magda N and Wally AS (2013) Effect of gibberellic acid alone or combined with two antioxidants on fruit set, yield and fruit quality of "Hollywood" and "Golden Japanese" plum cultivars. *Egypt J. Hort.,* **40**(1):121- 132

Ngullie Chonpenthung R (2014) Effect of salicylic acid and humic acid on flowering, fruiting, yield and quality of mango (*Mangifera indica* L.) cv. Kesar. Thesis submitted to the Navsari Agricultural University Navsari, Gujarat.

Niranjala Perera ODA and Karunaratne A (2001) Response of bananas to post-harvest acid treatments. *The Journal of Horticultural Science and Biotechnology*, **76**(1): 70-76

Nkansah GO, J Ofosu-Anim and Mawuli A (2012) Gibberellic acid and Naphthalene acetic acid affect fruit retention, yield and quality of keitt mangoes in the coastal savanna ecological zone of Ghana. *American Journal of Plant Physiology,* **7**: 243-251

Nour IAM (2007) Chemical control of fruit ripening in guava. Doctoral dissertation, Department of Horticulture Faculty of Agriculture, University of Khartoum.

Nour IBM and Goukh ABAA (2010) Effect of ethrel in aqueous solution and ethylene released from ethrel on guava fruit ripening. *Agri. and Bio. J. Nort. Amer.,* **1**(3):*232-37*

Obeed RS (2011) Enhancing the shelf life and storage ability of Flame Seedless grape by agro chemicals pre-harvest foliar applications. *Middle-east J. Sci. Res.,* **8** (2): 1936-1943

Olaeta JA and Undurraga P (2003) Effect of ethephon (2 chloro ethylphosphonic acid) applied to the trees on fruit ripening in ' Golden Nugget' loquat (*Eriobotrya japonica* Lindl.) In: Llácer G (ed.), Badenes ML (ed.) *First international symposium on loquat* Zaragoza: CIHEAM, Pp 123-127 Valencia (Spain).

Olaiya CO and Osonubi O (2009) Effects of pre-sowing seed treatments on tomato (*Lycopersicon esculentum* (L) Mill.) seedling emergence. *Int. J. Eng. Technol.,* **1**: 321-323

Padmavathamma B (1990) Post-harvest studies on processing qualities and storage behaviour of some cultivars of guava (*Psidium guajava* L.) under different storage conditions. Doctoral dissertation, Andhra Pradesh Agricultural University, Hyderabad.

Paliyath G and Subramanian J (2008) Phospholipase D inhibition technology for enhancing shelf life and quality In : Paliyath G, Murr D P, Handa A K and Lurie S, (ed.) *Post-harvest Biology and Technology of Fruits, Vegetables and Flowers*, 1^{st} ed. Pp 195-239 Wiley-Blackwell, USA.

Pandey A, Tripathi VK, Pandey Manjul, Mishra AN and Kumarl D (2012) Influence of NAA, GA3 and zinc sulphate on fruit drop, growth, yield and quality of ber cv. Banarsi Karaka. *Proc. International Symposium on Minor Fruits and Medicinal Plants for Health and Ecological Security*, December 19-22, West Bengal, India pp: 184-187

Pandey DK, Pathak RA and Pathak RK (1988) Studies on the foliar application of nutrients and plant growth regulators in Sardar Guava (*Psidium guajava* L.) I-Effect on yield and fruit quality. *Indian J. Hort.*, **45**(3 and 4):197-202

Pandey V (1999) Effect of NAA and GA_3, spray on fruit retention, growth, yield and quality of ber (*Zizyphus maunitiana* Lamk.) cv. ‘Banarasi Karakai. *Orissa J. Hort.*, **27**(1): 69-73

Pantastico ERB (1975) Physico-chemical changes during growth of storage organs. *Post-harvest Physiology, Handling and Utilization of Tropical and Subtropical Fruit and Vegetables.* pp 41-54 The AVI Publishing Co. Inc. West port, Connecticut.

Panwar KS, Sharma Suneel and Sehrawat SK (1994) Effect of plant growth regulators on uneven ripening of Beauty Seedless grapes (*Vitis vinifera* L.) II Fruit characters and maturity time. *International Journal of Tropical Agriculture*, **12**(2): 2 163-166

Parfitt J, Barthel M and Macnaughton S (2010) Food waste within food supply chains: quantification and potential for change to 2050. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, **365** (1554): 3065-3081

Parimita S, Karunakar Yadav KC and Arora Puneet (2016) Study on effect of hot water blanching on vital parameters of Allahabad Safeda guava (*Psidium guajava* L.). *International Journal of Innovative Research in Engineering & Management*,**3** (5):436-441

Parkhe PB, Kulkarni SS, Durgude RA and Mali DS (2015) Effect of chemicals on yield and quality of guava cv. Sardar. *Bioinfolet-A Quarterly Journal of Life Sciences,* **12**(2b): 491-493

Parviainen MT and Nyyssonen K (1992*)* Ascorbic acid in*:* modern chromatographic analysis of vitamins (eds. APD Leenheer, W.E. Lambert and H. Nelis), Marcel Dekker, New York.Pp. 271-300

Patel U, Varu DK and Chaudhari J (2015) Effect of pre-harvest spray of chemicals on shelf-life and quality of mango cv. Kesar. *Asian J. of Hort.*, **10** (2): 187-193

Pawar CD, Patil AA and Joshi GD (2011) Physico-chemical parameters of sapota fruits at different maturity stages. *Karnataka Journal of Agricultural Sciences*, **24**(3):420 - 421

Pawar PS, Jagtap DD, Garad BV and Shirsath HK (2005) Effect of plant growth regulators on maturity, yield and fruit weight of pomegranate cv. Mridula. Adv. *Pl. Sci.,* **18:167-**170

Phani Deepthi V, Chandra Sekhar and R Srihari D (2015) Effect of maturity stage and NAA, GA_3 and BA on the organoleptic quality of guava fruits (Lucknow-49) during cold storage. *International Journal of Current Research*, **7** (8), 19395-19405

Pool KM, Weaver RJ and Kliewer KM (1972) Effect of growth regulators on changes in fruits of Thompson Seedless during cold storage. *J. Amer. Soc. Hort. Sci.,* **97:** 67-70.

Prasanna Lakshmi N (2005) Studies on the effect of post-harvest application of chemicals and growth regulators in extending shelf life of mango. M.Sc. Thesis, Acharya NG Ranga Agricultural University, Hyderabad, India.

Prasanna V, Prabha TN, Tharanathan RN (2007) Fruit ripening phenomena-an overview. *Critical Reviews in Food Science and Nutrition*, **47** (1): 1–19

Praveena Bindu R (2011) Studies on the effect of packaging and ventilation on post-harvest shelf life and quality of sapota (*Manilkara achras* (Mill) Forsberg) cv. Kalipatti. Doctoral dissertation, College of Horticulture, Andhra Pradesh Horticultural University Venkataramannagudem, WGDT.

Rajput CBS and Singh CN (1982) Effect of growth regulators on vegetative growth and fruiting of ber (*Zizyphus mauritiana* Lamk.). *Bangladesh Hort.*, **10** (1):19-22

Rajput CBS and Singh NC (1982) Effect of growth regulators on chemical composition of ber fruits. *Bangladesh Hort.*, **10:57**-58

Rajput Rajindrasinh Pratapsinh (2008) Effect of Boron and various plant growth regulators on yield quality of guava (*Psidium guajava* L.) cv. Lucknow-49. Thesis submitted to Junagadh Agricultural University, Junagadh

Rajput RP, Senjaliya HJ, Vala GS and Mangroliya GS (2015) Effect of various plant growth regulators on yield and quality of guava (*Psidium guajava* L.) cv. Lucknow-49. *International Journal of Agricultural Sciences*, **11**(1): 179-182

Ramprasad V, Reddy YN and Reddy, MGDM (2004) Studies on extension of shelf-life of grape through antioxidants and alternative inhibitors. *Acta Hortic.* **662**: 397-402

Rana PD, Parasana JS and Kotecha AV (2015) Effect of post-harvest treatment with packaging and lining materials on physiological loss in weight during storage of mango (*Mangifera indica* L) cv. Mallika. *Trends in Bio. Sciences*, **8**(2): 522-527

Ranjbar H, Zou Alfaghari Nasab R, Ghasemnezhad M and Sarkhoush A (2007) Effect of methyl jasmonate on inducing chilling tolerance in pomegranate fruit. *Pajouhesh-Va-Sazandegi Agron Hort.*, **20:** 43-49

Ranjbaran E, Sarikhani H, Bakhshi D and Pouya M (2011) Investigation of salicylic acid application to reduce post-harvest losses in stored 'Bidaneh Ghermez'table grapes. *International Journal of Fruit Science*, 11(4): 430-439

Rao VNM, Shanmugavelu KG, Srinivasan C and Iah DRP (1971) Studies on the effect of ethrel (2-chloroethyl phosphonic acid) on the ripening of fruits. *South Indian Horticultural Journal*, **19**: 1±8.

Rattan CS and Bal JS (2008) Effect of nutrient and growth regulators on fruit yield and quality of Umran ber. J. Res. (PAU), **45** (3 and 4): 144-47

Ravikiran Reddy Y (2007) Effect of gamma irradiation and antioxidants on post-harvest shelf life of papaya (*Carica papaya*) cv. Red lady. M.Sc. Thesis submitted to Acharya NG Ranga Agricultural University, Hyderabad.

Ray DP, Samanta S, Dora DK, Sahu P and Das BK (1991) Effect of plant growth regulators on fruit set, retention, development and quality of sapota (*Achras sapota* L.) cv. Cricket Ball. *Indian Agri*., *36* (1): 09-18

Reddy P N (1992) Effect of transportation, packages and chemical treatment on physico-chemical changes and shelf-life of guava (*Psidium guajava* L.) cv. 'Allahabad Safeda'. Ph.D. Thesis, RAU, Bikaner.

Reddy SVR, Sharma RR, Srivastava M and Kaur C (2016) Effect of pre-harvest application of salicylic acid on the post-harvest behavior of 'Amrapali' mango fruits during storage. *Indian J. Hort.*, **73**(3): 405-409

Reddy T Sukumar, Babu J Dilip and Polaiah AC (2014) Effect of antioxidants on shelf life of guava (*Psidium Guajava* L.) cv. Allahabad Safeda. *Plant Archives,* **14** (1): 575-578

Reddy, TS (2009) Effect of gamma irradiation and antioxidants on shelf life of guava (*Psidium guajava* L.) cv. Allahabad Safeda. Doctoral dissertation, Andhra Pradesh Horticultural University.

Rema J and Sharma VP (1993) Chemicals as an aid for mechanical harvesting in phalsa (*Grewia sub- inaequalis* DC). *South Indian Horticulture,* **41**(1): 8-13

Reyes MU and Paull RE (1995) Effect of storage temperature and ethylene treatment on guava (*Psidium guajava* L.) fruit ripening. P*ost-harvest Biology and Technology*, **6** (3-4): 357-365

Ribereau-Gayon G (1968) Etude des mechanismes de synthese et de transformation de l'acide malique, de l'acide tartrique et de l'acide citrique chez (*Vitis vinifera* L.).*Phytochemistry*,**7**: 1471-1482

Russo L Jr, Dostal HC and Leopold AC (1968) Chemical regulation of fruit ripening. *Bioscience, **18**:109-116.*

Sakhale BK, Pawar VN and Kapse BM (2006) Studies on extension of shelf life of Kesar mango (*Mangifera indica* L.). In VIII International Mango Symposium, 820: 643-652

Salami P, Ahmadi H, Keyhani A and Sarsaifee M (2010) Strawberry post-harvest energy losses in Iran. *Researcher*, **4**: 67-73

Saltveit, ME (1999) Effect of ethylene on quality of fresh fruits and vegetables. *Post-harvest Biology and Technology*, **15**(3): 279-292

Sandhu SS and Thind SS (1988) Effect of NAA sprayed on fruit set on general appearance and quality of Umran ber. *Indian J. of Hort.*, **45**(3 and 4): 274-282

Sandhu SS, Thind SS and Bal JS (1989) Effect of pre-harvest spray of ethephon on size, quality and ripening of ber (*Ziziphus mauritiana* L.) cv. Umran. *Indian J. Hort.*, ***48***: 23-27

Sandhu SS, Thind SS and Bal JS (1990) Effect of NAA on physico-chemical characters of Umran ber. *Punjab Hort. J.*, **30** (1-4): 123-130

Sanjay S (2000) Effect of season on the vegetative and reproductive attributes of Sardar guava (*Psidium guajava* L.). *Orissa Journal of Horticulture*, **28** (2):77-80

Sawale AA, Tayde GS, Ghawade SM and Dadmal SM (2001) Effect of fruit thinning on quality of Nagpur mandarin (*Citrus reticulata* L.) under akola conditions. *Indian J. Agri. Sci.*, ***35***(2): 136-138

Sayyari M, Babalar, M, Kalantari, Serrano S and M Valero D (2009) Effect of salicylic acid treatment on reducing chilling injury in stored pomegranates. *Post-harvest Biology and Technology*, **53:** 152-154

Selvan MT and Bal JS (2005) Effect of post-harvest chemical treatments on shelf life of guava during ambient storage. *Haryana J. Hort. Sci.* **34**(1/2): 33-35

Selvan MT and Bal JS (2005) Effect of different treatments on the shelf life of Sardar guava during cold storage. *J. Res.* (PAU), **42**: 28–33

Selvin T (2002) Effect of different treatments on the shelf-life of Sardar guava. M.Sc. dissertation, Punjab Agricultural University, Ludhiana.

Serrani JC, Fos M, Atarés A and García-Martínez JL (2007) Effect of gibberellin and auxin on parthenocarpic fruit growth induction in the cv. Micro-Tom tomato. *Journal of Plant Growth Regulation*, **26**(3): 211-221

Shafiee, M Taghave TS and Babalar M (2010) Application of SA to nutrient solution combined with post-harvest treatments (hot water, SA and Ca dipping) improved post-harvest fruit quality of strawberry. *Sci. Hortic.*, **124**:40-45

Shanta Krishnamoorthy and Subramanyam H (1970) Respiratory climacteric and chemical changes in the mango fruit (*Mangifera indica* L.). *J. Amer. Soc. Hort. Sci.,* **95**(3): 333-337

Sharma P, Singh AK and Sharma RM (2005) Effect of plant bio-regulators (PBRs) and micro-nutrients on fruit set and quality of litchi cv. Dehradun. *Indian J. Hort.,* ***62***(1): 24-26

Sharma Raghavendra (2013) Effect of plant growth regulators on growth, yield and quality of guava (*Psidium guajava* L.) cv. Allahabad Safeda. Thesis submitted to Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (MP).

Sharma RK and Dashora LK (1999) Effect of .mustard oil, benzyladenine on the post-harvest shelf-life of guava (*Psidium guajava* L.) cv. 'L-49'. National seminar on plant physiology at Interface of Agri Horticulture and Industry, held at Rajasthan College of Agriculture, Udaipur.

Shaybany B and Sharifi H (1973) Effect of pre-harvest application of ethephon on leaf abscission, fruit drop and constituent of fruit juice in pomegranate. *HortScience,* **48**(3):293-296

Siddiqui MW and Dhua RS (2009) Standardization of ethrel treatment for inducing ripening of mango var'Himsagar'. *Proc. International Conference on Horticulture* (ICH-2009), Bangalore (pp 9-12).

Siddiqui S and Gupta OP (1989) Effect of pre-harvest spray of calcium on shelf life of ber (*Ziziphus mauritian*a Lamk.) fruits. *Research and Development Reporter,* **6**: 172–176

Siddiqui S and Gupta OP (1995) Effect of post-harvest applications of some chemicals on shelf life of ber (*Zizyphus maurtiana* Lamk.) fruits. *Haryana J. Hort. Sci.,* **24**, (4): 19-23

Singh A (1998) Studies on maturity, ripening and storage behaviour of guava (Psidium guajava L.) fruits. M.Sc. Thesis, Punjab Agric. Uni., Ludhiana

Singh A and Singh HK (2015) Application of plant growth regulators to improve fruit yield and quality in Indian gooseberry (*Emblica officinalis* Gaertn). *Journal of Agri. Search*, **2**(1): 20-23

Singh AK, Mughal MS and Vachkoo AM (2002) Effects of ethrel and naphthalene acetic acid on fruit quality and fruit drop of 'Royal Delicious' apple. *Indian J. Hort.*, **59**(4): 355-358

Singh AR, Shukla PK, Singh K and Singh A (1989) A note on chemical composition and metabolites of ber (*Zizyphus mauritiana* Lamk.) as influenced by boron, zinc and NAA. *Haryana J. Hort. Sci.,* **18** (3-4): 235-36

Singh B, Singh S, Zubair M and Chandi KS (2009) Effect of pre-harvest application of nutrients and bio-regulators on fruit quality, yield and post-harvest performance of Sardar guava. *Haryana J. Hort. Sci.*, **38**(1/2): 70-71

Singh C and Bal JS (2006) Effect of nutrients and growth regulators on fruit drop, size and yield of ber (*Zizyphus mauritiana* Lamk.). *Int. J. Agri. Sci.,* **2**(2): 358-360

Singh G (1988) Effect of calcium nitrate and plant growth regulators on the storage of Allahabad Safeda guava. *Indian J.Hort.*, **45**(1 and 2): 45-50

Singh G (2006) Effect of post-harvest treatments on ripening and storage of winter guava (*Psidium guajava* L.). M.Sc., Thesis, Punjab Agricultural University, Ludhiana, India.

Singh G, Pandey D, Rajan S and Singh AK (1996) Studies in crop regulation in guava through different crop regulating treatments. *Fruits,* **51**(4): 241-246

Singh HJ and Bal JS (2006) Effect of pruning and growth regulators on physico-chemical characters of guava during rainy season planted at different spacing. *Int. J. Agri. Sci.***,** **2:** 533-537.

Singh H, Mehrotra NK and Shergill TS (1994) Effect of urea spray on the crop regulation of guava cv. Allahabad Safeda. *Indian J. Hort.,* **51**:331-36

Singh HK, Singh IS and Chauhan KS (1979) Effect of pre-harvest application of ethephon on ripening and quality of guava cv. Sardar. *Udyanika,* **2:** 117-120

Singh IP, Singh BP and Singh SP (1986) Effect of 2, 4-D and GA3 on fruit drop and fruit quality of mango (*Mangifera indica* L.) cv. Samar Bahist Chausa. *Haryana J. Hort. Sci.,* **15**(1-2): 29-32

Singh IS and Chundawat BS (1978) Effect of ethephon on ripening of late grape cultivars. *Haryana J. Hort. Sci.,* **7** (1-2): 52

Singh J, Prasad N and Singh SK (2017) Post-harvest treatment of guava (*Psidium guajava* L.) fruits with boric acid and NAA for Quality Regulation during Ambient Storage. *International Journal of Bio-Resource & Stress Management*, **8**(2):201-206

Singh K (1980) Effect of various chemicals on pre and post-harvest application on shelf life of guava at various temperatures. Ph.D. Thesis, submitted to Haryana Agricultural University, Hissar.

Singh K and Chauhan KS (1982) Effect of pre-harvest application of calcium, potassium and Alar on fruit quality and storage life of guava fruits. *Haryana Agri. Univ. J. Res.*,**12:**649–654

Singh K and Randhawa JS (2001) Effect of growth regulators and fungicides on fruit drop, yield and quality of fruit in ber cv. Umran. *J. Res*. (PAU), **38** (3 and 4):181-185

Singh K, Sharma M and Singh SK (2017) Effect of plant growth regulators on fruit yield and quality of guava (*Psidium guajava* L.) cv. Allahabad Safeda. *Journal of Pure and Applied Microbiology*, **11**(2): 1149-1155

Singh M Gautam, RKS Prasad Y and Singh AK (1986) Effect of growth regulators on ripening of Phalsa. *Haryana J. Hort. Sci.***15:** 196-199

Singh MK, Singh P, Malik S, Kumar M, Kumar V and Singh SP (2009) Response of various physico-chemical treatments on physiological attributing characters in mango (*Mangifera indica* L.) cv. Amrapali. *J. Plant Dev. Sci.*, **1** (1/2): 31-34

Singh Priyanka, Sanjay K and Sutanu M (2012) Effect of ethrel on post-harvest changes in papaya (*Carica papaya* L.) fruits. *Hort. Flora Research Spectrum*, **1**(3): 225-230

Singh R and Singh R (1981) Effect of nutrient sprays on granulation and fruit quality of 'Dancy Tangerine' mandarin. *Scientia Hort.*, **14**(3): 235-244

Singh R, Chaturvedi OP and Singh R (2004) Effect of pre-harvest spray of zinc, boron and calcium on the physicochemical quality of guava fruits (*Psidium guajava* L). In: Internal. Seminar on Recent Trend in Hi-Tech Horticulture and Post-Harvest Technology. Pp 4–6

Singh R, Godara NR and Ahlawat VP (2002) Qualitative attributes as affected by foliar sparys of nutrients and growth regulators in ber (*Zizyphus mauritiana* Lamk.) cv. Umran. *Haryana J. Hort. Sci.*, **31**(1/2), 23-24

Singh R, Singh SN, Gupta MR and Dhaliwal GS (1992) Studies of winter cropping in guava cv. 'Allahabad Safeda.' *Indian J. Hort.*, **49**: 127-133

Singh Rajbir and Bal JS (2008) Pruning in ber (*Zizyphus mauritiana* Lamk.). *Agri. Rev.*, **29** (1) 61-67

Singh Room and Singh Ranjit (1981) Effect of GA_3, planofix (NAA) and ethrel on granulation and fruit quality in 'Kaula' mandarin. *Scientia Hort*, **14:315**-321

Singh S, Gaikwad AB and Karihaloo JL (2009) Morphological and molecular analysis of intracultivar variation in Indian mango (*Mangifera indica* L.) cultivars. *Acta Hort.*, **829:** 205-212

Singh S, Kumar P, Brahmachari V and Singh D (1995). Effect of pre-harvest spray of GA_3 and ethrel on storage life of mango cultivar 'Amraplli'. *Orissa Journal of Horticulture*, **23**:112±8

Singh UR and Singh N (1976) Effect of plant regulators on fruit drop, size and quality of ber (*Zizyphus mauritiana* Lamk.) var. Banarsi. *Haryana Journal of Horticultural Science,* 5:1-8

Singh VK, Saini JP and Misra AK (2001) Response of salicylic acid on flowering, floral malformation, fruit set, yield and associated bio-physical and biochemical characters of mango. *Indian J. Hort.*, **58**(3): 196-201

Singh Z, Singh RK, Sane VA and Nat P (2013) Mango-postharvest biology and biotechnology. *Critical Reviews in Plant Sciences,* **32**(4), 217-236

Singla RK, Chharia AS and Kumar Surinder (1992) Effect of ethephon on ripening and quality of grape cv. Thompson Seedless. *Haryana J. Hort. Sci.*, **21**(1-2):56-59

Srivastava MK and Dwivedi UN (2000) Delayed ripening of banana fruit by salicylic acid. *Plant Sci.,* **158:** 87-96

Suleman M, Sharma JR, Kumar R, Gupta RB and Singh S (2006) Effect of different chemicals on crop ping pattern, and quality of guava cv. Sardar. *Haryana J. Hort., Sci.*, **35**: 226-227

Sultan MZ, Khalefa SM, Elhamamsy SM and Mostafa YS (2015) Effect of post-harvest anti-oxidant treatments on loquat fruit deterioration during storage at room temperature. *Acta Hort*., **1092**: 173-179

Summy U and Jawandha SK (2015) Physico-chemical changes in peach fruit during storage. *International Journal of Processing and Post-harvest Technology,* **6**(2): 172-176

Suryanarayana V and Goud PV (1984) Effect of post-harvest ethrel treatment on ripening of sapota fruits. *Andhra Agricultural Journal,* **31**(4): *308-311*

Tandon DK, Adsule PG and Karla SK (1984) Effect of certain post-harvest treatments on the shelf life of the guava fruits. *Indian J. Hort.,* **41**(1-2):88-92

Tareen MJ, Abbasi NA, and Hafiz IA (2012) Post-harvest application of salicylic acid enhanced antioxidant enzyme activity and maintained quality of peach cv. 'Flordaking' fruit during storage. *Scientia Hort.*, **142**: 221-228

Teaotia SS, Tripathi RS and Singh RN (1972) Effect of growth substances on ripening quality of guava (*Psidium guajava* L.). *J. Food Sci. and Tech.,* **9** (1): 38-39

trichloro-2-pyridyloxyacetic acid on fruit size at maturity. *J. Hort. Sci.,* **70**: 855-862

Tripathi D, Pandey AK, Pal AK and Yadav MP (2009) Studies on effect of plant growth regulators on fruit drop, development, quality and yield of ber (*Zizyphus mauritiana* Lamk.) cv. Banarasi Karaka. *Prog Hort.,* **4**(2): 184-186

Tsomu Thupten (2013) Effect of post-harvest treatments of chemical and plant growth regulators on physico-chemical characteristics and shelf life of sapota [*Manilkara achras* (mill.) Forsberg] fruits cv. Kalipatti. M.Sc. thesis submitted to the Anand Agricultural University, Anand

Turmanidze T, Jgenti M, Gulua L and Shaiashvili V (2017) Effect of ascorbic acid treatment on some quality parameters of frozen strawberry and raspberry fruits. *Annals of Agrarian Science*, **15**(3): 370-374

Valero D, Martinez-Romero D, Serrano M and Riquelme F (1998) Post-harvest gibberellin and heat treatment effects on polyamines, abscisic acid and firmness in lemons. *J. Food Sci. and Tech.,* **63**(4): 611-615

Vijayalakshmi D and Srinivasan PS (2000) Imp0roving the quality attributes of' off' year Alphonso mango through chemicals and growth regulators. *Orissa Journal Horticulture*, **28** (1): 31-33

Wang L, Chen S, Kong W, Li S and Archbold DD (2006) Salicylic acid pre-treatment alleviates chilling injury and affects the antioxidant system and heat shock proteins of peaches during cold storage. *Post-harvest Biology and Technology,* **41:** 244-251

Waskar DP and Gaikwad RS (2005) Effect of various post-harvest treatments on extension of shelf life of Kesar mango fruits. *Indian J. Agri Sci.,* **39**(2): 95-102

Weston LA and Barth MM (1997) Pre-harvest factors affecting post-harvest quality of vegetables. *HortScience*, **32**: 812– 816

Wills RB McGlasson, Graham D and Joyce D (1998) Post-harvest, and introduction to the physiology and handling of fruit and vegetables and ornamentals (4th Ed.) Sydney, Australia: University of New South Wales Press Ltd, University of New South Wales.

Wilson RR (1938) Hoticultural Colour Charts. Wilson Colours Ltd. In collaboration with the Royal Horticultural Society and British Colour Council.

Wolucka BA, Goossens A and Inzé D (2005) Methyl jasmonate stimulates the de novo biosynthesis of vitamin C in plant cell suspensions. *J. Exp. Bot.,* **56:** 2527-2538

Wongmetha O and Ke LS (2012) The quality maintenance and extending storage life of mango fruit after post-harvest treatments. World Academy of Science, *Engineering and Technology*, **69**: 936-941

Yadav HC, Yadav AL, Yadav DK and Yadav PK (2011) Effect of foliar application of micro nutrients and GA_3 on fruit yield and quality of rainy season guava. *Plant Archives,* **11**(1): 147-149

Yadav PK and Rathore PS (2004) Effect of foliar spray of thiourea and ferrous on the yield and quality of ber fruit (*Zizyphus mauritiana* Lamk.). *Prog. Agri.*, **4**(1): 85-86

Yadav S, Bhatia SK, Godara RK and Rana GS (2001) Effect of growth regulators on the yield and quality of winter season guava cv. L-49. *Haryana J. Hort. Sci.,* **30:** 1-2

Yadav S, Bhatia SK, Godara RK and Rana GS (2001) Effect of growth regulators on the yield and quality of winter season guava cv. 'L-49'. *Haryana J. Hort. Sci.*,**300-2**: 1-2

Yeganeh MA, Hadavi E and Kalhori M (2013) Effects of salicylic acid on quality of 'Bidaneh Sefid' table grapes during cold storage. *International Journal of Agriculture and Crop Sciences*, **5**(18): 2041

Yeshayahu M, Greenberg J, Beni Y, Cadmon E and Talmor Z (2001) Increasing fruit size of ‘Myovaze’ satsuma mandarin by spray with plant growth regulators. *Alon Hanotea,* **55**(5):205-207

Zainuri JL and Terry L (2001) Effects of phosphonate and Salicylic acid treatments on anthracnose disease development and ripening of ‘Kensington Pride’ mango fruit. *Australian Journal of Experimental Agriculture*, **41**: 805-813

Zeng Kaifang, Jiang and Weibo (2008) Effects of salicylic acid applied at growing stage on mango fruit quality and disease. *Acta Hort. Sinica,* **35** (3):427-32

Zhang Y, Kunsong C, Zhang S and Ferguson I (2003) The role of salicylic acid in post-harvest ripening of kiwi fruit. *Post-harvest Bio. Tec.,* **28**:67-74

Zhao ZH, Liu MJ, Liu P, Liu XY, Dai L, Yang L and Tian SL (2009) Effects of citric acid treatments on post-harvest fruit quality of *Zizyphus jujuba* Mill. ‘Linyilizao’. *Acta Hort.,* **840**: 513-16

Zheng Y and Q Zhang (2004) Effects of polyamines and salicylic acid post-harvest storage of ‘Ponkan’ mandarin. *Acta Hort.*, **632**: 317-320

Zhu X, Wang Q, Cao J and Jiang W (2008) Effects of chitosan coating on post-harvest quality of mango (*Mangifera indica* L. cv. Tainong) fruits. *Journal of Food Processing and Preservation*, **32**(5): 770-784

Zhulong C and Shipping T (2006) Induction of H_2O_2 metabolizing enzymes and total protein synthesis antagonistic yeast and salicylic acid in harvested sweet cherry fruit. *Post-harvest Biology and Technology*, **39:**314-20