STUDIES ON THE EFFECT OF EDIBLE COATINGS ON THE QUALITY ATTRIBUTES OF GUAVA FRUIT

A Thesis

Submitted in partial fulfillment of the requirements for the award of the degree of

DOCTOR OF PHILOSOPHY

in

Fruit Science

By

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Supervised By

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LOVELY PROFESSIONAL UNIVERSITY
PUNJAB
2020

DECLARATION

I hereby declare that the thesis entitled "**Studies on the effect of edible coatings on the quality attributes of guava fruit"** is an authentic record of my work carried out at Lovely Professional University as requirement for the degree of Doctor Of Philosophy in the discipline of **Horticulture (Fruit Science)**, under the guidance of Dr. Deepika Saxena, Assistant Professor, School of Agriculture and no part of this thesis has been submitted for any other degree.

Mr. Sudhir Pratap
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CERTIFICATE- I

This is to certify that thesis titled **"Studies on the effect of edible coatings on the quality attributes of guava fruit"** submitted in partial fulfillment of the requirement for the award of degree of **Doctor Of Philosophy** in the discipline of **Horticulture (Fruit Science)** is a bonafide research work carried out by **Mr. Sudhir Pratap (Registration No. 41700102)** under my supervision and that no part of this thesis has been submitted for any other degree or diploma.

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CERTIFICATE- II

This is to certify that the thesis entitled "**Studies on the effect of edible coatings on the quality attributes of guava fruit"** submitted by Mr. Sudhir Pratap to the Lovely Professional University, Phagwara in partial fulfillment of the requirements for the degree of **Doctor Of Philosophy** in the discipline of Horticulture (Fruit Science) has been approved by the Advisory Committee after an oral examination of the student in collaboration with an External Examiner.

(Dr. Deepika Saxena)
Advisor

External Examiner
( )

(Dr. Anis Ahmad Mirza)
Head of the department

(Dr. Ramesh Kumar)
Dean, School of Agriculture

Dedication

My humble effort I dedicated to my parents

Mr. Subhash Bishnoi

Mrs. Sunita Bishnoi

Whose affection, love, encouragement and prays of day

And nights made me able to get such success and honor.

Abstract

The present investigation was carried out in three trials. The first trial include 40 combination of coating materials *viz.* Aloe Vera gel [1/3(25%), 1/2(33%) and 1/1(50%)], Corn starch (0.5, 1, and 1.5 %), Calcium chloride (0.5, 1, and 1.5 %), Chitosan (0.1, 0.2, and 0.3 %) for increasing the shelf-life of guava at ambient conditions. The effect of coating material on physiological loss in weight, vitamin C, acidity, total soluble solids and TSS/acid ratio was observed. The different treatments showed variation in physiological and bio-chemical parameters. Out of these 40 treatments, treatment T_1 [Aloe vera 1/3(25%)], T_2 [Aloe vera 1/2(33%)], T_{10} (chitosan 0.1%), T_{11} (chitosan 0.2%), T_{12} (chitosan 0.3%), showed the best result as compared to other treatments.

The second trial include the studies of the shelf-life of guava using the best 5 treatments under ambient and cold conditions among them T_5 (chitosan 0.3 %) showed the best result in terms of physiological loss in weight, vitamin C, acidity, TSS/acid ratio, reducing sugar, Non-reducing sugar, sugar/acid ratio under cold conditions where's physiological loss in weight, vitamin C, TSS, total sugar, reducing sugar, Non-reducing was found best under ambient conditions.

The third trial include the studies of the shelf-life of guava using different packaging materials *viz.* Cling (10µ), HDPE (20µ), PP (40µ), PP (60µ), LDPE (100µ). Among them chitosan (0.3%) along with LDPE (100µ) showed best result in terms of physiological loss in weight, vitamin C, acidity, TSS/acid ratio, reducing sugar, Non-reducing sugar, sugar/acid ratio, phenol and DPPH under both cold and ambient conditions. In the T_5 [LDPE (100µ) + chitosan (0.3%)] treatment, the shelf life of fruit increases up to 21 days under ambient conditions and 30 days under cold conditions.

ACKNOWLEDGEMENT

With great humility, I thank God, The Almighty for bestowing me with such affectionate parents, whose love, dedication and inspiration encouraged me to go through this juncture.

With the overwhelming sense of legitimate pride and genuine obligation which gives me exuberant and privilege to express my eternal gratitude to my learned and revered advisor Dr. Deepika Saxena, Chairman of my Advisory Committee; Dr. Saurabh Kumar, assistant Professor of Fruit Science, Dr. Shailesh kumar singh, Ex HOD of horticulture department, Dr. Anis Ahamd Mirza, HOD of horticulture department, Dr. Vikas Chhopra, Ex HOL and assistant Professor of Food Science for his excellent and praiseworthy guidance, keen interest, adroit admonition, juvenile encouragement and parental affection during whole course of my study and particularly at times of research and preparation of this manuscript. I shall always remain indebted to her.

I thank Head, Department of fruit Science, Dean, College of Agriculture, Registrar and staff members of University Library, Director of Research & Development and worthy Honorable Chancellor and Pro-Chancellor for providing necessary facilities to complete this study.

I express my sincere thanks to all the teachers of the Department of fruit Science for their kind cooperation and impeccable guidance during the course of study. Thanks are duly acknowledged to the field and official staff for timely and sincere help during the course of examination.

A special word of appreciation is due to my friends Rupinder Singh, Sandeep Bagri, Jaihoon Rafie, Reetu Banger, Kusum, Anmol mahey, Smile Bajaj, Sandeep Kumar, Davendra kumar, Naveen Saini, Anil sharma, Dinesh patil, Madhu kumari, Ankush, Engelina and Diksha choudhary for their love affection, inspiration, encouragement, selfless help & cheerful company.

Where the emotions are involved, words cease to mean. My vocabulary fails to accentuate my profound reverence and sincere regards to my Mom and Dad for their ceaseless inspiration, moral and spiritual support, profound love and unending encouragement, guiding me to achieve success at every step in life. Words fail to explain the love and affection of my brothers Ravi, Chander, Vishnu, Late Surya and sister Anju Bishnoi who always encouraged me during my studies.

I apologize for the faux pass of the persons who have extended the help in a way or other and deserved such thanks.

October, 2020 *(Sudhir Pratap)*

Phagwara ***Author***

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ABBREVIATIONS USED IN THE MANUSCRIPT

%	: Percent	NS	: Non-Significant
&	: And	Nm	: Nanometer
/	: Per	no.	: Number
@	: at the rate of	O2	: Oxygen
A.O.A.C	: Association of Official Agricultural Chemists	°B	: Degree Brix
CAP	: Controlled Atmospheric Packaging	°C	: Degree Centigrade
CD (0.05%)	: Critical difference at 0.05% Level	°F	: Degree Fahrenheit
CFB	: Corrugated fiber box	PE	: Poly ethylene
Cm	: Centimeter	PF	: Poly film
CO2	: Carbon dioxide	pH	: puissance de hydrogen
cv.	: Cultivar	PLW	: Physiological loss in weight
DAS	: Days After Storage	PP	: Polypropylene
DCPIP	: 2,6 dichlorophenol Indophenols	Ppm	: Parts per million
et al.	: and Co-workers	PVC	: Polyvinyl chloride
CRD	: Complete Randomized Design	RH	: Relative humidity
Fig.	: Figure	Mm	: Millimeter
FSI	: Fruit Shape Index	Mg	: Milligram
G	: Gram	S.Em	: Standard error of mean
HDPE	: High density polyethylene film	µm	: Micrometer
i.e.,	: that is	TSS	: Total soluble solids
Kg	: Kilogram	*Viz.*,	: Namely
LDPE	: Low density polyethylene film	W	: Weight
LLDPE	: Linear low density Polyethylene	µ	: Micro
		Mg/100 ml	: Milligram per 100 milliliter
LPU	: Lovely Professional University	MAP	: Modified Atmosphere Packaging
MA	: Modified atmosphere		

CHAPTER –I

INTRODUCTION

Guava (*Psidium guajava* L.) is a tropical fruit belonging to family Myrtaceae. Chromosome number is 2*n* = 22. Under this genus, more than 5000 species are present. Guava is commonly known as 'Apple of Tropics'. Tropical America is considered as the origin of guava. During 17^{th} century, it was introduced in India and at present it is widely cultivated on commercial scale **(Menzel, 1985)**. It has been reported that Indo-Gangatic plains have much genetic diversity of guava **(Rajan *et al*., 2007)**.

According to the report of **Anonymous (2018),** India is the leading guava producing country, which is followed by its neighboring countries China, Pakistan and Indonesia. In India, the total area under guava cultivation is 2, 65 thousand hectares (ha.) with annual production of 4054 thousand metric tonnes (MT) and productivity 15.29 MT/ha. It occupies 4^{th} position in terms of total area covered by fruit crops. The leading state in production of guava fruit is U.P which is followed by M.P and Bihar. Number of varieties is commercially cultivated in India. Some of the most popular and widely grown varieties are Sardar guava, Shweta, Allahabad Safeda, Arka Mridula, Chittidar, Lalit, and Pant Prabhat.

Guava is also the important crop of Punjab and ranks second after citrus. It grows well in almost all the districts of the state covering an area of 2.5 lakh ha. yielding 195.60 thousand MT accounted for 3.97% of area and 4.42 % of production. The average productivity of guava is now 15.9 MT/ha (**Anonymous, 2018).**

Guava is well adapted to various ecological conditions which also include the wastelands and soils with high range of pH value (8.6 to 9.6). Guava tree requires minimum care and give high economic returns because of its highly productive nature, toughness and adaptability. The fruits of guava can be eaten as raw and also can be used

for processing products like jam, juice, nectar wine and fruit leather. **(Jaiswal and Amin, 1992)**.

Guava is one of the nutritious fruit. Each 100gm guava contain 228.3 mg Vitamin C, 80.80g Water, 68kcal Energy, 2.55g Protein, 0.95g Total lipid (fat), 14.32g Carbohydrate,5.4g Fiber,8.92g Sugars,18mg Calcium, 0.26mg Iron, 22mg Magnesium, 40mg Phosphorus, 417mg Potassium, 2mg Sodium, 0.23mg Zinc, etc. **(Singh, 2005).**

Under ambient conditions, the shelf life of guava is about 3-4 days. The fruit is climacteric in nature. Thin exocarp layer that makes it hard for the fruit to retain moisture. Research on guava has led to the development of some promising varieties which are good on size and nutrition but still post-harvest storage under ambient conditions is a challenge for most of the food technologists and researchers. Of the various methods, to increase the storage life of fruits, edible coating is in practice. It prolongs the storability and keeping quality of fruits. Coatings act as a barrier between fruit and external environment, which further leads to improve the storage of fruits under cold conditions and ambient condition.

Exogenous application of chemicals such as chitosan, $CaCl_2$, polyamines and gibberellins are being used to retard the physiological changes of the produce so as to increase the shelf-life. Chitosan is a high molecular weight cationic polysaccharide. It is made up of glucosamine and N-acetylglucosamine with a β-1-4 glycosidic linkage **(Hadwiger and McBride, 2006)**. Chitosan is biodegradable and, exhibits excellent biocompatibility, non-toxicity and antioxidant property **(Zhelyazkov *et al*., 2014; Hussein *et al*., 2015)**. Chitosan application on fruit surface act as a barrier **(Elsabee and Abdou, 2013)**, which makes it potential for coating. It acts as an excellent semi-permeable barrier against the exchangeable gases like oxygen and carbon dioxide. It also minimizes the loss of moisture, thus which reduces the rate of respiration and water loss, which reduces the shrinkage of fruits **(Velickova *et al*., 2013; Petriccione *et al*., 2015)** hence retarding ripening and senescence. Structure of membrane and cell wall is enriched with the calcium ions **(Oms-Oliu *et al*., 2010)**. Calcium (Ca) delays the process of

ripening particularly the softening and hence, increases the shelf-life by altering intercellular and extracellular processes **(Shehata *et al*., 2009).**

Various researchers have tried different coating materials on different fruit crops such as *Aloe vera*, guar gum, chitosan, bee wax, petroleum jelly, corn starch, neem extract, citric acid, cellulose, calcium chloride, pectin, olive oil, xanthan gum, carnauba wax, soy protein, sorbitol, coconut etc. and various packaging materials like LDPE, HDPE, PP, cling film, shrink film etc. which yielded positive outcomes in enhancing storability of various fruits. Edible coating is beneficial in order to maximize the life of fruits & delay the ripening in guava fruit **(Wijewardane and Guleria, 2009).**

Hypothesis for research:

i. Edible coating and packaging material may increase the shelf life of guava.
ii. Edible coating and packaging material may have beneficial effect on the quality parameters of guava.

Objectives

Understanding the importance and benefits of coating and packaging materials, the present investigation "Studies on the effect of edible coatings on the quality attributes of guava" was conducted on guava *cv*. Allahabad Safeda under ambient and cold conditions in consideration with following objectives:

- To evaluate the performance of various edible coatings on post-harvest quality of guava fruit during storage.
- To standardize a suitable coating material for guava fruits for better market ability
- To evaluate the effect of various packaging materials on the quality of edible coated guava.

CHAPTER-II

REVIEW OF LITERATURE

A good proportion of literature is available regarding use of coating and packaging materials for shelf life and quality enhancement of fruit crops. Various researchers have contributed to the field of post-harvest shelf life extension of fruits using various coating and packaging materials. A comprehensive review of literature is mentioned below:

Effect of coating materials on physical and chemical attributes of fruits:

Ochoa-Reyes *et al.*, (2019) conducted study on use of edible coating formulation for improvement of shelf-life quality of green sweet peppers by using 3 biopolymers like pectin, Xanthum gum & Arabic gum in combinations with Candelilla wax and jojoba oil, hydrophobic phase by way of plasticizer and crude extract of polyphenols as basis of bioactive compounds. All treated green sweet peppers were found significantly different in weight loss when compared to control. Although slow rate of decline was found in fruit coated with arabic gum, however visual form remained same amongst fruits treated with various different coatings.

Adiletta *et al.*, (2018) performed an experiment by coating chitosan over loquat at 7°C for 21 days. They found the improved activity of enzyme catalase, superoxide, dismutase, ascorbate and peroxidase. Also fruit membrane integrity was maintained by chitosan.

Baraiya *et al.*, (2018) studied the complex coating acts as a base of antioxidants and increases the quality & post-harvest shelf life of table grapes. In Thompson seedless, 0.1ml olive oil in 100ml and 0.3ml xanthan gum in 100ml was used and achieved better result with olive oil incorporated + xanthan gum with gallic acid which increases the quality and postharvest storage lifespan of grapes.

Hassanein *et al.*, (2018) conducted experiment on gamma irradiation along with coating of guava fruit with calcium chloride and lemon grass and monitor the growth of fungus and fruit quality during cold storage and concluded that calcium chloride and lemongrass strongly inhibit physiological activity and fungal growth in guava fruit under cold storage conditions.

Lopez-Palestina *et al.*, (2018) evaluated the effect of coating treatment with tomato oil extract on antioxidant and physicochemical properties of grambullo and observed that there was upsurge in antioxidant activity up to 5 days after coating whereas there was reduction recorded on 10^{th} and 15^{th} day with no significant difference.

Mandal *et al.*, (2018) explained the impact of coating (edible) application on postharvest quality and storage life of mango, in which they informed that throughout the storage period, TSS increase and Titrable acidity decrease in fruits. Therefore TSS/ acid were increased due to more moisture loss from fruit. More utilization of acid and increased respiration might be lead to depletion of organic acids.

Romani *et al.*, (2018) studied the effect of starch coating incorporated with pink pepper phenolic compounds on apple and advocated that the coating was helpful in lowering enzymatic browning in apples by inhibiting the enzyme peroxidase.

Sapper and Chiralt (2018) evaluated the preservation of vegetables and fruits by using starch based coatings in which they concluded that edible coatings are another method of preservation of fruits and vegetables or preservation technology which change the gas composition of fruits by generating a modified environment or barrier between the internal and external atmosphere gaseous exchange like oxygen, carbon dioxide and volatiles and also reduce water transfer.

Sucharitha *et al.*, (2018) studied the influence of chitosan coating on storage strength of tomatoes in which they coated tomatoes with 0.25% and 0.5% chitosan. The microbial load and physic-chemical parameters were calculated for 30 days and found that lower 0.25% concentration was more effective than 0.5% chitosan treatment and

control in terms of pH, TSS, Titrable acidity, Vitamin C (ascorbic acid), weight loss, moisture percent and also reduces microbial growth.

Abdi *et al*., (2017) observed the coating influence of pectin comprising of essential oils for enhancing the appearance of strawberry in which orange and lemon peel oil along with pectin. Outcomes revealed that pectin + lemon's essential oil has good impact on quality of fruit and visual form as compare to chief free pectin treatment and orange essential oil which increase shelf-life of strawberry 12 days more as compare to control.

Abebe *et al*., (2017) observed the effect of edible coating material and stages of maturity at harvest on quality and storage life of tomatoes with pectin and chitosan and investigation was done on different harvesting phases of fruit which was matured green, red & light red and observed that treatments delays the ripening process of fruits as compare to uncoated fruits. Results showed that maximum shelf-life of 17 days achieve in turning stage which were coated with pectin, 15 days shelf-life observed in chitosan and 10 days shelf life in control.

Jain *et al*., (2017) studied the influence of various edible coatings & chemical in which they use GA_3 @ 40 ppm, Aloe vera gel, $CaCl_2$ @1%, Almond oil and Olive oil for treatment and kept under cold storage (3-5^o C and 85-95 Relative humidity) and ambient conditions. The results showed that fruits coated with $CaCl_2$ @1% at cold storage conditions expand 30 days life period of fruit as comparison to control which is 9 days at ambient situations.

Jawandha *et al*., (2017) reported the effect of *Aloevera* gel, chitosan & carboxymethyl cellulose over Punjab Beauty pear and found out that the palatable quality of fruit was best till 67 days after harvesting but after 74 days the quality was poorly degraded.

Krasniewska *et al*., (2017) determined the effect of pullulan treatment on quality and post-harvest shelf-life of high bush blueberry and concluded that those fruits coated

with pullulan coating were more protected as compare to uncoated fruits and fruits decrease less weight, slower rate of change in sugars content that maybe the effect of diminishing in the degree of transpiration & respiration which also retains the attractiveness and freshness of fruits.

Mani *et al*., (2017) observed the influence of various coating of *Aloe vera* on physiology and quality of ber under ambient conditions in which they use 1% corn starch, 2% *Aloe vera* gel and study revealed that fruit coated with *Aloe vera* gel were more efficient in maintaining better quality of fruits in a storage period of 15 days. *Aloe vera* treated fruit showed less weight loss, lowest shrinkage percentage, and slower rate of reducing and total sugar development due to ripening.

Singh *et al*., (2017) studied the effect of oil coatings to enhance the quality and shelf life of guava fruit in which they used almond oil, mustard oil, grape seed oil, olive oil & coconut oil at ambient condition and cold storage. Investigation showed that shelf-life extended significantly those fruits coated were with olive oil at room temperature up to 16 days and for 28 days in controlled storage and those fruits which were coated with mustard oil showed minimum physiological weight loss when comparing with other treatments.

Ullah *et al*., (2017) observed the effect of different coatings on bio-chemical traits of fruits and storability of bell pepper fruit in which they observed that coating with *Aloe vera* gel, gum Arabic and cinnamon oil, the storage life was enhanced and quality of sweet pepper fruit for longer time period was maintained as compared to control treatment. Sweet pepper treated with gum Arabic (12%) significantly decreased ascorbic acid, total soluble sugars, membrane leakage, decay development, weight loss, TA, sugars and pH of fruit. So they suggested 12% gum Arabic may possibly a potential coating for sustaining postharvest value and increasing storage life period of fruit.

Yimenu *et al*., (2017) investigated the effect of linseed oil and bee wax coatings and frequency of dipping on the organoleptic and biochemical quality of orange juice and

observed that fruits treated with three layer bee wax emulsion showed better results as compare to linseed oil and untreated fruits.

Ali *et al.*, (2016) studied the influence of *Aloe vera* gel (0%, 10%, 20%, 30% and stored with poly packaging) coating treatment on shelf life of grapes which stored under $0^{o}C$ and $30^{o}C$ in incubator and refrigerator and found that 20% *Aloe vera* gel coating concentration was more efficient and appropriate for enhancing the shelf life of grapes. They concluded that applying lower temperature during storage grouped with edible coating treatment and packaging enhances the marketability by decreasing rate of water loss and spoilage caused by fungal infection can be curtailed.

Gardesh *et al.*, (2016) conducted a trial to study nano chitosan based coatings on apple *cv*. Golab Kohanz. They found that percentage of weight loss after harvesting was decreased comparatively and also the rate of respiration, ethylene production and peroxidase activity was significantly reduced.

Rao *et al.*, (2016) investigated the effect of alginate olive oil coating to prolong the storability and postharvest value of ber fruit in which they evaluated the impact of composite coatings olive oil (0.2%) and Sodium alginate (2%) alone and with conjugation of citric acid & 1% ascorbic acid on postharvest nutritive storage-life as well as quality of fruit which stored at $25 \pm 2^{o}C$ and 65% relative humidity in which revealed that composite coating of olive oil and sodium alginate was more effective in maintaining the quality of fruit by using composite enriched coatings with citric acid and ascorbic acid enhance the level of antioxidants and maintained.

Rokaya *et al.*, (2016) studied the influence of diverse coating treatments on postharvest quality and storage period of mandarin fruit. The decaying in control fruits started in first week of storage whereas in other treatments, decaying started in second week only excluding bavistin treatment. In third week, spoilage loss occurred in all treatments. Most efficient treatment which preventing the spoilage loss was bavistin 0.7%

followed by bavistin 0.1% + wax 10% and wax 10% where the highest spoilage loss was observed in control.

Vivek *et al.*, (2016) studied the effect of different coating with combination of NaOCL and ultrasound treated kiwi at cold storage conditions and concluded the loss of pH, vitamin C, TSS (total soluble solids), firmness, acidity, total phenolic content, respiration loss, all sensory quality and microbial count and observed that fruit coated with 0.80% and 1.00% chitosan decreases the overall losses, respiration rate, microorganism growth and maintain the sensory quality of sodium hypochlorite (NaOCL) with ultrasound treated fruits during 10 days of cold storage treatment at 5^{o} C.

Ali *et al.*, (2015) examined the effect of chitosan combined with lemongrass oil on antimicrobial activity against anthracnose of bell pepper. Lemon grass oil of concentration 0.5% and 1.0% was enriched with chitosan solution of 0.5 % and 1.0% and control of anthracnose of bell pepper in vivo and in vitro was evaluated. 0.5% lemongrass oil and 1.0% chitosan found more effective in controlling fungal growth in vitro. The in vivo results confirmed that the use of 1.0% chitosan and 0.5% lemongrass oil was significantly superior in keeping. However, chitosan individually works effectively in anthracnose disease incidence and in extension of bell pepper storage-life.

Bhowmick *et al.*, (2015) examined effectiveness of coating material on ber's shelf life (*Zizyphus mauritiana* Lamk.) fruits kept at room temperature by using different concentration of chitosan, guar gum and gum tragacanth in which as compare to others 1.5% concentration of guar gives better results. After 3 days of treatment there is minimum loss in weight was observed minimum (8.89%) in T_5 followed and there was maximum physiological weight loss found in T_{10} (15.15%) in the fruits under ambient conditions. Minimum reduction found in T_5 probably due to coating treatments which made a hurdle against oxygen, carbon dioxide and moisture by which transpiration and respiration rate is reduced.

Cruz *et al*., (2015) investigated the influence of diverse coating material on sensory quality and storage life of pears using edible coating treatment in which they use different concentration of gum Arabic, candelilla wax, pomegranate polyphenols and jojoba oil were used to maintain the quality and shelf life of fruit and results showed that fruits treated with gum Arabic 4%, candelilla wax 3%, pomegranate polyphenols 0.015% and jojoba oil 0.15% increase their shelf-life of pears and accepted by consumers.

Khaliq *et al*., (2015) analyzed the effect of 10% gum arabic coating with 3% $Cacl_2$ on biochemical, physiological and quality of mango fruits stored at 6^oC and 90% RH for 28 days and shifted to 25^oC for additional 5 days shelf life. Significant results were analyzed in fruits coated with 3% $CaCl_2$ and 10% gum arabic as compared to uncoated fruits. Combined coating of 3% calcium chloride and 10% gum arabic significantly improved chilling injury, electrolyte leakage and malondialdehyde content recorded as compare to control. Results suggested that application of 3% calcium chloride combined with 10% gum arabic might be enhance low temperature tolerance by reducing oxidative damage and improving the antioxidant defense system of mango.

Mahfoudhi and Hamdi (2015) analyzed the use of gum arabic and almond edible coating to maintain postharvest sweet cherry quality and delayed ripening at 2^oC and 90-95% RH for 15 days. The use of gum arabic or almond gum (10%) increased postharvest shelf-life & quality of fruit. Fruits treated with Arabic/almond gum recorded significant decrease in fruit respiration rate resulting in decreased ethylene production. Coating also delayed firmness, soluble solids concentration, weight loss, Titrable acidity and color development as compared to untreated fruits. Result concluded that use of almond gum coating was more effective and can delay ripening which extends the storage life of fruit kept at 2^oC for a time period of 15 days lacking off flavor and decay.

Meighani *et al*., (2015) examined the effect of various coating treatments on bioactive compounds and post-harvest quality of pomegranate fruits by using chitosan (1% and 2% w/v), resin wax and carnauba wax which kept at 4.5^0C up to 120 days & at

20^{o}C for 3 additional days and concluded that carnauba wax coated fruits maintain bioactive compounds and quality of fruits than other treatments.

Panahirad *et al.*, (2015) measured the effect of edible coating treatment grounded on pectin and carboxymethyl cellulose to increase the shelf life of plum by using pectin with four different concentrations of carboxymethyl cellulose (0, 0.5, 1.0 and 1.5%) and stored at 19^{0}C & relative humidity (65%) and detected that expect firmness and vitamin C, other parameters were affected by carboxymethyl cellulose pectin coatings. Best result found in 0.5% pectin + 0.5% carboxymethyl cellulose in all parameters which was suggested to apply on plum in postharvest periods to reduce the losses after harvesting.

Petriccione *et al.*, (2015) examined the effect of chitosan coating on loquat to judge its nutraceutical traits. They found that bioactive compounds and activity of antioxidants was greater in coated fruits rather than the untreated ones. This was also revealed that the level of deterioration was higher in non-coated fruits.

Sharmin *et al.*, (2015) examined the influence of different concentration of *Aloe vera* gel on shelf-life of papaya in which they concluded that *Aloe vera* gel coatings was another choice as compare to artificial preservative to improve the postharvest life period of vegetables and fruits. They used 0.5%, 1%, 1.5% along with control and results showed that 1.5% *Aloe Vera* gel coated fruits helps in maintaining the shelf-life of fruit papaya as compare to 0.5%, 1% and control.

Widodo and Zulferiyenmi (2015) considered the impact of chitosan and 1-methylcyclopropene on fruit quality and storage life of Cavendish banana and concluded that fruit responded differently to treatments of 1-methylcyclopropene and chitosan at early and late stage. At early stage, fruit coated with chitosan showed deterioration in quality of fruit and slow color development, but at late stage, fruit coated with chitosan accelerated ripening by which there was quick decreases of firmness, decrease of TSS

and increase of acidity. The combined treatment of 1-methylcyclopropene and chitosan was best applied at yellowing stage of fruit.

Xing *et al*., (2015) determined the influence of chitosan treatment by means of cinnamon oil on physiological & quality of Chinese jujube in storage at 4^{o}C for a period of 60 days and reported that the decaying and weight loss of ber fruit were considerably decreases by using chitosan along with cinnamon oil throughout 60 days of storage period and showed beneficial effect on maintaining the sensory quality. However, vitamin C, Titrable acidity reduced to 3.08 mg and 0.342% respectively in coated jujube fruits with 1.0% and 0.10%. Results suggested that chitosan along with cinnamon oil might be helpful in preservation of jujube fruits throughout storage.

Bahnasawy and Khater (2014) examined the impact of different concentration of paraffin wax (0, 25, 50, 75 and 100%) and stored at 4 temperature (5^{o}, 10^{o}, 15^{o} and room temperature at 25^{o} C). Change in volume, weight loss, length, diameter, surface area, hardness and TSS were considered & observed that storage life of fruit increases as concentration of wax increases but it increases with temperature from 173.4 to 231.6 hours with increasing concentration of wax from 0–100% and the shelf-life of fruits increased from 98.40–288.48 hours when temperature increased from 5^{o} C-25^{o} C.

Chauhan *et al*., (2014) reported the efficiency of $Cacl_2$ and chitosan coating on postharvest storage life of mango and in combination of hurdle technology in which they used both coating separately with combination of hurdle technology for the enhance the storage life of mango during storage at 15± 1^{o}C & 85% relative humidity. Shelf-life of fruits was recorded 60 days which treated with chitosan and calcium chloride. But with combination of hurdle technology 65 days shelf was noticed along with chitosan and calcium chloride treatment. Weight loss firmness, microbial count, TA ,skin color, TSS were evaluated by using $Cacl_2$ and chitosan and combination of chitosan and $Cacl_2$ coated fruit showed more effectiveness.

Davila-Avina *et al*., (2014) observed the influence of coating treatments on antioxidant and bioactive compounds of tomatoes at different stages with carnauba wax and mineral oil coating on 2 maturity stages over 28 days and stored at 10^{o} C and accomplished that flavonoid, total phenolic and lycopene content were considerably inferior for treated fruits than untreated fruits. Despite that, the content of vitamin C was found high in carnauba wax treated breaker fruits followed by fruit striated with mineral oil and untreated. No significant difference found in pink tomatoes. Radical scavenging activity and trolox equivalent antioxidant capacity values were found higher in control as compare to coated fruits and concluded that edible coatings was another way of preservation but it changes the antioxidant activity and bioactive compounds of tomatoes which was negative effect of coatings. Both edible coatings had a significant impact on antioxidant capacity and bioactive compounds of fresh tomatoes. While lycopene and phenol values were found more in control fruits. Treated fruits showed higher antioxidant capacity values in fruits as compare to control.

Gill (2014) reported that 100 ppm vitamin C treated guava fruits disclosed the lowest average physiological loss in weight in comparison with control.

According to **Hassan *et al*., (2014)** studied that influence of wax treatment on tangerine citrus fruit and concluded that at lower temperature during the storage period (5^{o} C), the decay % age of treated fruits was lesser in relation to non-coated fruits and 15% wax coated fruits has higher spoilage percentage at ambient conditions (25^{o} C).

Hassanpour (2014) reported the influence of *Aloe vera* gel treatment on antioxidant enzyme activities, antioxidant capacity & deterioration in raspberry. The investigated parameters included total anthocyanin, antioxidant enzyme activities, antioxidant capacity, total phenol and post-harvest quality after eight days of storage period at 4^{o}C, compared to the control fruit group. Coated fruit showed a higher anthocyanin, total phenols and antioxidant capacity than untreated berried group. There was less decaying found during storage period at 4^{o}C than untreated berries which

increased the post-harvest life of *Aloe vera* treated berries. However, pH, acidity, TSS was primarily affected in storage period.

Hedayati and Niakousari (2015) examined the influence of coatings with gum arabic and silver nanoparticles on microbial properties and physico-chemical properties of green sweet pepper for the duration of 21 days in storage. Arabic Gum mixed with silver nano particles significantly lowered physico-chemical losses, hindered microorganism growth and exhibited the better performance in extending the storage life of green sweet peppers.

Ibrahim *et al.*, (2014) examined the effect of chitosan coating having less molecular weight on shelf-life & physico-chemical properties of annanas at ambient condition (30 ± 1^{o} C /75 ± 5% relative humidity) and observed that irradiated (15 kGy) chitosan showed superiority in extending the life period of fruit and help of maintain quality during storage period with least loss of moisture, enlarged ascorbic acid, shriveling, protection against growth of fungus and maintain superior sensory characteristics.

Kou *et al.*, (2014) examined the influence of pullulan (1%), chitosan (2%) and calcium chloride (2%) coating treatment on antioxidant activity in pear concluded that chitosan 2% and pullulan 1% are finest coatings for pear *cv*. huang guan.

Krishna and Rao (2014) observed the delay in ripening process & extended storage life up to seven days at ambient temperature of cv. Allahabad Safeda of guava fruits when treated with 1 percent chitosan. Along with this, the post-harvest quality and desirable texture of the fruit has been retained till the close of their storing life.

Mahajan and Singh (2014) examined the effect of coating on storage life & post-harvest physiology of kinnow fruit under controlled conditions in which they use terpenoidal oligomer, cellulose, sta-fresh and citrashine at 18-20^{o}C and 80-85% relative humidity and revealed that fruit treated with terpenoidal oligomer or citrashine can be

effectively stored for 15 days in controlled conditions as compare to control in which fruit storage life maintained for 7 days only.

Misir *et al.*, (2014) examined the effect of edible *Aloe vera* matrix treatment on fresh fruit. They concluded that colour of the fruit is one among the significant visual attributes. *Aloe vera* gel coating hindered the green colour damage of the skin of apple fruit kept at cold conditions (2^0 Celsius) for six months. The colour of skin of grapes exhibited lower increment in *Aloe vera* coated fruits than those kept in control. Grape fruit is rich source of anthocyanin's and accounts for the red colour of fruit. The ripening procedure of grape is connected to anthocyanin compounds. Towards the end of cold storage (1^o Celsius, 95% Relative Humidity), untreated fruits showed a more red and dark colour than *Aloe vera* treated fruits. The ethylene production rate is altered by the modified conditions created by the *Aloe vera* gel coating, resulting ripening delay, anthocyanin accumulation, chlorophyll degradation, and carotenoid synthesis and eventually decay in color change in fruits.

According to **Mahajan *et al.*, (2013)** concluded that the kinnow fruits coated with Nipro Fresh SS 50T or SS 40T shows noteworthy delay in TSS change, Titrable acidity and ascorbic acid content under storage.

Brishti *et al.*, (2013) examined the influence of bio-preservatives on papaya to calculate the influence of coating on appearance and ripening behavior of papaya. The average size value of *Aloe vera* (86.730 mm) & papaya leaf extract included *Aloe vera* gel (86.12 mm) coated fruits was significantly dissimilar from fruits in control (69.99 mm) subsequently after 8 days of storage water loss, shrinkage of fruit and weight loss. The size of the fruit was determined to conclude the impact of coating material on fruit shrinkage. The drop was maximum (16.98 mm) in the papaya leaf extract included aloe gel coated fruits (0.45 mm) subsequently after 8 days of storage. It was because of the high loss of moisture in fruits kept under control & less in treated fruits.

Gol and Rao (2013) observed the influence of waxing treatment on ripening of banana fruits in which calcium chloride 1% and 1.5% ($CaCl_2$), chitosan 1% and 1.5 %

alone and with GA_3 100 ppm, glycerol 98% and jujoba wax coatings & evaluated the postharvest quality and shelf-life of banana which kept at 34 ± 1^{o} C and 70-75% RH. They concluded that chitosan 1.5% alone and with GA_3 100 ppm observed most efficient and defending coating treatment on banana fruit for maintaining the shelf life, quality and protect the important characteristics of banana during the storage.

Hassan *et al*., (2013) conducted a study on tangerine citrus (*Citrus reticulata*) to examine the effect of wax coatings on fruits. Various concentrations of wax viz. (10, 12 and 15%) were used as a treatment on fruits and were kept at 2 different temperature stages (5^{0}C and 25^{0}C) with RH (85-90%). The study concluded that 12 % wax along with storage of fruits at 5°C stated as greatest promising.

Mahajan *et al*., (2013) studied the effect of exterior coating on kinnow fruits. The fruits coated with "Nipro Fresh SS 40T and SS 50" formulations, desiccated & kept in CFB containers, exhibited substantial impact in suspending loss of weights.

Shariatifa and Jafarpour (2013) observed the effect of coating treatments on shelf-life span and post-harvest quality of apple in which they compared coated and non-coated fruits and stated that fruits respire continuously after harvesting and coating treatment is a way to minimize the post-harvest losses of fruits. They noticed that coating treatments considerably decreased the weight loss and delayed softening of apple fruit. Taste, appearance, color, tenderness and overall acceptability of treated fruits were better while storage at 4^{o}C for 112 days.

Shiri *et al*., (2013) determined the influence of chitosan layer to improves the post-harvest quality and shelf life of table grape by using 0.5% and 1% chitosan concentration at 0^{o} C for 60 days and observed that TSS, acidity, TSS/acidity levels were superior in coated fruits but there was not any major dissimilarity found among 0.50% and 1.0% treatment of chitosan. However total amount of phenolic, antioxidant capacity & catechin were delayed in coated berries, whereas total quercetin and quercetin 3-galactoside were found high in control treatment.

Boonyakiat *et al.*, (2012) studied the influence of different coating material on small (92-98 g) and large (135-140 g) sized tangerine fruits treated with Fomesa or Zivdar along with a control non-coated treatment stored at normal temperature (24±3^{0}C) and RH (59±6%) for ten days. They reported that the fruits of big size have less loss in weight, better visual appearance and good flavor than the small sized fruits. Also, the size of fruit had impact on TSS, hue angle of peel color, pH & Titrable acidity but had little effect on juice ethanol content, internal CO_2, internal O_2, alcohol dehydrogenase (ADH) activity, pyruvate decarboxylase (PDC), TSS/TA ratio & ascorbic acid content. Least loss in weight was exhibited in tangerine fruit coated with Fomesa.

Diaz-Mula *et al.*, (2012) observed the effect of alginate coatings on bioactive compounds and fruit quality of sweet cherry fruit during storage in which sodium alginate based edible coatings were used in diverse concentrations (1, 3, and 5% w/v) and reported that coating treatment were effective on postharvest related parameters such as loss of Titrable acidity, color and reduction of the rate of respiration. In addition, coatings also helps to maintaining higher concentration of antioxidant as well as phenolic activity as comparison to untreated fruits due to senescence and over ripening process.

Study conducted by **Ergun and Satici (2012)** examined the effect of coating of Aloe Vera gel of various concentrations on apple. They found that aloe Vera gel considerably retarded the loss of green colour of Granny Smith apples but it had no effect on Red delicious apples.

Hong *et al*. (2012) reported that 2.0 % chitosan significantly reduced firmness; weight loss increases the anti-oxidant ability of guava by delaying the ripening process.

Moalemiyan and Ramaswamy (2012) investigated the effect of pectin based film coating on Mediterranean cucumber for increasing the shelf- life and quality retention. They conducted that the pectin based film coating delay spoilage and increase shelf-life of cucumber which was observed by external appearance, shrinkage, loss of color, spoilage and loss in weight. The loss of colour, spoilage, weight loss and wilting

was high in uncoated as compare to coated cucumbers stored at 12^{o}C and 23^{o}C. And most suitable storage period for uncoated fruits which was for 2 days at 23^{o} C and the coated fruits were accepted for 10 days. It is possible to enhance the storage life of cucumber for long time using coating at the right time and manage the variations at the time of storage of fruits at different conditions.

Study conducted by **Mohebbi *et al.*, (2012)** exhibited the influence of gum tragacanth and *Aloe vera* gel coatings on physicochemical properties of bell pepper and kinetics of its color change at the time of storage at 4^{o}C, 10^{o}C, 15^{o}C and 23^{o}C for 30 days. 4^{o}C and 10^{o}C showed significantly superior then other temperatures and control in terms of shrinkage, hardness and weight loss. Higher temperature resulted in more rapid changes.

Moraes *et al.*, (2012) analyzed the influence of carrageenan (0.5%) and alginate (2 %) coating to improve the shelf-life of Williams's pear & investigated that coatings influenced chemical and physical characters of fruit like pH, color, weight loss, TSS and firmness. Alginate coated fruits showed the superlative results and helped in increasing shelf-life fruit.

Ali *et al.*, (2011) worked on effect of chitosan coating on papaya physicochemical characteristics during cold storage conditions at 12^{o}C and 55-90% relative humidity. They reported that chitosan was helpful in maintaining firmness, soluble solids concentration, delayed changes in peel colour, weight loss during storage period of 5 weeks. The amount of titratable acidity declined during the storage period at slower pace in the chitosan treatment in comparison to uncoated fruits. Chitosan coating also retained the effectiveness in sensory properties and can be used commercially for extending storage of Eksotika II papaya fruit.

Chauhan and Bawa (2011) carried out an experiment by coating apple slices with shellac and aloe vera gel paste coating. They found that treated samples had reduction in polyphenol oxides and peroxidase activity. Rate of respiration, ethylene

production and electrolyte leakage were also restricted by application of aloe vera gel.

Ghasemnezhad *et al.*, (2011) performed an experiment by treating loquat with chitosan coating at temperature of 7°C and RH 88±2 % for 28 days. They revealed that coating had restricted the flesh browning and weight loss at lower temperature than control. Also the content of vitamin C, pH and total soluble solids had increased. At low temperature it was helpful in maintaining antioxidant capacity of fruits.

Hu *et al.*, (2011) examined the influence of wax covering on after harvest physiology & appearance of pineapple in cold store and concluded that in wax coating and control treatment weight loss was increasing continuously with storage period. The loss in weight in control was significantly more in wax coating on 7^{th} and14^{th} day of storage. At the end, wax treated fruits showed 2.6% weight loss where the control showed 3.1% loss in weight.

Mahajan *et al.*, (2011) examined the influence of edible coatings on storage life and quality of pear under cold storage (20-22^{o} C & 80-85% Relative Humidity) & ambient conditions (30-32^{o} and 60-65% RH) by using stay-fresh, carnauba, citrashine and oligomer terpenoidal. They concluded that citrashine followed by terpenoidal oligomer treatments found more operative in storage-life extension & retain the quality of pears in ordinary and super market conditions.

Marpudi *et al.*, (2011) examined the influence of antimicrobial *Aloe vera* coating to enhance the storage life and quality of papaya fruit. Coated fruits with aloe vera (50%), papaya leaf extract included *Aloe vera* gel 1:1 & 2.5% chitosan & stored at 30^{o} C & 42-55% relative humidity and observed that the treated fruit survived for 15 days where untreated control fruits decay within 10 days. On the bases of overall experiment all physiological changes, antimicrobial *Aloe vera* gel treatment has been found as a appropriate way to enhance the storage lifespan of papaya fruits.

Navarro-Tarazaga *et al.*, (2011) worked on coated plums postharvest quality (Angeleno) revealing that HPMC based edible film that contained bee wax expressively

decreased plum weight loss, while no weight loss variances were observed in non-coated and HPMC coated fruit of plum with no bee wax. They recommended that coatings must contain a hydrophobic compound to improve moisture barrier of 'Angeleno' plums.

Shahid and Abbasi (2011) studied the influence of bee wax at the amount of 1.3% and 5% on physiological changes in sweet orange and revealed that bee wax (5%) used with benlate (0.5%) showed better result which is more efficient to upsurge the shelf life of fruit sweet orange *cv*. Blood red at normal conditions during January, February and March.

Xing *et al*., (2011) observed the effect of chitosan treatment enriched with cinnamon oil on quality of sweet pepper and stored at 8^{o}C for 35 days. Chitosan and along with cinnamon oil coating showed the effectiveness on decay of sweet pepper. At the end, fruit coated with chitosan coating maintained better sensory suitability, where the sensory superiority of uncoated fruits grows into non-acceptable. The high activity of scavenging antioxidant enzymes includes superoxide dismutase; peroxidase and catalase in coated peppers at 35^{th} day should be added to chitosan combined with coating of cinnamon oil. Result suggested that chitosan along with cinnamon oil might be effective coating which maintain the quality of sweet peppers.

Ali *et al*., (2010) analyzed the edible coatings for augmenting shelf life and also the post-harvest appearance of tomato fruits by taking gum arabic in aqueous solutions (5, 10, 15 and 20%) application on green and matured tomatoes kept at 20^{0}C and relative humidity (80-90%) for 20 days. Fruits treated with gum Arabic (10%) revealed delay in softening, soluble solids concentration, decay percentage, weight, Titrable acidity, Vitamin C and colour development in relation to uncoated fruit. 10% gum arabic was effective in delayed ripening process and extended storage life of tomato fruits stored at 20^{o}C.

Maqbool *et al*. (2010) studied the use of chitosan on banana and established that the chitosan supressed the progression of *Colletotrichum musae in* comparison to control.

The chitosan treated bananas with 1.5% concentration exhibited highest fungicidal effects followed by chitosan (1%).

Abbasi *et al.*, (2009) examined influence of the chitosan coating treatment on postharvest worth of mango fruit, stored at $15^0C \pm 1^0C$ and 85% relative humidity. They revealed that crab chitosan when irradiated @ 200 kGy has prolonged the life period of fruit mango in which there is less loss of fruit weight, fruit able to keep its sensory characteristics and increased ascorbic acid content. Irradiated chitosan coating protected the fruit from disease attack which helps to improving the shelf-life well as fruit quality.

El-Anany *et al.*, (2009) observed the effect of coatings on storability & appearance of anna apple in cold stores in which they evaluate the effect of jojoba wax, Arabic gum, soybean gum, glycerol and paraffin oil coating at 0^o C along with 90-95% relative humidity. Results showed that treated fruits found a significant effect which delays the firmness, weight loss, colour, total soluble solids and Titrable acidity change in relation to untreated ones.

Mahajan *et al.*, (2009) studied the 5% loss of weight of guava fruit during storage was the maximum permissible limit beyond which the guava fruit show shriveling sign and turn out to be unmarketable.

Pandey *et al.* (2009) examined the influence of growth retardants, gamma-irradiation & coatings on storage-life of winter guava fruit by using liquid paraffin, coconut oil and mustard oil during storage. And concluded that coconut oil treated fruits were adequate to improve the storage life of fruits of guava and harmless which reduces of PWL, TSS, total sugars, vitamin C and firmness.

Saputra *et al.*, (2009) observed the effect of chitosan treatment on organic fruits as preservatives and observed that the coating of chitosan on decreases the loss in weight of sliced mango fruits. After 7 days in storage period, there was less weight loss recorded in coated sliced mango 10.27% as compare to control which was 19.86%. The coating

treatment modified the internal atmosphere or turn as an obstruction between internal & external atmosphere which decreases the transpiration, respiration and ripening of fruits.

Wijewardane and Guleria (2009) observed that coating apple with potato starch @2% + apricot kernel oil (2%) demonstrated most efficient in holding the whole quality followed by apricot kernel oil (2%) and corn starch @ 2% +. All treatments potato starch (2%), rice starch (2%), corn starch (2%) along with neem kernel oil (0.5, 1, 2°/o) and apricot kernel oil (2%) resulted in significant reduction in PLW , fruit firmness, pectin content and Titrable acidity during period of storage.

Dang *et al.*, (2008) observed the coating influence on fruit quality, ripening behavior and aroma biosynthesis of mango in which hard mature green mangoes were treated with semperfresh (0.6%), *Aloe vera* gel (100%) and mango/carnauba (1:1 v/v). After coating, fruits were dried at normal temperature and were kept in soft board trays for ripening at 21± 1^{o}C & 55.2 ±11.1% RH till eating firm stage. Carnauba coating was beneficial in delaying fruit softening & ripening and enhancing fruit quality including level of aroma volatiles and fatty acids. *Aloe vera* and super fresh slightly delayed ripening of fruit but reduced volatile aroma development. *Aloe vera* treatment did not outstrip the marketable carnauba wax & semperfresh in improving aroma volatile biosynthesis and delaying ripening of mango fruit.

Geraldine *et al.*, (2008) assessed the influence of agar-agar based (1 %) coatings added with chitosan (0.2 %), acetic acid 0.2% on minimal processed cloves of garlic. Water loss in treated cloves of garlic was, 3 times lower compared to the control. Along with significant upsurge in colour difference of control cloves as related to the further treatments. Aerobic mesophilic and filamentous fungus were noted when cloves of garlic coated with CH_3COOH + chitosan incorporated antimicrobial compounds.

Hernandez-Munoz *et al.*, (2008) observed the influence of chitosan treatment combined with postharvest calcium treatment on strawberry fruit in refrigerated conditions (10^{o} C and 70± 5% Relative Humidity) in which they coated the fruits with

chitosan 1% or 1.5% or chitosan with calcium gluconate. Chitosan coated fruit@1.5%were observed less PLW and decreasing darkening. Whereas 1% chitosan coating increased the firmness of fruits.

Liu *et al*., (2008) observed the influence of chitosan on pear at normal temperature and concluded that it had positive effect on keeping decay of fruits in control and shelf life was also prolonged. Also, 1.5% chitosan proved better in controlling decay of fruits.

Reddy *et al*., (2008) observed the influence of different wrapping material on quality and storage life of citrus (acid lime). The protective covering material of fruit with LDPE set up to be more efficient in reducing the increase in TSS, vitamin C, pH and Titrable acidity and effective in preventing the PLW.

Shein *et al*., (2008) studied the effect of wax on "Sai Nam Peung" mandarin fruits after harvesting. The treated fruits with food grade shellac and 18% teva wax and kept in cold store conditions for 30 days. In this study, this was seen that there was not at all substantial change in TSS/Acid ratio during storage.

Tapia *et al*., (2008) investigated that adding L-ascorbic acid into the coatings/films assisted to reserve the natural Vitamin C content in the freshly cut papaya It also helped in maintaining nutritional quality.

According to **Zhou *et al*., (2008)** investigated the effect of different coatings on pear. The coatings that were applied are carboxy methyl chitosan (2.0 g), Semperfresh TM (1.0gm), shellac (14.3g) individually in 100ml of water in cold storage (4°C). The TSS, Titrable acidity and vitamin C rate in pears reduced greatlyin all coatings after 2 months in storage period.

Chien *et al*., (2007) observed the effect of various treatments on mango (sliced) with solutions of chitosan (0%, 0.5%, 1% or 2%) and then stored at 6^0C. Changes in flavor, hue and moisture loss were recorded. The chitosan coating decreased moisture

loss and, increased the Titrable acidity, TSS and ascorbic acid content. Along with this, the microorganism's growth was also inhibited.

Chlebowska-Smigiel *et al*., (2007) studied the effect of the pullulan protein and pullulan edible coatings on apple during storage. Pullulan edible coatings expressively restricted apple mass loss. The apples treated with coating material exhibited lower mass loss than the untreated ones. Smallest mass loss was recorded in apple fruits treated with the coatings where the pullulan to protein ratios were 6:4 and 5:5. It was exhibited that when protein was added to pullulan, the coating gets stick better to apple surface. Throughout the storage period, the protein-comprising layer was less vulnerable to decaying & to peel off.

Jitareerat *et al*., (2007) studied the influence of chitosan coating treatment on mango enzymatic activity, disease development and ripening by using 0.5%, 1.0%, 1.5%, and 2.0%/ chitosan in 0.5% acetic acid and concluded that coating contain chitosan effected less, however high concentration like 1.5% and 2.0% were effected than the 0.5%, 1.0% and control. Chitosan coatings showed delayed ripening, ethylene synthesis and reduce the degree of respiration & loss of weight, Titrable acidity and ascorbic acid in mangoes. But in sensory quality, the firmness of mangoes coated with above 1% affected more in terms of noticeable decline.

Durango *et al*., (2006) reported that the presence of chitosan at the concentration of 1.5 % in the coatings inhibits the development of lactic acid bacteria during the storage.

Hernandez-Munoz *et al*., (2006) evaluated the effectiveness of chitosan (CS) 1 and 1.5 percent of chitosan mixed in calcium gluconate to prolong the storage of Strawberry. Firmness in strawberry had been increased by addition of calcium to the chitosan solution.

Martínez-Romero *et al*., (2006) observed the effect of *Aloe vera* as coating on postharvest safety & quality maintenance in sweet cherry and concluded that during cold

storage period, untreated fruit exhibited increase in PLW, enhanced softening, respiration rate, color change, microbial population and stem browning. Whereas *Aloe vera gel* treated sweet cherry fruits showed marked delay in postharvest quality loss parameters and sensory evaluation parameters. *Aloe vera* gel would be novel and fascinating coating for commercial use and a substitute of postharvest chemical coatings.

Matuska *et al*., (2006) found that double or single sodium alginate coatings suppressed leakage upon freezing/thawing of osmotically treated fruits of strawberry.

According to **Serrano *et al*. (2006)** stated that table grapes coated with Aloe vera stored for 35 days at 1^{o}C and monitored at 20°C indicated that clusters which were uncoated exhibited a quick decline of functional compounds like total phenols & acerbic acid.

DelValle *et al*., (2005) studied the effect of prickly pear, cactus mucilage, as an edible coating to improve the storability of strawberry fruit and were tested to regulate their influence on colour, sensory quality & texture of fruit. Use of coatings increased strawberry shelf life.

Jayachandran *et al*., (2005) observed that the shelf life of superior physico-nutritional status of guava fruit was improved by antioxidant application after harvesting.

Kamble and Chavan (2005) reported that Corn starch (6°/o) treated custard apple fruits which were fully mature & freshly harvested found to be extended storage period up to 8 days.

Ladaniya *et al*., (2005) studied the effect of cold storage of "Nagpur mandarin" in combination with coating of wax& alternating warming. The outcomes exposed, alternating heating and coating with wax were beneficial in increasing the storage ability of "Nagpur mandarin" for seventy five days.

Maftoonazad and Ramaswamy (2005) observed the effect of coating based on methyl cellulose on the colour, respiration rate and fruit texture of avocados kept at

ambient temperature. The appearance of brown spots normally related to ripening was hindered in fruits coated.

Tanada-Palmu and Grosso (2005) observed the impact of wheat-gluten based layers on strawberry fruit quality under refrigerated condition. The film of wheat-gluten, stearic & palmitic acids and bee wax had a positive impact on the firmness, weight loss.

According to **Ayranci and Tunc (2004)** evaluated the performance of the edible coating on vitamin C and water loss of green peppers. Major component of the coatings were polyethylene glycol and methyl cellulose. Ascorbic acid and stearic acid were added in coating formulation and found that coatings reduced the water loss in green peppers and apricots. Coating formulation methyl cellulose - polyethylene glycol – stearic acid was found most valuable in water loss in jujube fruits. Ascorbic acid in coating formulation as antioxidant lowered the loss of vitamin C. Edible coating of different compositions on fresh fruits of apricot and green pepper reduced the rate of water loss from green peppers and apricot.

Han *et al*., (2004) studied the performance of the chitosan coating on strawberry and red raspberry. Strawberries (*Fragaria* × *ananassa* Duch.) & red raspberries (*Rubus ideaus*) were stored for 3 weeks at 2^{o}C(Temp.) and 88% (RH) or at -23^{o}C up to 6 months respectively after coating with 2% chitosan. The results showed that fresh strawberries & red raspberries stored at 2^{o}C& 88% RH showed less spoilage in comparison to control.

Plotto *et al*., (2004) observed the effect of submerging mango fruit for thirty sec. in N -acetyl- L-cysteine (0.5%), calcium ascorbate (2%) and chlorine dioxide (5ppm) (antioxidants), or in maltodextrin (CMM) (0.5%) or carboxymethylcellulose or CMC (1%) coatings. The treated fruits and those treated with antioxidants and kept at 5°C sustained better outer appearance next 3 weeks when related with control. When kept at 10°Celsius, the outer appearance of the 2 control treatments were the least, but overall, no treatment was satisfactory 14 days afterwards. CMC-treated fruits tend to be more firm when kept at 5°Celsius in storage after 11 days, but not at 10°Celsius.

Zhang *et al*., (2004) observed the physical and physiological changes in

cucumber after coating with edible films & ozone water. The experiment revealed that the use of coatings can also subordinate the TSS (total soluble solids) content and prevent the PPO (polyphenol oxidases) activity.

Lee *et al*., (2003) determined the influence of several coatings with anti-browning agents on apple slices. In carrageenan (0.5 g/100 mL)-coated fruits, there was decrease of 5% in respiration rate while fruits coated with whey protein concentrate (5 g/100 mL) showed 20% decrease of respiration rate at 25 °C. Use of edible coatings mixed with anti-browning agents enhanced the storage ability of apple slices for fourteen days when kept at 3^0C.

According to **Salvador *et al*. (2003)** edible coatings retard moisture loss, slows physiological loss in weight, prevent microbial spoilage, softening and retain the fruits colour during storage.

Hoa *et al*., (2002) observed the effect of different coating treatments on the shelf life of mango and used four coatings containing shellax, carnauba wax, zein and cellulose. Carnauba wax was superior then all other coating materials which reduced the weight loss for a long time. After 17 days of storage, fruits treated with carnauba wax showed less weight loss 15 %, which was minimum when compared to control treatment and other coatings. Coating was most successful for retarding weight loss. The reason for the weight loss reduction may be due to the blockage of stomata that results in reduction of respiration and gas exchange.

Yaman and Bayoundurlc (2002) revealed that to increase the lightness in sweet cherry, the sucrose polyester (SemperfreshTM) coating found to be effective.

Jiang and Li (2001) studied that chitosan coating could prolong the post-harvest life of longan fruit and maintain their quality.

Chen and Nussinovitch (2000) compared performance of locust bean gum and non-gelling xanthan gum as wax formulations on Nova and Michal cultivars of citrus. Both treatments contributed in reducing loss in weight of the fruit.

Rasool (2000) reported that in "Red Delicious" apple, the maximum average (9.60%) of total sugars were found after storage for 105 days under ambient condition in case of control and minimum of 9.06% were found in Stay fresh treated fruits. Similarly, the maximum average (7.11%) of reducing sugars in case of control and minimum of 6.67% in fruits treated with Stay fresh.

Arvanitoyannis (1999) reported that chitosan is being biodegradable and edible coating material, has a great potentiality for use in food packing, thus, making it a potential raw material for edible coatings and films.

Dashora *et al.*, (1999) stated that in ber variety (Umran) 2°/o edible oil coating prolong the storage period up to 12 days at room conditions & decreased the losses during postharvest without any unfavorable impact on acidity, TSS, ascorbic acid and amount of sugars during storage.

Tasdelen *et al.*, (1998) recorded that edible semperfresh coated tomatoes were significantly effective at storage temperature to delay changes in firmness, PH, TSS, acidity, sugar, weight loss ,ascorbic acid & reduced microbial spoilage during storage.

According to **Singh *et al.*, (1997)** fruits of guava fruit cultivar Allahabad Safeda were found to retain good organoleptic properties up to 12 days of storage at ambient condition when coated with 6-12 % Waxol or 3-6 % corn starch.

Das and Medhi (1996) suggested that 6% corn starch treatment noticeably decrease weight loss, change of color, increases (TSS) Total Soluble Solids and Total amount of sugars after twenty-one days of storage period.

Lerdthanangkul and Krochta (1996) studied the post-harvest effect of edible coating on green bell peppers. They concluded that no coating applied showed significant

effect on color changes at the time of storage. Results showed that color of treated green pepper bell did not change in relation to control treatment.

Sindhu and Singhrot (1996) recorded extreme deterioration harm in mustard oil as compared to Til oil coated fruits. TSS, Titrable acidity and vitamin C of lemons were increased with increasing storage periods.

Study conducted by **Sarkar *et al*., (1995)** revealed that banana fruit can be stored for fourteen days after harvesting without significant influence on the post-harvest quality when they were treated with 6 percent waxol.

Jagdeesh (1994) reported that sardar guava fruits after post-harvest treatments of 6 percent corn starch prolonged the storage period of fruits to 9 days. The fruits which were treated showed decreased PLW and reserved higher content of TSS, vitamin C, acidity, total amount of sugars, reducing sugars and organoleptic scores during storage period.

Singh *et al*., (1993) exhibited that wax coating were superior in extending storage ability of guava (*cv*. Allahabad Safeda). They found less PLW, refining color development gloss and retaining chemical constituents during fruit storage.

Aworh *et al*., (1991) established that waxing minimized loss of weight in oranges & grape fruits. Over 31 days of storage, weight loss in control was 20 percent compared with 13.8 percent in waxed fruit.

El-Ghaouth *et al*., (1991) observed that storability of various perishable fruits such as strawberry had been improved by chitosan coating.

Guatam and Chundawat (1990) observed that the accumulation of TSS during the process of ripening in sapota. But, when the fruits treated with different chemicals the accumulation of TSS decrease or lower in comparison to untreated control. In sapota cv. Kalipatti, there was a slow decline in Titrable acidity throughout the period of ripening. However, the decline of Titrable acidity diverse among treatments being most quick in

GA (30 ppm) and the lowest in the control. The upsurge in TSS content in sapota delay when stored at zero energy cool chamber and ripening of fruit also delay **(Reddy and Nagaraju 1993)**.

Desai *et al*., (1989) confirmed that the Tal-prolong treated fruits had significantly higher values of starch, indicating the ripening process in these banana fruits was retarded significantly followed by those banana treated with Topsin plus wax emulsion, benomyl plus wax emulsion and wax emulsion alone. Wax emulsion was as effective as the Tal-prolong and gave the best outcome when used in combination with benomyl or Topsin.

Shivaramareddy and Thimmaraju (1989) observed a reduction in spoilage and weight loss when mango fruits (*cv*. Alphonso) were coated with wax emulsion (2, 4 and 6 %) and stored in perforated polyethylene bags. They found 6 percent wax emulsion as best coating concentration over the 2 and 4% concentration of wax emulsion.

Dashora and Mohammad (1988) observed that 100 PPM 2,4-D along with 4 and 8 percent whey protein concentrate turnout to be the most suitable postharvest treatment for loss of weight, reduction of rotting, and also for maintaining superiority of fruits and increasing the shelf life & hindered ripening of fruit till 40 days.

Farooqhi *et al*., (1988) conducted a study on effect of wax emulsions SB65, Britex-561 and Fruitex on oranges, grape fruits, lemons and Kinnow. It was found that the wax coating enhanced the outer advent of fruits and decreased loss of weight, reserved fruit firmness, & fresh looks. Coating has also gained importance in reducing the moisture loss and maintaining the firmness during storage.

Singhrot *et al*., (1987) recorded enhanced shelf life (up to 35 days) of Baramasi lemon with the treatment of waxol and captan.

Ahmad *et al*., (1986) observed the influence of lining material & waxing on storage ability of kinnow fruits & detected that the treatment were having better impact

on quality traits. The outcomes showed that the amount of Vitamin C & citric acid tends to decrease, in vice versa, sugar content and sugar/acid ratio upsurged during storage period.

Rao and Chundawat (1986) recorded significantly lesser % age of ripened banana *cv*. Lacatan fruits coated with waxol (12%) as compared with control on the 12th day of storage.

Wild and Scott (1983) could maintain lime fruits, green and marketable for 4 months by treating with wax containing GA plus 2, 4-D and storing in controlled atmosphere (1% C02, 12% O2), with ethylene removed, at10^0C.

Passam (1982) noted extended shelf-life of mango fruit when coated with wax 3 percent emulsion of stay-fresh wax at room temperature (28^0-32^0C) during the experiment.

Singh and Chauhan (1982) reported that waxol (1-12%) coating with pre-cooling treatment improved shelf-life of guava by two days. It also reduced fruit rotting and retained higher sugars. They also found that the activity of cellulose and pectinase were lowest among wax treated guava fruits. Thus the fruit with wax coating can securely be kept for 4 days at room temperature. Wax emulsion applied to guava fruits reduced weight loss and produced a surface shine. Yellow skin color developed normally and respiration rate and ethylene production were not affected.

Wild (1981) observed that the wax coating reduced the weight loss from 11.5 to 4.3 percent in oranges stored for 21 days.

Bhullar and Farmahan (1980) indicated that wax coating of guava fruits @6 percent postponed the ripening rate and prolonged the storage life up to 10 days; with minimum PLW (8.2%) and fruit rot (5.0%). **Jawanda *et al*. (1980)**, similarly, also recorded less storage loss (9.32- 9.52) in ber fruit *cv*. umran and sameur, respectively, when treated with wax emulsion dipped for 30 seconds and stockpiled in polythene bags.

Roy *et al*., (1980) reported that the wax emulsion treatment that the Himsagar and Langra mango were found most effective in extending storage life to 10 days when compared control which was 6 days. They also conveyed that the loss in weight was maximum in control (14-15 %) and it was lowest (4.2-7.3%) in combined treatment of wax emulsion with Maleic hydrazide. In a trail to prolong the storage life of kinnow, it was found that wax emulsion (12%) was the best coating material as a treatment to minimize the weight loss of fruit. Wax emulsion (6-12 %) with and without 2, 4-D (50-100 ppm) and cycocel (500-1000 ppm) gave better retention of juice during storage. Wax emulsions alone or in combination with 2, 4-D retarded the rate of normal change of TSS.

Pillai *et al*., (1978) showed that W-12 wax emulsion prolonged the storage life by 5-6 days in banana cv. Dwarf Cavendish and Nendran.

Sheikh *et al*., (1977) found extended shelf-life of mango fruits using fungicidal wax emulsion coating.

Garg *et al*., (1976) reported significantly least weight loss 25.7 and 18.4 percent in guava (*cv*. Allahabad Safeda) treated with wax emulsion, after 9 days at normal and 21 days at lower storage temperature condition respectively. Preservation of acidity and ascorbic acid was better in waxed fruits with relation to control.

Garg and Ram (1973) observed that submerging mango *cv*. Lucknow Safeda for time period of 30 to 60 sec. in 6 % wax emulsion with added sodium orthophenylphenate 0.4% for 30-60 seconds prolonged the storage life of fruit by 3 days in comparison to the control treatment at 30 degree Celsius.

Dalal *et al*., (1971) suggested that the usage of wax emulsions (4-6%) extends the shelf-life of the several fruits minus any negative impact on the quality.

Garg *et al*., (1971) stated that the reducing sugars in untreated fruits were maximum as compared to treated fruit. In Patharnakh variety of pear, when storage period extended, the amount of total sugars also increased.

Muthuswamy *et al*., (1971) reported reduced PLW (%) of banana fruits treated with of 6 and 12 percent wax emulsion. Further, they concluded that the application of paraffin wax to cut end surface slightly reduced PLW (%).

Fruits are living tissues, as they continue to transpire and respire even after harvest. PLW is mainly because of the respiration and transpiration **(Krishnamurthy and Subramanyam 1970)**. **Davies *et al*., (1981)** found that desiccation and shriveled appearance of fleshy fruits are because of PLW which indicate moisture lost during ripening and storage.

Srivastava (1962) studied the storage life of guava fruits by treating with a carnauba-paraffin or carnauba-resin wax by 80 percent at room temperature and by 50 percent at 8-10^{0}C. Similarly, extended storage life of banana about a week has been recorded by **Agnihotri and Ram (1971)**.Waxing of banana fruits was found to reduce the PLW while in non-waxed fruits increased PLW up to a period of seven days of storage under ambient condition.

Effect of packaging materials on physical and chemical attributes of fruits:

According to **Dhillon *et al*., (2016)** demonstrated about the influence of several packing materials on keeping ability & post-harvest appearance of Daisy mandarin under room temperature. Fruits were packed in various packaging materials *viz*., LDPE (25 µ) film, heat cling (15 µ) & shrinkable film (15 µ). The outcomes exposed that the shrink film shown to be most efficient in prolonging storage time & maintenance of appearance up to 15 days in relation to control i.e. 5 days.

Singh and Yadav (2015) determined that the storage of kinnow fruit in evaporative cool chamber in combination with rice husk ash (RHA) combined with packaging in 100 gauge LDPE bag packaging preserved dominance in expression of maximum overall suitability.

Study conducted by **Chaudhary *et al*., (2015)** reveled that as grapefruit *cv*. "Star Ruby" when kept up to 16 weeks at 10^0C in either macro or micro punched bag does not showed -ve values for vitamin C, acidity, and TSS content.

According to a study done by **Mahajan *et al*., (2015),** the harvesting of peach fruits were done at color break stage & were kept in paper moulded trays followed by wrapping in diverse packing films *viz*. low density polyethylene (LDPE) film, cling film, cryovac heat shrinkable RD-106 and kept in storage under 2 different situations *i.e*. ordinary market conditions (28–30°C; 60–65% RH) and super-market conditions (18–20°C; 90–95% RH). As a result RD-106 film was established helpful in increasing the storage life & holding post-harvest quality for 9 days when stored in super market conditions (SMC) & 4 days in OMC, respectively, whereas only 6 days in super market conditions and 2 days under ordinary market conditions in case of unpacked fruits in control.

Mahajan and Singh (2014) found in their study that kinnow fruit showed better quality retention and improved storage life up to 20 days in relation to ten days with control.

Ahmed *et al*. (2013) recorded the impact of transparent, white, yellow polyethylene packing on storability for life delay of plum fruit kept in refrigerator (1-4°C) & ambient temperature (25±°C). Maximum total soluble solids (9.92°Brix), decay index (22.11), weight loss (5.79), and titratable acidity (0.78) was observed in sample T_0 and minimum acidity (0.65), loss in weight (1.64), decay index (4.73) and TSS (8.34°Brix) and were observed in TF. Highest Vitamin C (5.95 mg/100g) amount was found in YR while lowest vitamin C (5.05 mg/100g) was observed in TF. The maximum firmness was obtained in TF and minimum in YR. TF obtained highest average score of judgment for colour (6.92), texture (6.37), flavour (6.37) & total suitability (7.03) while lowest score rate was in specimen T0. Treatment TF (transparent colored packaging at cold conditions) reserved utmost quality traits & also got highest score for organoleptic estimation.

Pongener *et al*., (2011) exhibited the stimulus of various packaging material on shelf life & post-harvest appearance of peach fruit under cold store. The shrink film was best among all the films in maintaining superior quality up to 28 days of storage. The highest fruit firmness (7.55 lb force), total soluble solids (12.16%), total sugars (9.12%), Titrable acidity (0.76%) and lower weight loss (0.93%) was obtained by shrink film. The control fruits maintained marketable quality up to 14 days.

Pongener *et al*., (2010) conducted a study on the impact of packaging materials on storage life of fruit of peach under supermarket conditions. Peach (*Prunus persica* L.) fruits picked at colour break stage, & packed within paper moulded tray and firmly stretch wrapped in various packaging materials *viz*. cling, LDPE, HDPE and shrink films. The packed fruits and control (without packaging) were stored under super-market conditions *i.e*. 20-21°C and 90-95% RH and analyzed for physicochemical parameters after every 2 days interval. Shrink film was established to be most efficient in maintain the storage ability of peach fruit up to 8 days and maintained good quality as indicated by higher organoleptic rating. Desirable fruit firmness, total sugars, TSS, acidity lower PLW & colour development was observed. Whereas the control maintained marketable quality for 4 days only.

According to **Sonkar *et al*., (2009)** revealed that kinnow showed good performance under cling film packaging and there was less weight loss under normal room conditions.

Singh *et al*., (2009) entailed the impact of wrapping peaches (*Prunus persica* L.) with individual warmth recoil. Fruits were examined utilizing heat shrinkable 50µ LDPE and 20µ LLDPE film to upgrade the timeframe of realistic usability in cold storage (5 ± 1°C & RH 90 – 95%). The PLW was 0.67% in LDPE (50µ) and 0.7% of LDPE (20µ). The Percentage Loss in Weight definitely lessened when contrasted with control i.e. 44.26% following forty two days of storage capacity. The waste of organic products was 7% in LDPE (20µ) wrapped natural products. No natural product rot was observed in non-wrapped examples; however every one of the organic products wilted following

fourteen days of storage capacity. The immovability of natural products was better with LDPE (20µ) when contrasted with control. It might be reasoned that the time span of usability of the natural products in cool chamber might be stretched up to 42 days by singular warmth contract packing in 20µ LDPE film after postharvest treatment with 500 ppm carbendazim.

Jadhao *et al*., (2008) conducted a study on storage of kagzi lime in punched polypropylene bags (200 gauge) for 70 days under cold storage and observed lowest damage in TSS/acid ratio, Total Soluble Solids & the highest amount of titratable acidity & Vitamin C up to 70 days in cool store.

Ramin and Khoshbakhat (2008) observed the effects of packaging films on acid lime with HDPE (high density polyethylene) bags with 30µm thickness. The film was found to have micro perforations and as the result minimized weight loss of acid lime was observed in storage of fruits at 10°C and 20^0C.

Salari *et al*., (2008) reported the effects of packaging material on Iranian dates throughout storage. These dates were packed with coatings like synthetic resin, plastic and plastic wrap. These dates were hold on for 6 month at 3 completely different temperatures i.e. 25^oC, 5^oC and -18°C and their chemical properties viz. total sugars, TSS, moisture, acidity, pH, reducing sugars, lightness worth and redness to spectral colour ratio were observed every 2 months of interval. For storing, 2 month letter and PP causes a reduction in TSS, reducing and total sugars.

Sharma et al., (2007) observed that maximum reduction in PLW of kinnow mandarins packed in polythene bags (150 gauges) with bay leaf extract treatment in comparison to control.

Sudha *et al*., (2007) investigated that the independently wrapped sapota fruits reserved maximum Vitamin C content which was attributed to lesser availability of O_2 and thus lesser oxidation of ascorbic acid content. **Suryanarayana and Goud (1984)**

studied that in sapota cv. Oval the estimated ascorbic acid content on the day of harvest was 33.0 mg/100g which decreased by the 10th day of ripening to 18.1 mg/100g.

According to the study of **Jindal *et al*., (2005)** sapota fruits wrapped in polythene contained maximum amount ascorbic acid in comparison with control due to low PLW accompanied by low respiration and transpiration losses.

Hussain *et al*., (2004) worked on an experiment of 45 days of storage to check the influence of uni-packing of citrus fruits with polythene. They reported that vital impact was found in fruits for prolonging the period of storage and maintaining the external look, taste and texture of citrus fruits but no significant impact was detected on the pH range of citrus fruit. During storage, increase in T.S.S was observed but uni-packaging showed no significant impact on the TSS. In vice versa, Vitamin C was found to be reduced from 1.59 percent to 0.63 percent in storage condition.

Juliana *et al*., (2004) analyzed the microbiological and physicochemical characters of slightly processed "Champagne" orange (*Citrusreticulata*× *Citrussinensis*) under various packaging treatments for 8 days of storability. The fruits, minimally processed, which were packed in polystyrene containers having a lid, PVC and polyethylene films retained superiority in fresh visual quality of fruits with a few microbiological and physico-chemical variations. Generally, increasing trend throughout the ripening process is shown by TSS (Total Soluble Solids) of fruits. **Kumbhar & Desai (1986) and Gautam and Chundawat (1990)** showed the increase in TSS of sapota fruit during harvest till ripening and then as the fruits started senescing there was decrease in TSS.

In a study **Raghav and Gupta (2003)** found that separately packed fruits retained better storability for 84 days with lesser Physiological weight loss (4.0%) & edible quality, which were set up to be at insignificant rate up to 40 days in (37.0%) untreated control at room temperature. Also, the wax treatments were useful in prolonging the storability & retreating Physiological loss in weight even after 21 DAS.

Ladaniya (2003) found that packaging "Mosambi" orange in stretchable cling; LDPE and shrinkable cryovac bring about in lowest loss in weight and spoilage of fruit under 20^0C to 25^0C storage for up to 40 days.

Nain *et al*., (2002) conducted an experiment of wrapping 'Dashehari' mangoes in cling films and observed that the favorable effect of the film on the PLW and decay loss in fruits. They also reported that cling film wrapped fruits had better retention of acidity and ascorbic acid content in comparison to others.

Hussain *et al*., (2001) found that when apple fruits are wrapped in polythene wrap of thickness 0.01cm, there was less decrease in acidity per cent than control. They also found that acidity percentage decreased as storage period increased. **Hayat *et al*., (2000)** reported lesser decrease in acidity per cent in polyethylene wrapped apple fruits in comparison to control and wax treated apple fruits.

According to **Nanda *et al*., (2001)** reported the impact of shrink film wrapping and storage temperature on appearance of pomegranate *cv*. Ganesh. Storage time & appearance of soft-seeded "Ganesh" pomegranates were studied by wrapping individual fruit in shrink film with 2 polyolefin films and waxing the skin with a plant product polyester (SPE) Semperfresh™, carried at temperature 8, 15 and 25°C. The pomegranates wrapped with shrink film was unbroken for 12, 8 and 4 weeks as compared to 8, 6 and a pair of weeks by SPE coating at 8^oC, 15^oC and 25°C, whereas unwrapped fruits were well hold on for seven, five and one week underneath same storage conditions. Peeling thickness and firmness of the fruits were maintained and PLW gradually decrease in shrink wrapping. Changes in sugars, acidity& ascorbic acid of the packed fruits were less when compared to non-packed fruits throughout the storage at 8°C for 12 weeks.

According to a study done by **Raghav & Gupta (2000)** the separate kinnow fruits shrink wrapping with film of 25 micron thickness exhibited lower total sugar amount than non-wrapped kinnow fruits. The treated fruits retained good quality (Sugars, TSS,

Ascorbic acid, Acidity) and flavor up to 8 weeks in comparison to the untreated fruits kept at room conditions & other conditions.

Hayat *et al*., (2000) reported the highest TSS content in control and lowest TSS content in apples packed in polyethylene bags during 60 day of storage. The upsurge in the TSS content was exhibited during storage.

Deshmukh *et al*., (1999) determined about the impact of lower temperature (5-6^0C) and film wrapping on keeping quality of Mosambi *cv*. of sweet orange & stated that both treatments showed positive results with all the parameters taken viz., reduced weight loss and fruit size.

Perez-Guzman (1999) examined the impact of discrete seal packaging viz. PVC (0.025 mm) and polyolefin (0.019 mm) on weight loss of fruits of "Dancy" mandarin (*Citrus reticulata*) which resulted in minimum weight loss in both under refrigerated storage.

According to **Singh *et al*., (1998)** observed that with rise in storage periods of "Amarpali" mango causes decrease in ascorbic acid. Similar findings have been reported **by Kumar (1998)** in "Sipia" mangoes. **Mohamed *et al*. (1996)** exhibited the effect of different methods of MAP at 5^oC, 10^oC, 15°C and ambient temperature on fruit. Packaging in LDPE was highly efficient in preserving the weight and texture of cold-storage fruits. Highest vitamin C was observed in vacuum-packed fruits than the other LDPE packagings. Studies showed that LDPE packaged cold-stored chiku fruit have highest sensory scores for taste, colour, texture and overall acceptability.

Slaughter *et al*., (1998) stated that the per cent acidity slowly decreased in Bartlett pear fruit packed in polyethylene film bags as compared to unwrapped fruit. Ethylene production, respiration & catalase activity in Bartlett pear were rapid at ambient temperature of 29-31°C

In a study **Sonkar and Ladaniya (1998)** stated that tray-over wrapping system of Nagpur mandarin fruit with direct LDPE stretch cling film after carbendazim treatment increased its shelf life up to 2 months in cool environment & hold least loss in weight.

Ladaniya *et al*., (1997) stated that decay injury was less in Nagpur mandarin shrink wrapped fruit and maximum in unwrapped fruit during storage**. Slaughter *et al*., (1998)** found that the Bartlett pears when packed in bags of polyethylene film resulted in very low decay as compared to the unwrapped Bartlett fruits.

Generally, sapota fruit contains 12-14% sugars **(Roy and Joshi, 1997). Shanmugavelu and Srinivasan (1973)** established that there are variations in total sugars (7-12.3%) in various varieties of sapota.

Timm *et al*., (1996) found that the sugar content was minimum in an apple fruit wrapped individually in Shrink wrap film of thickness of 25 micron than non-wrapped apple fruit and an increase in sugar content with increasing storage period.

Dhatt *et al*., (1995) reported highest recorded loss in weight 25.57 & 45.30 % in unpacked fruit after thirty & 60 days in comparison with separately packed fruit i.e. 1.54 (500 ppm Imazalil), 3.85 (1000 ppm Imazalil) & 6.33 %(2,4-D 200 ppm) at 30, 60 & 90 DAS.

Reddy and Nagaraju (1993) reported the impact of evaporative cool chamber on the storage life of sapota fruit variety. Kalipatti. There was substantial reduction in physiological weight in loss & shriveling under cool chamber storage. Firmness was high with delay in ripening and a delay in rise of TSS, dropping the total sugars, acidity and low percentage rotting of fruit was detected which leads to save higher percentage of marketable fruit.

Singh (1993) reported the minimum spoilage on first harvest dates and simultaneous increase in spoilage with the enhancement of harvest dates in Patharnakh and Le Conte pears. The minimum and maximum spoilage was reported after 30 and 90 days cold storage in all the LDPE and HDPE films in pear respectively.

Yuen (1993) studied the effect of cling film wrapping on mango fruit variety 'kensington pride' and observed that after 10 days that mango had attractive appearance and good eating quality.

Dhatt *et al*., (1991) observed the lowest (6.1%) average weight loss in treatment done with polymeric packed film and highest in unwrapped (23.4%). a rapid upsurge in sugars content when packed in individual shrink wrapping in relation to control unwrapped fruits of kinnow under storage and extended storage life about 8 weeks in separately packed fruits of kinnow with HDPE (High Density Polyethylene) film at ambient conditions.

Mann *et al*., (1990) observed the highest weight loss after 30 days of Baggugosha pear wrapped in polyethylene when retained at normal temperature, while has the minimum loss (0.2%) was observed in polythene wrapped fruits stored in cold storage circumstances.

Banik *et al*. (1988) analyzed the effect of permanganate-silica gel at 10–12°C with polyethene bags on sapota. It was observed that fruits can be stored up to 18 days with lowest rate of spoilage (30 per cent) while other treatments were not responsive after 12 days of storage. Untreated fruits survived for only 9 days in storage. Percentage weight loss was always least in fruits stored at lower temperature & most in fruits under control. TSS and sugar content increased during the storage period in all treatments. Ascorbic acid and Acidity content of fruits declined as the storage period increased.

Bhowmik & Sebris (1988) observed the higher value of TSS in unwrapped peach fruits as compared to the individual shrink wrapped peach fruit**. Singh (1993)** observed that TSS content was highest in LDPE than HDPE packed Patharnak pear as well as in LeConte pear. The value of TSS decreased significantly from 30 to 90 DAS in both the LDPE than HDPE wrappings**. Ladaniya *et al*., (1997)** found less TSS content in Nagpur Mandarin shrink wrapped fruit and higher TSS content was found in the Nagpur Mandarin unwrapped fruit.

Miller *et al*., (1988) reported the effect of film wrapping in various fruits. The polyethylene wrapping reduced structure loss, retard softening and maintained characteristic freshness and less decay per cent during extended period of storage and marketing.

Hale *et al*., (1986) observed the maximum TSS content in case of unwrapped Florida grape fruit as compared to the individual shrink wrapped fruit with increase in storage period. **Greg and Santi (1987)** reported maximum TSS content in unwrapped tomato fruit than individual shrink wrapped fruit with increasing storage. Highest TSS content was detected in untreated fruits i.e. 12.30% after 90 days in storage at 19±8°C because of higher rate of evapotranspiration **(Singhrot *et al*. 1987).**

Kropp and Ben (1985) noticed that when apples were wrapped in polyethylene bags then there was less rises in sugars in comparison to control. Total sugars in red delicious apples reported to be increased during 150 days storage period **(Mahajan, 1994)**. **Dhatt *et al*., (1991)**, also reported that slow sugar increasing during storage. Results also showed that in kinnow fruits sugars exhibited slow upsurge in individually shrink wrapped fruits than non-wrapped fruits.

Selvaraj and Pal (1984) reported that amount of titrable acidity in sapota, which was more in 30-day old samples, deteriorated and reached to lowest in ripe fruit. At all the developmental stages, malic acid was the major one. The amount of titrable acidity of sapota decreased as storage period advanced **(Banik *et al*., 1988).**

Singh and Mathur (1984) observed that as the storage temperature increases, the amount of total soluble solids (TSS) increases. **Sundararajan and Rao (1967)** established the range of TSS content of sapota is between 18 to 25 %. The shelf-life of sapota fruit increased TSS in all treatments including control **(Banik *et al*., 1988).**

Dhillon *et al*., (1981) demonstrated the role of various wrapping material on the keeping behavior of sub-tropical pear & reported that the reducing and total sugars increased in case of all the wrappers. The highest amount of total sugar content was

recorded in the paper wrapped fruit, followed by polyethylene and paddy straw wrapping, and while reducing sugars were maximum in the paddy straw wrapped followed by paper and polyethylene, wrapped fruits.

Flores and Rivas (1975) reported that sapota fruit is highly perishable if stored at room temperature and could not be kept for eight days. Whereas, **Kumbhar and Desai (1986)** in a study found that storage life of sapota increased at ambient condition for up to 11 days, when treated with GA_3 (75 ppm) and packed in polyethylene bags of 100 gauges.

Bain (1961) observed that if William pear was harvested early, then during storage it showed 3.2% loss in weight as against 2.2% loss in fruits at late harvested. The loss in weight is about 3.6% in pear, after stored for 55 days when it wraps with polyethylene **(Dhillon *et al*. 1981)**. The loss in weight was minimum in Patharnak and Le conte pears, when wrapped with low density polyethylene films (**Randhawa *et al*. 1982).**

Effect of coating and packaging materials on physical and chemical attributes of fruits:

Mandal (2015) evaluated the importance of citrashine, lac wax & shrink wrap on storage ability of kinnow fruit. The fruit were coated with wax solutions & independently shrink wrapping was done with LDPE (19μ). After this treatment, the fruits were packed in CFB boxes of 4 kg capacity and kept in storage under normal condition. The outcomes showed that loss in weight was maximum in fruits kept as control, while, lac-treated & shrink wrapped fruit efficiently minimized PLW and Coated fruits expressed better quality traits even under the storability of fruits for 21 days in ambient conditions.

Jawandha *et al*. (2014) evaluated the effect of MOP on Baramasi lemon. The healthy fruits were selected and disinfested with bavistin solution (0.1%) for 2 minutes, wax coated and packed (4 fruits per pack) in HDPE and LDPE bags. The outcomes revealed that the fruits that were applied with 0.1% bavistin & been wrapped in LDPE

bags showed bitterness in taste with reference to juice percent content & Titrable acidity during room storage (50 days).

Jawandha *et al.*, (2012) observed effect of packaging (LDPE) & numerous chemicals on favorable room storage of kinnow. The outcomes showed that the fruits application with 3% boric acid + packaging without perforation (LDPE) showed lower PLW.

Nasciment *et al.*, (2011) assessed the influence of using modified atmosphere in cold storage on citrus *cv*. Murcott mandarins and detected the fruit which are applied with wax and packed packaging films, prolonged the storage life of fruit for 30 days. The remarks on disease incidence and biochemical characters of fruits showed that the observation of fruits at 10±1°C during the thirty days of storage, retained large intensity of fruit skin.

Randhawa *et al.*, (2009) evaluated the influence of packaging (HDPE) in conjunction with coatings of wax and eatable oil on storage quality of kinnow. After room storage for 45 days, the palatability assessment was noted highest in HDPE packed. There was minimum spoilage and highest juice content in the neem oil coated fruits with HDPE packaging. However, the highest value for PLW and TSS was recorded with untreated control treatment.

Upadhaya and Sanghavi (2006) conducted a trial with various different treatments with $CaCl_2$ (4%) on kinnow mandarin and the fruits were packed in perforated poly bags (0.2%). The outcomes showed that during storage the treatment tends to lower the PLW of fruit and extended storage ability up to 42 days in ambient condition.

Kaur *et al.*, (2004) worked on the efficacy of using combination of fungicides and wax upon the storability performance of kinnow (seal packaged) mandarins. The interpretations related to physico-chemical traits were noted after thirty and sixty DAS period at ambient conditions which showed that fruits treated with Imazalil (1 g^{-L}) and HDPE film verified good quality, fruit look and slow pathological rot.

Thakur *et al*., (2002) reported that fruits treated with carbendazim solution & packed in LDPE bags of thickness 150 gauges were found to be effective in keeping better quality of fruits under storage. Besides, the amount of total sugar in fruits tends to get increased throughout the storage period.

Kaushal and Thakur (1996) stated that in cool chamber storage, the reduced level of Titrable acidity was recorded under treatment sealed packaging. The fruits which were applied bavistin (1%) and covered with poly bags observed reduced amount of Vitamin C in storage. Though, the fruit kept in sealed packs revealed slow upsurge in total sugar amount in comparison to the ones kept as control.

Kariyanna *et al*. (1993) reported impact of packaging material on sapota. When polyethylene bag with 150 gauges and 1 percent vents was used, the loss in physiological weight (PLW) decreased significantly; however, the maximum spoilage was due to fungal rot. However, this could be overcome by treating the fruit with Bavistin (500 ppm) before packaging. Fruit packed within polyethylene bags showed better effect in relation with other treatments.

Karibasappa and Gupta (1988) found that the packaging with the polythene reduced loss of weight. However the retention of ascorbic acid was recorded maximum in Benlate plus waxol treated Khasi mandarin's fruits, after 7 weeks of storage. Postharvest treatment with fungicides along with wax emulsification lowered the weight loss & increased the palatability rating of the fruits of Kinnow mandarin. The wax emulsified fruits were having more palatability rating and the effect increased with its increasing concentration. Fungicides and wax emulsification treatments helped in drop of fruit rotting during the period of storage.

Kumbhar and Desai (1986) observed that the cumulative total loss in weight during the time of storage of sapota was considerably high in the open fruits. The loss in weight in polyethylene packed fruit was 46.3 % as against 72.1% in open fruit after 11 days in storage. A significant reduction in the weight loss was observed in 75 ppm GA

treated fruit packed in polyethylene bag after 11 days, the loss was 11.89 % as against 90.2% in untreated open fruit. Percentage of acidity decreased from 0.27 to 0.04 during ripening. The reduction in acidity was slow in polyethylene packed fruits besides open fruit and in treated fruit as compared to the fruit which is untreated. Decrease in acidity was slower in GA_3 as compare to IBA.

Garg *et al*., (1971) evaluated organoleptic quality of mango *cv*. Dashehari, under room temperature with different treatments. Combinations of prepackaging and waxol scored the highest of 86.6 followed by 77.0, 72.3 and 60.3 in waxol treatment, control and prepackaging indicated the supremacy of prepacking of the waxol coated fruits above the non-treated ones.

CHAPTER-III

MATERIALS AND METHODS

The present investigation entitled "**Studies on the effect of edible coatings on the quality attributes of guava fruit**" were conducted in Laboratories of Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara, Punjab during the academic year 2018-19 and 2019-20. The detail of the materials and methods used during the experimentation are described as under:

Selection and harvest of fruits

The fresh guava fruits (*cv*. Allahabad safeda) of uniform size at well mature green stage were harvested. Apart, other traits of healthiness for fruits free from that of disease and bruising on skin were also taken into consideration for selection of fruits. The selected fruits were randomly picked from entire periphery of the plant with the help of secateurs from the orchard of Maheru village, Phagwara, Punjab. The fruits for experiment first, experiment second and experiment third was harvested in month of august 2018, September 2018 and February 2019 respectively. Before the application of the treatments, the fruits were thoroughly washed and dried. healthy and uniform fruits of equal size were selected for experimentation. In each replication 15 fruits were taken for observation. Fruit sample were analyzed for physiochemical observations at an interval of 2 days after treatments.

Preparation of coating material

Chitosan coating

To prepare 0.1/0.2/0.3% chitosan (Loba company) coating solution, 1/2/3g of chitosan each in 1000 ml of distilled water were dispersed in which glacial acetic acid (25ml) was added to dissolve the chitosan. The pH value of chitosan solution was adjusted as 5.0 with 1.0 mol^{-1} NaOH. After dipping, fruits were dried for 4 hrs. at 25^0C **(Jiang and Li, 2001)**.

Calcium Chloride coating

Dissolve 5/10/15g of calcium chloride in 1000 ml of deionized water each to prepare 0.5/1.0/1.5 percent solution of calcium chloride respectively. The fruits were submerged in the calcium chloride solution for 15 min at ambient condition and then dried for period of 24 hours at room temperature **(Kou *et. al.*, 2014)**.

Flow chart of fruit coating

Selection of uniform physiologically matured sized fruits

↓

Fruits were kept under running water

↓

Fruit were kept in shade for drying

↓

Various coating materials were used for experimentation

↓

Fruit were immersed in coating materials

↓

Fruits were kept on paper sheet at ambient conditions

↓

Fruits were kept as per their treatment plan

***Aloe vera* coating**

For preparation of *Aloe vera* coating material, aloe vera gel matrix was extracted from the outer cortex of the *Aloe vera* leaves and the neutral hydro parenchyma was blended in the mixer. The resultant matrix was sieved to remove fibers. The fluid obtained contained fresh *Aloe vera* gel matrix. This gel matrix was subjected to pasteurization at 70ºC for 45 minutes For stabilizing, the gel, it was cooled immediately at room temperature and L-ascorbic acid (1.9 to 2g per litre) was added; then citric acid (4.5 to 4.6g per litre) was further added to keep the pH at 4.00. 25/33/50g of this *Aloe vera* gel was added to 100 ml of distilled water each to get 25, 33 and 50% *Aloe vera* coating solution. The coating efficiency and viscosity of aloe vera gel was enhanced by

using commercial gelling agent (1%) and was used as aloe gel (AG) coating. The fruits were dipped in the *Aloe vera* solution prepared for 15 min at ambient temperature and dried for 24 hours at room temperature **(Adetunji *et al*, 2012)**.

Corn starch coating

Dissolve 5/10/15g of Corn starch (procured from lab) in 1000 ml of deionized water each to prepare 0.5/1.0/1.5 percent solution of Corn starch respectively. The fruits were submerged in the Corn starch solution for 15 min at ambient temperature and then dried for 24 hours at room temperature **(Kou *et. al.*, 2014)**.

Details of experiment

Experiment-: To standardize the effect of different types of edible coating on the quality attribute of guava.

a. Aloe Vera gel [1/3(25%), 1/2(33%) and 1/1(50%)]

b. Corn starch (0.5, 1, and 1.5 %)

c. Calcium chloride (0.5, 1, and 1.5 %)

d. Chitosan (0.1, 0.2, and 0.3 %)

Concentrations of coating material - 3

Types of coating material- 4

Number of replications-3

Statistical analysis- Completely randomized design (CRD) factorial

Variety- Allahabad Safeda

Packaging materials for fruits

The packaging films used in this experimentation were purchased from Phagwara commercial market area. The packaging materials include LDPE (100 micron), HDPE (20 micron), PP film (40 & 60micron) and Cling film (10 micron).

Experiment: - 1 Effect of various edible coating on guava fruit *cv*. Allahabad Safeda under ambient conditions.

Treatment	Aloe vera	Corn starch	Calcium Chloride	Chitosan	Treatment	Aloe vera	Corn starch	Calcium Chloride	Chitosan
T_0	-	-	-		T_{20}	½			0.2%
T_1	1/3				T_{21}	1/1			0.3%
T_2	½				T_{22}		0.50%	0.50%	
T_3	1/1				T_{23}		1.00%	1.00%	
T_4		0.50%			T_{24}		1.50%	1.50%	
T_5		1.00%			T_{25}		0.50%		0.1%
T_6		1.50%			T_{26}		1.00%		0.2%
T_7			0.50%		T_{27}		1.50%		0.3%
T_8			1.00%		T_{28}			0.50%	0.1%
T_9			1.50%		T_{29}			1.00%	0.2%
T_{10}				0.1%	T_{30}			1.50%	0.3%
T_{11}				0.2%	T_{31}	1/3	0.50%	0.50%	
T_{12}				0.3%	T_{32}	½	1.00%	1.00%	
T_{13}	1/3	0.50%			T_{33}	1/1	1.50%	1.50%	
T_{14}	½	1.00%			T_{34}		0.50%	0.50%	0.1%
T_{15}	1/1	1.50%			T_{35}		1.00%	1.00%	0.2%
T_{16}	1/3		0.50%		T_{36}		1.50%	1.50%	0.3%
T_{17}	½		1.00%		T_{37}	1/3	0.50%	0.50%	0.1%
T_{18}	1/1		1.50%		T_{38}	½	1.00%	1.00%	0.2%
T_{19}	1/3			0.1%	T_{39}	1/1	1.50%	1.50%	0.3%

Experiment 2 Effect of various coating materials on guava *cv*. Allahabad Safeda under cold (7°C) and ambient conditions.

Treatment at Cold conditions (7°C)	**Details**	**Treatment at Ambient conditions**	**Details**
T_0	Control	**T_0**	Control
T_1	Aloe Vera 1/3	**T_1**	Aloe Vera 1/3
T_2	Aloe Vera ½	**T_2**	Aloe Vera ½
T_3	Chitosan 0.1 %	**T_3**	Chitosan 0.1 %
T_4	Chitosan 0.2 %	**T_4**	Chitosan 0.2 %
T_5	Chitosan 0.3 %	**T_5**	Chitosan 0.3 %

Experiment 3 Effect of various edible coating & packaging on guava fruit *cv*. Allahabad Safeda under cold (7°C) and ambient conditions.

Treatment at Cold temperature (7°C)	**Details**	**Treatment at Ambient temperature**	**Details**
T_0	Chitosan 0.3% (Control)	**T_0**	Chitosan 0.3% (Control)
T_1	Chitosan 0.3% + Cling (10µ)	**T_1**	Chitosan 0.3% + Cling (10µ)
T_2	Chitosan 0.3% + HDPE (20µ)	**T_2**	Chitosan 0.3% + HDPE (20µ)
T_3	Chitosan 0.3% + PP (40µ)	**T_3**	Chitosan 0.3% + PP (40µ)
T_4	Chitosan 0.3% + PP (60µ)	**T_4**	Chitosan 0.3% + PP (60µ)
T_5	Chitosan 0.3% + LDPE (100µ)	**T_5**	Chitosan 0.3% +LDPE (100µ)

OBSERVATIONS RECORDED

Physiological Parameters

Physiological loss in weight (%)

The percentage of physiological weight loss was calculated by taking the difference between initial weight of the fruit and weight of fruit after storage and was expressed as percentage. The percentage loss of weight for each statement was calculated by using following formula as suggested by **Srivastava and Tandon (1968).**

$$\text{PLW (\%)} = \frac{Initial\ weight - Final\ weight}{Initial\ weight}\ X\ 100$$

Quality Parameters

Randomly selected fruits in each treatment of the experimentation were used for assessing the quality parameters.

Total soluble solids (˚Brix):

The TSS of ripe fruit juice was determined with the help of a digital refractrometer. The TSS was expressed in ˚Brix.

Titratable acidity (%)

A known weight of the fruit juice was taken in a 100 ml volumetric flask and the volume was made up to 100 ml by adding distilled water. Take 10 ml of filtrate in another flask. Add 2 drops of phenolphthalein as an indicator and titrate against 0.1 N (4g/1000g) sodium hydroxide. The end point was determined by the appearance of a faint pink colour. Note the readings and calculate using the formula **(Rangana, 1986).**

$$\frac{Titre\ X\ Normality\ of\ alkali\ X\ eq.wt.of\ acid\ X\ 100}{Volume\ of\ sample\ taken\ X\ wt.of\ sample\ taken\ X\ 100}$$

Vitamin C content (mg/100g pulp)

It was determined as per standard A.O.A.C. method **(A.O.A.C., 2010)** using 2, 6-dichlorophenolindophenol dye. The sample extracted in 3% m-phosphoric acid was titrated with the dye to an end point of pink colour. Results were expressed as mg per 100 g of sample and calculated by using the following formula:

$$\frac{Titre\ X\ Dye\ factor\ X\ volume\ made\ up\ X\ 100}{aliquot\ of\ extract\ taken\ X\ weight\ of\ sample\ taken}$$

TSS/Acid ratio

TSS/Acid ratio was measured by dividing the Total Soluble Solids value with the titratable acidity per cent and mean values were expressed.

Total sugars (%)

Total sugars content in fruit juice was determined as per Lane and Eynon Method **(Ranganna, 1986)**. Fifty ml filtered juice was mixed with 100 ml distilled water and neutralized with normal NaOH solution using phenolphthalene as indicator was added in the solution and allowed to stand for ten minutes. Than 8 ml of potassium oxalate solution was added and total volume was made up to 250 ml by adding distilled water. 50 ml of the extract was taken in burette and titrated against 10 ml mixed Fehling solution (5 ml Fehling solution A + 5 ml Fehling solution B) using methylene blue as indicator. The end point was indicated by decolourization of the solution. The following formula was used for determining the total sugar in fruits.

$$\text{Total sugars (\%)} = \frac{\text{Factor for fehling solution X dilution X 100}}{\text{Titre X weight or volume of sample for estimation}}$$

Reducing Sugars (%)

Reducing sugars were estimated by Lane and Eynon method as described by **Ranganna (1986)**. The extract was taken and titrated against 10 ml of mixed Fehling solution using methylene blue as indicator. Sufficient amount of extract was run to reduce Fehling solution treated and boiled for 2 minutes. The end point was identified when the

discolouration of indicator to reduce. Results were expressed as percentage of reducing sugar.

$$\text{Reducing sugars (\%)} = \frac{\text{Sugar mg of invert X dilution X 100}}{\text{Titre value X Weight or volume of semple taken for estimation x100}}$$

Non-reducing sugars (%)

The amount of non-reducing sugars were calculated by subtracting reducing sugars from total sugars and multiplying the difference by factor 0.95 as suggested by **AOAC (1980)** and expressed as non-reducing sugars (%).

Sugar/acid ratio

Sugar/Acid ratio was calculated by dividing the Total Sugar value with the total titratable acidity per cent and mean values were expressed.

Total Phenols

Total Phenols were extracted by refluxing dried fruit samples (500 mg) in 80% ethanol. The alcohol was evaporated from the supernatant by heating on water bath. The residue was dissolved in distilled water to a volume of 100 ml. This served as extract for total phenol. Total phenolic content was estimated according to the Folin-Ciocalteau procedure (**Swain and Hillis, 1959**). The absorbance was measured at 725 nm after 1 h against a reagent blank. Standard curve was prepared using different concentration of tannic acid. Total phenol value was expressed as mg tannic acid equivalents (TAE)/ g dry weight (DW).

Antioxidant activity (DPPH)

Antioxidant activity was measured using stable 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical as per the method described by **Shimada *et al*. (1992)**. Five hundred mg of fruit pulp was macerated in 10 ml methanol and centrifuged at 4,000 rpm for 15 min. The volume of supernatant was diluted with methanol and used for the estimation of antioxidant activity. The absorbance was read at 517 nm on spectrophotometer. Dye

mixed with 0.5 ml methanol was used as blank and the per cent scavenging of DPPH was calculated using the following formula:

% scavenging capacity of DPPH = [(Ao – A1)/Ao] ×100 %

Where Ao = Absorbance of blank

A1 = Absorbance of sample

The antioxidant activity was also expressed in terms of Vit. C equivalents/g using (5 to 30 µg) ascorbic acid.

Statistical Analysis

The data collected for various parameters were used to calculate the mean value for each character and the mean replicated data were used for statistical analysis. The data were statistically analyzed in factorial CRD for calculating CD using software 'Statistical Package for Agriculture Scientists', OPSTAT (available online at www.hau.ernet.in).

Mean performance: Mean performance of each parameter was calculated by using the formula as given below:

$$\bar{X} = \frac{\sum Xi}{n}$$

Where,

$\bar{X}$ = mean

X_i = value of its fruit for a trait

n = total number of fruits

Plate 1. Collection of freshly harvested Guava fruits

Plate 2. Washing and drying of Guava fruits

Plate 3. Application of coating by dipping method

Plate 4. Guava fruits kept in cold conditions

Plate 5. Various packaging materials used for packaging of Guava fruits

LDPE (100µ)

PP (60µ)

Cling (10µ)

HDPE (20µ)

PP (60µ)

Plate 6. Dried pulp of Guava fruits

Plate 7. Spoilage of fruits during storage

Plate 8. Estimation of guava attributes during experimentation

CHAPTER-IV

RESULTS AND DISCUSSION

The observations taken for different physiological, quality and organoleptic parameters during the present investigation entitled "**Studies on the effect of edible coatings on the quality attributes of guava fruit"** were analyzed by following the standard procedure as per the experimental design and other statistical techniques. The results of the present study so arrived have been thoroughly examined, interpreted, explained and mentioned in this chapter under sub-headings:

Experiment 1- Effect of various edible coatings on guava fruit *cv.* Allahabad Safeda under ambient conditions

4.1. Physiological parameters

4.1.1. Physiological loss in weight (%)

Different coating materials had significant effect on PLW of guava fruit throughout storage according to the data given in table 1 and Fig. 1 Among treatments, maximum PLW was observed in T_0 (11.51%) and minimum in T_{11} (7.26%) followed by T_{12} (7.47%), T_{10} (7.59%), T_1 (8.28%), T_2 (8.90%). PLW increased with duration of storage showing maximum PLW of weight on 6^{th} DAS (12.95%) and least on 3^{rd} DAS (6.06%).

Generally irrespective of coating materials the weight loss of the guava fruit increases with the storage period. Increase in PLW was observed in all the treatments with increase in storage period because of moisture loss by transpiration and reserved food material by respiration. During respiration process, various reserved food materials present in fruits are used. Also the process of transpiration from fruit surface continues even after harvest. The results are corresponding to the findings of **Joshi and Roy (1985)** in mango, **Aworth *et al.*, (1991)** in citrus, **Jitender *et al.*, (2000)** on kinnow and **Pandey *et al.*, (2006)** on apple.

Table 1: Effect of various coating materials on PLW (%) of guava *cv.* Allahabad Safeda under ambient conditions

Treatment Details	Storage Days		Mean	Treatment Details	Storage Days		Mean
	3	6			3	6	
T_0	6.75	16.26	11.51	T_{21}	5.58	12.81	9.20
T_1	6.23	10.32	8.28	T_{22}	5.95	13.13	9.54
T_2	7.13	10.68	8.90	T_{23}	7.00	12.14	9.57
T_3	6.38	11.45	8.92	T_{24}	5.94	13.44	9.69
T_4	7.27	14.80	11.04	T_{25}	5.54	13.38	9.46
T_5	6.50	13.96	10.23	T_{26}	6.01	13.87	9.94
T_6	6.37	13.92	10.15	T_{27}	5.66	12.81	9.23
T_7	7.17	14.37	10.77	T_{28}	6.61	14.61	10.61
T_8	7.28	15.53	11.40	T_{29}	4.99	13.71	9.35
T_9	6.27	12.49	9.38	T_{30}	5.99	13.42	9.71
T_{10}	5.15	10.02	7.59	T_{31}	7.01	15.95	11.48
T_{11}	4.55	9.98	7.26	T_{32}	6.47	12.84	9.66
T_{12}	5.09	9.85	7.47	T_{33}	6.76	14.47	10.61
T_{13}	6.49	12.70	9.60	T_{34}	6.23	13.63	9.93
T_{14}	5.25	11.82	8.53	T_{35}	6.33	13.54	9.93
T_{15}	6.50	14.12	10.31	T_{36}	5.62	13.24	9.43
T_{16}	6.48	13.62	10.05	T_{37}	7.58	13.90	10.74
T_{17}	5.91	12.95	9.43	T_{38}	6.36	13.14	9.75
T_{18}	5.89	13.85	9.87	T_{39}	5.71	13.59	9.65
T_{19}	5.77	12.80	9.29	**Mean**	6.06	12.95	
T_{20}	4.76	14.00	9.38	**C.D (at 5%)**	1.515	2.094	

Treatment details

T0 : Control-Room temp.
T1 : Aloe vera (1/3)
T2 : Aloe vera (1/2)
T3 : Aloe vera (1/1)
T4 : Corn starch (0.50%)
T5 : Corn starch (1.00%)
T6 : Corn starch (1.50%)
T7 : Calcium Chloride (0.50%)
T8 : Calcium Chloride (1.00%)
T9 : Calcium Chloride (1.50%)
T10 : Chitosan (0.1%)
T11 : Chitosan (0.2%)
T12 : Chitosan (0.3%)
T13 : AV (1/3) + CS (0.50%)
T14 : AV (1/2) + CS (1.00%)
T15 : AV (1/1) + CS (1.50%)
T16 : AV (1/3) + CC (0.50%)
T17 : AV (1/2) + CC (1.00%)
T18 : AV (1/1) + CC (1.50%)
T19 : AV (1/3)+Chitosan (0.1%)
T20 : AV (1/2)+Chitosan (0.2%)
T21 : AV(1/1)+Chitosan(0.3%)
T22 : CS(0.50%)+CC(0.50%)
T23 : CS(1.00%)+CC(1.00%)
T24 : CS(1.50%)+CC(1.50%)
T25 : CS(0.50%)+Chitosan(0.1%)
T26 : CS(1.00%)+Chitosan(0.2%)
T27 : CS(1.50%)+Chitosan(0.3%)
T28 : CC(0.50%)+Chitosan(0.1%)
T29 : CC(1.00%)+Chitosan(0.2%)
T30 : CC (1.50%) +Chitosan (0.3%)
T31 : AV(1/3)+CS(0.50%)+CC(0.50%)
T32 : AV(1/2)+CS(1.00%)+CC(1.00%)
T33 : AV(1/1)+CS(1.50%)+CC(1.50%)
T34 : CS(0.50%)+CC(0.50%)+Chitosan(0.1%)
T35 : CS(1.00%)+CC(1.00%)+ Chitosan(0.2%)
T36 : CS(1.50%)+CC(1.50%)+Chitosan (0.3%)
T37 : AV (1/3) + CS (0.50%) + CC (0.50%) + Chitosan (0.1%)
T38 : AV (1/2) + CS (1.00%) + CC (1.00%) + Chitosan (0.2%)
T39 : AV (1/1) + CS (1.50%) + CC (1.50%) + Chitosan (0.3%)

CD(5%): Critical difference @ 5% level

AV- Aloe vera
CS - Corn starch
CC - Calcium Chloride

As per **Haard and Salunkhe (1975)** respiration, transpiration, and other degradation processes that occurs during storage of fruits results in PLW. In this experimentation, minimum PLW was observed in $T_{11,}$ $T_{12,}$ $T_{10,}$ T_1 & T_2 and maximum in T_0 (control). This might had happened because of restriction in gas dispersal and reaction mechanism ensuing sluggish rate of transpiration and respiration. These results are in conformity of **Joshua and Sathiamoorthy (1993)** in sapota and **Venkatesha and Reddy (1994)** in guava.

4.2. Bio-chemical parameter

4.2.1. Vitamin C (mg/100gm)

Data depicted in Table 2 and Fig. 2 showed that different coating materials had significant effect on vitamin C of guava during the storage period. In the findings, it was observed that, among treatments, the maximum value (177.10) was observed in T_{12} followed by T_{10} (174.90), T_{11} (174.10), T_1 (173.90) and T_2 (172.60) and minimum value in T_0 (156.40). Generally, vitamin C of guava decreases with increase in period of storage. Maximum vitamin C (163.10) quantity was observed on 3rd day of storage and minimum (143.13) vitamin C was observed on day 6.

In all the treatments, % of Vitamin C in fruit gradually reduced during storage because of its enzymatic oxidation to dehydro-ascorbic acid in the presence of enzyme ascorbinase. In this investigation, the highest vitamin C was observed in $T_{12,}$ $T_{10,}$ $T_{11,}$ T_1 & T_2 and the minimum in T_0 (control). These findings resembles with the findings of **Das and Dash (1967)**. In comparison to T_0, higher retention of vitamin C was detected in fruits coated by different concentration of coating materials due to the low PLW accompanied by low respiration rate and transpirational losses. These findings are similar with the observations made by **Venkatesha and Reddy (1994)** in guava and **Sudha *et al.* (2007)** on sapota.

Table 2: Effect of various coating materials on vitamin C (mg/100gm) of guava *cv.* Allahabad Safeda under ambient conditions

Treatments Details	Storage Days			Mean	Treatments Details	Storage Days			Mean
	0	3	6			0	3	6	
T_0	195.38	151.32	122.38	156.36	T_{21}	195.38	165.84	139.40	166.87
T_1	195.38	170.36	155.85	173.90	T_{22}	195.38	154.86	130.28	160.20
T_2	195.38	172.15	150.27	172.60	T_{23}	195.38	151.50	133.47	160.10
T_3	195.38	166.30	140.74	167.50	T_{24}	195.38	154.25	140.29	163.30
T_4	195.38	163.50	146.74	168.50	T_{25}	195.38	170.12	140.54	168.70
T_5	195.38	167.24	142.30	168.30	T_{26}	195.38	161.50	143.80	166.90
T_6	195.38	165.50	139.53	166.80	T_{27}	195.38	155.15	140.59	163.70
T_7	195.38	172.50	143.40	170.40	T_{28}	195.38	158.84	140.43	164.90
T_8	195.38	168.75	140.98	168.40	T_{29}	195.38	167.54	137.47	166.80
T_9	195.38	165.87	144.42	168.60	T_{30}	195.38	160.20	145.56	167.00
T_{10}	195.38	174.01	155.16	174.90	T_{31}	195.38	169.40	140.65	168.50
T_{11}	195.38	170.40	156.60	174.10	T_{32}	195.38	161.56	145.67	167.50
T_{12}	195.38	176.25	159.56	177.10	T_{33}	195.38	165.54	149.30	170.10
T_{13}	195.38	166.90	140.20	167.50	T_{34}	195.38	152.27	138.21	162.00
T_{14}	195.38	162.40	148.52	168.80	T_{35}	195.38	163.45	145.20	168.00
T_{15}	195.38	160.20	145.14	166.90	T_{36}	195.38	147.20	131.21	157.90
T_{16}	195.38	155.40	138.40	163.10	T_{37}	195.38	165.89	145.78	169.00
T_{17}	195.38	158.41	137.52	163.80	T_{38}	195.38	153.40	140.87	163.20
T_{18}	195.38	167.64	148.71	170.60	T_{39}	195.38	160.54	144.23	166.70
T_{19}	195.38	160.84	144.35	166.90	**Mean**		163.10	143.13	
T_{20}	195.38	169.24	149.75	172.10	**C.D (at 5%)**		1.660	1.639	

Treatment details

T0 : Control-Room temp.
T1 : Aloe vera (1/3)
T2 : Aloe vera (1/2)
T3 : Aloe vera (1/1)
T4 : Corn starch (0.50%)
T5 : Corn starch (1.00%)
T6 : Corn starch (1.50%)
T7 : Calcium Chloride (0.50%)
T8 : Calcium Chloride (1.00%)
T9 : Calcium Chloride (1.50%)
T10 : Chitosan (0.1%)
T11 : Chitosan (0.2%)
T12 : Chitosan (0.3%)
T13 : AV (1/3) + CS (0.50%)
T14 : AV (1/2) + CS (1.00%)
T15 : AV (1/1) + CS (1.50%)
T16 : AV (1/3) + CC (0.50%)
T17 : AV (1/2) + CC (1.00%)
T18 : AV (1/1) + CC (1.50%)
T19 : AV (1/3)+Chitosan (0.1%)
T20 : AV (1/2)+Chitosan (0.2%)
T21 : AV(1/1)+Chitosan(0.3%)
T22 : CS(0.50%)+CC(0.50%)
T23 : CS(1.00%)+CC(1.00%)
T24 : CS(1.50%)+CC(1.50%)
T25 : CS(0.50%)+Chitosan(0.1%)
T26 : CS(1.00%)+Chitosan(0.2%)
T27 : CS(1.50%)+Chitosan(0.3%)
T28 : CC(0.50%)+Chitosan(0.1%)
T29 : CC(1.00%)+Chitosan(0.2%)
T30 : CC (1.50%) +Chitosan (0.3%)
T31 : AV(1/3)+CS(0.50%)+CC(0.50%)
T32 : AV(1/2)+CS(1.00%)+CC(1.00%)
T33 : AV(1/1)+CS(1.50%)+CC(1.50%)
T34 : CS(0.50%)+CC(0.50%)+Chitosan(0.1%)
T35 : CS(1.00%)+CC(1.00%)+ Chitosan(0.2%)
T36 : CS(1.50%)+CC(1.50%)+Chitosan (0.3%)
T37 : AV (1/3) + CS (0.50%) + CC (0.50%) + Chitosan (0.1%)
T38 : AV (1/2) + CS (1.00%) + CC (1.00%) + Chitosan (0.2%)
T39 : AV (1/1) + CS (1.50%) + CC (1.50%) + Chitosan (0.3%)

CD(5%): Critical difference @ 5% level
AV- Aloe vera
CS - Corn starch
CC - Calcium Chloride

4.2.2. Total Soluble Solids (ºBrix)

The data given in Table 3 and Fig. 3 reveled that different coating materials had substantial effect on TSS of guava during the storage period. Highest value of TSS was observed in T_0 (11.49) and minimum value in T_{12} (10.23) followed by T_{10} (10.29), T_{11} (10.37), T_1 (10.56) and T_2 (10.56). Generally with the increasing storage period TSS of guava increases up to a certain period and then starts decreasing. Maximum TSS (11.95) was observed on 6th day of storage and minimum (10.84) was noted on 3rd day of storage.

Table 3: Effect of various coating materials on TSS (ºBrix) of guava *cv.* Allahabad Safeda under ambient conditions

Treatments Details	Storage Days			Mean	Treatments Details	Storage Days			Mean
	0	3	6			0	3	6	
T_0	9.82	11.42	13.22	11.49	T_{21}	9.82	10.84	11.86	10.84
T_1	9.82	10.64	11.21	10.56	T_{22}	9.82	10.94	12.10	10.95
T_2	9.82	10.54	11.32	10.56	T_{23}	9.82	10.76	11.96	10.85
T_3	9.82	10.56	11.35	10.58	T_{24}	9.82	10.78	11.86	10.82
T_4	9.82	10.75	11.85	10.81	T_{25}	9.82	10.77	11.81	10.80
T_5	9.82	10.79	11.87	10.83	T_{26}	9.82	10.96	12.12	10.97
T_6	9.82	10.86	11.91	10.86	T_{27}	9.82	10.97	12.15	10.98
T_7	9.82	10.74	11.82	10.79	T_{28}	9.82	10.92	12.09	10.94
T_8	9.82	10.68	11.79	10.76	T_{29}	9.82	11.03	12.23	11.03
T_9	9.82	10.72	11.83	10.79	T_{30}	9.82	11.09	12.31	11.07
T_{10}	9.82	10.11	10.95	10.29	T_{31}	9.82	11.08	12.28	11.06
T_{11}	9.82	10.24	11.04	10.37	T_{32}	9.82	11.11	12.36	11.10
T_{12}	9.82	10.02	10.84	10.23	T_{33}	9.82	11.17	12.41	11.13
T_{13}	9.82	10.83	11.89	10.85	T_{34}	9.82	11.15	12.39	11.12
T_{14}	9.82	10.95	12.05	10.94	T_{35}	9.82	11.12	12.49	11.14
T_{15}	9.82	10.69	11.81	10.77	T_{36}	9.82	11.16	12.47	11.15
T_{16}	9.82	10.73	11.86	10.80	T_{37}	9.82	11.17	12.53	11.17
T_{17}	9.82	10.68	11.78	10.76	T_{38}	9.82	11.19	12.51	11.17
T_{18}	9.82	10.65	11.45	10.64	T_{39}	9.82	11.21	12.58	11.20
T_{19}	9.82	10.76	11.79	10.79	**Mean**		10.84	11.95	
T_{20}	9.82	10.82	11.92	10.85	**C.D (at 5%)**		0.097	1.103	

Treatment details

T0	:	Control-Room temp.	T15	:	AV (1/1) + CS (1.50%)	T30	:	CC (1.50%) +Chitosan (0.3%)
T1	:	Aloe vera (1/3)	T16	:	AV (1/3) + CC (0.50%)	T31	:	AV(1/3)+CS(0.50%)+CC(0.50%)
T2	:	Aloe vera (1/2)	T17	:	AV (1/2) + CC (1.00%)	T32	:	AV(1/2)+CS(1.00%)+CC(1.00%)
T3	:	Aloe vera (1/1)	T18	:	AV (1/1) + CC (1.50%)	T33	:	AV(1/1)+CS(1.50%)+CC(1.50%)
T4	:	Corn starch (0.50%)	T19	:	AV (1/3)+Chitosan (0.1%)	T34	:	CS(0.50%)+CC(0.50%)+Chitosan(0.1%)
T5	:	Corn starch (1.00%)	T20	:	AV (1/2)+Chitosan (0.2%)	T35	:	CS(1.00%)+CC(1.00%)+ Chitosan(0.2%)
T6	:	Corn starch (1.50%)	T21	:	AV(1/1)+Chitosan(0.3%)	T36	:	CS(1.50%)+CC(1.50%)+Chitosan (0.3%)
T7	:	Calcium Chloride (0.50%)	T22	:	CS(0.50%)+CC(0.50%)	T37	:	AV (1/3) + CS (0.50%) + CC (0.50%) + Chitosan (0.1%)
T8	:	Calcium Chloride (1.00%)	T23	:	CS(1.00%)+CC(1.00%)			
T9	:	Calcium Chloride (1.50%)	T24	:	CS(1.50%)+CC(1.50%)	T38	:	AV (1/2) + CS (1.00%) + CC (1.00%) + Chitosan (0.2%)
T10	:	Chitosan (0.1%)	T25	:	CS(0.50%)+Chitosan(0.1%)			
T11	:	Chitosan (0.2%)	T26	:	CS(1.00%)+Chitosan(0.2%)	T39	:	AV (1/1) + CS (1.50%) + CC (1.50%) + Chitosan (0.3%)
T12	:	Chitosan (0.3%)	T27	:	CS(1.50%)+Chitosan(0.3%)			
T13	:	AV (1/3) + CS (0.50%)	T28	:	CC(0.50%)+Chitosan(0.1%)			AV- Aloe vera
T14	:	AV (1/2) + CS (1.00%)	T29	:	CC(1.00%)+Chitosan(0.2%)			CS - Corn starch
		CD(5%): Critical difference @ 5% level						CC - Calcium Chloride

The rise in level of TSS of fruits was detected with increase in storage period up to 6th day but as after that the fruits had got rotten at ambient temperature hence afterwards reading has not been taken. Rise in total soluble solids up to 6th day of storage of fruits was correlated with the increase in PLW. These outcomes are in conformity with the previous results of **Panwar (1980)** in ber. The highest TSS value was observed in T_0 and the lowest in $T_{12,}$ $T_{10,}$ $T_{11,}$ $T_{1,}$ and T_2. The coating materials used for fruits had less total soluble solids compared to control. Slow conversion of starch into sugars and lesser PLW is the reason for this. These outcomes resemble those of **Venkatesha and Reddy (1994)** on guava and **Meena *et al.*, (2009)** on ber.

4.2.3. Acidity (%)

Data presented in Table no. 4 and Fig. no. 4 showed that various coating materials had substantial effect on acidity of guava during the storage period. Maximum value of acidity among treatments was observed in T_{12} (0.54) followed by T_{11} (0.52), T_1 (0.52),T_2 (0.51),and T_{10} (0.51), while minimum in T_0 (0.43). In general, acidity of guava decreases with increasing period of storage irrespective of coating materials used. On day 3 acidity recorded was maximum i.e 0.50 and least (0.44) on day 6.

Table 4: Effect of various coating materials on acidity (%) of guava *cv.* Allahabad Safeda under ambient conditions

Treatments Details	Storage Days			Mean	Treatments Details	Storage Days			Mean
	0	3	6			0	3	6	
T_0	0.61	0.47	0.39	0.43	T_{21}	0.61	0.50	0.44	0.47
T_1	0.61	0.54	0.50	0.52	T_{22}	0.61	0.47	0.43	0.45
T_2	0.61	0.53	0.49	0.51	T_{23}	0.61	0.49	0.43	0.46
T_3	0.61	0.50	0.48	0.49	T_{24}	0.61	0.52	0.46	0.49
T_4	0.61	0.49	0.44	0.47	T_{25}	0.61	0.49	0.45	0.47
T_5	0.61	0.47	0.43	0.45	T_{26}	0.61	0.53	0.46	0.50
T_6	0.61	0.48	0.45	0.47	T_{27}	0.61	0.54	0.43	0.49
T_7	0.61	0.51	0.47	0.49	T_{28}	0.61	0.47	0.42	0.45
T_8	0.61	0.48	0.43	0.46	T_{29}	0.61	0.48	0.42	0.45
T_9	0.61	0.49	0.42	0.46	T_{30}	0.61	0.51	0.44	0.48
T_{10}	0.61	0.55	0.47	0.51	T_{31}	0.61	0.51	0.45	0.48
T_{11}	0.61	0.55	0.49	0.52	T_{32}	0.61	0.52	0.45	0.49
T_{12}	0.61	0.57	0.50	0.54	T_{33}	0.61	0.50	0.43	0.47
T_{13}	0.61	0.52	0.45	0.49	T_{34}	0.61	0.47	0.44	0.46
T_{14}	0.61	0.51	0.46	0.49	T_{35}	0.61	0.49	0.47	0.48
T_{15}	0.61	0.51	0.44	0.48	T_{36}	0.61	0.52	0.42	0.47
T_{16}	0.61	0.49	0.43	0.46	T_{37}	0.61	0.46	0.43	0.45
T_{17}	0.61	0.50	0.42	0.46	T_{38}	0.61	0.48	0.42	0.45
T_{18}	0.61	0.47	0.41	0.44	T_{39}	0.61	0.51	0.44	0.48
T_{19}	0.61	0.48	0.44	0.46	**Mean**		0.50	0.44	
T_{20}	0.61	0.51	0.45	0.48	**C.D (at 5%)**		0.049	0.050	

Treatment details

T0 : Control-Room temp.
T1 : Aloe vera (1/3)
T2 : Aloe vera (1/2)
T3 : Aloe vera (1/1)
T4 : Corn starch (0.50%)
T5 : Corn starch (1.00%)
T6 : Corn starch (1.50%)
T7 : Calcium Chloride (0.50%)
T8 : Calcium Chloride (1.00%)
T9 : Calcium Chloride (1.50%)
T10 : Chitosan (0.1%)
T11 : Chitosan (0.2%)
T12 : Chitosan (0.3%)
T13 : AV (1/3) + CS (0.50%)
T14 : AV (1/2) + CS (1.00%)
T15 : AV (1/1) + CS (1.50%)
T16 : AV (1/3) + CC (0.50%)
T17 : AV (1/2) + CC (1.00%)
T18 : AV (1/1) + CC (1.50%)
T19 : AV (1/3)+Chitosan (0.1%)
T20 : AV (1/2)+Chitosan (0.2%)
T21 : AV(1/1)+Chitosan(0.3%)
T22 : CS(0.50%)+CC(0.50%)
T23 : CS(1.00%)+CC(1.00%)
T24 : CS(1.50%)+CC(1.50%)
T25 : CS(0.50%)+Chitosan(0.1%)
T26 : CS(1.00%)+Chitosan(0.2%)
T27 : CS(1.50%)+Chitosan(0.3%)
T28 : CC(0.50%)+Chitosan(0.1%)
T29 : CC(1.00%)+Chitosan(0.2%)
T30 : CC (1.50%) +Chitosan (0.3%)
T31 : AV(1/3)+CS(0.50%)+CC(0.50%)
T32 : AV(1/2)+CS(1.00%)+CC(1.00%)
T33 : AV(1/1)+CS(1.50%)+CC(1.50%)
T34 : CS(0.50%)+CC(0.50%)+Chitosan(0.1%)
T35 : CS(1.00%)+CC(1.00%)+ Chitosan(0.2%)
T36 : CS(1.50%)+CC(1.50%)+Chitosan (0.3%)
T37 : AV (1/3) + CS (0.50%) + CC (0.50%) + Chitosan (0.1%)
T38 : AV (1/2) + CS (1.00%) + CC (1.00%) + Chitosan (0.2%)
T39 : AV (1/1) + CS (1.50%) + CC (1.50%) + Chitosan (0.3%)

CD(5%): Critical difference @ 5% level
AV- Aloe vera
CS - Corn starch
CC - Calcium Chloride

In all the treatments, acidity of fruits decreased with the increase in storage period. The decrease in acidity is due to the activity of enzyme invertase which is responsible for transformation of acid into sugar. Due to the utilization of acids in metabolic activities might be the reason for this. In this study, the maximum acidity was observed in $T_{12,}$ $T_{11,}$ T_1, T_2 & T_{10} and the minimum in T_0 (control). These results corresponds with **Damodaran *et al*., (2001)** in sapota & **Yadav *et al*. (2010)** in kinnow. Fruits coated in coating material of different concentration retained more acidity in comparison with the control. The probable cause for this might be slow transformation of acids into sugars during ripening. These outcomes resembles with former reports of **Wavhal and Athale (1988)** in mango and **Nunes *et al*., (2006)** in strawberry.

4.2.4. TSS/Acid ratio

Data depicted in Fig. no. 5 and Table no. 5 displayed that different coating materials had substantial effect on TSS/acid ratio of guava during period of storage. Among all the treatments, maximum value (24.76) was observed in T_0 and minimum in T_{12} (18.45) followed by T_{11} (19.08), T_{10} (19.26), T_1 (19.41) and T_2 (19.70). In general, TSS/acid ratio of guava increases with prolonging storage period up to 6^{th} day but in certain treatments it has been following descending trend. Highest TSS-acid ratio (26.99) was witnessed on day 6 and lowest TSS/acid ratio (21.66) on day 3.

The increases or decreases in TSS/acid ratio of fruits depend on the coating materials or treatments with increasing storage period. In the current study, the maximum TSS/acid ratio was observed in T_0 and the minimum in $T_{12,}$ $T_{11,}$ $T_{10,}$ $T_{1,}$ T_2 .This is corresponding with that stated by **Joubert (1970)** in litchi and **Navjot (2005)** in peach during storage.

Table 5: Effect of various coating materials on TSS/Acid ratio of guava *cv.* Allahabad Safeda under ambient conditions

Treatments Details	Storage Days			Mean	Treatments Details	Storage Days			Mean
	0	3	6			0	3	6	
T_0	16.10	24.30	33.90	24.76	T_{21}	16.10	21.68	26.95	21.58
T_1	16.10	19.70	22.42	19.41	T_{22}	16.10	23.28	28.14	22.50
T_2	16.10	19.89	23.10	19.70	T_{23}	16.10	21.96	27.81	21.96
T_3	16.10	21.12	23.65	20.29	T_{24}	16.10	20.73	25.78	20.87
T_4	16.10	21.94	26.93	21.66	T_{25}	16.10	21.98	26.24	21.44
T_5	16.10	22.96	27.60	22.22	T_{26}	16.10	20.68	26.35	21.04
T_6	16.10	22.63	26.47	21.73	T_{27}	16.10	20.31	28.26	21.56
T_7	16.10	21.06	25.15	20.77	T_{28}	16.10	23.23	28.79	22.71
T_8	16.10	22.25	27.42	21.92	T_{29}	16.10	22.98	29.12	22.73
T_9	16.10	21.88	28.17	22.05	T_{30}	16.10	21.75	27.98	21.94
T_{10}	16.10	18.38	23.30	19.26	T_{31}	16.10	21.73	27.29	21.70
T_{11}	16.10	18.62	22.53	19.08	T_{32}	16.10	21.37	27.47	21.64
T_{12}	16.10	17.58	21.68	18.45	T_{33}	16.10	22.34	28.86	22.43
T_{13}	16.10	20.83	26.42	21.12	T_{34}	16.10	23.72	28.16	22.66
T_{14}	16.10	21.47	26.20	21.25	T_{35}	16.10	22.69	26.57	21.79
T_{15}	16.10	20.96	26.84	21.30	T_{36}	16.10	21.46	29.69	22.42
T_{16}	16.10	21.90	27.58	21.86	T_{37}	16.10	24.28	29.14	23.17
T_{17}	16.10	21.36	28.05	21.84	T_{38}	16.10	23.31	29.79	23.07
T_{18}	16.10	22.66	27.93	22.23	T_{39}	16.10	21.98	28.59	22.22
T_{19}	16.10	22.42	26.80	21.77	**Mean**		21.66	26.99	
T_{20}	16.10	21.22	26.49	21.27	**C.D (at 5%)**		2.150	3.009	

Treatment details

T0 : Control-Room temp.
T1 : Aloe vera (1/3)
T2 : Aloe vera (1/2)
T3 : Aloe vera (1/1)
T4 : Corn starch (0.50%)
T5 : Corn starch (1.00%)
T6 : Corn starch (1.50%)
T7 : Calcium Chloride (0.50%)
T8 : Calcium Chloride (1.00%)
T9 : Calcium Chloride (1.50%)
T10 : Chitosan (0.1%)
T11 : Chitosan (0.2%)
T12 : Chitosan (0.3%)
T13 : AV (1/3) + CS (0.50%)
T14 : AV (1/2) + CS (1.00%)
T15 : AV (1/1) + CS (1.50%)
T16 : AV (1/3) + CC (0.50%)
T17 : AV (1/2) + CC (1.00%)
T18 : AV (1/1) + CC (1.50%)
T19 : AV (1/3)+Chitosan (0.1%)
T20 : AV (1/2)+Chitosan (0.2%)
T21 : AV(1/1)+Chitosan(0.3%)
T22 : CS(0.50%)+CC(0.50%)
T23 : CS(1.00%)+CC(1.00%)
T24 : CS(1.50%)+CC(1.50%)
T25 : CS(0.50%)+Chitosan(0.1%)
T26 : CS(1.00%)+Chitosan(0.2%)
T27 : CS(1.50%)+Chitosan(0.3%)
T28 : CC(0.50%)+Chitosan(0.1%)
T29 : CC(1.00%)+Chitosan(0.2%)
T30 : CC (1.50%) +Chitosan (0.3%)
T31 : AV(1/3)+CS(0.50%)+CC(0.50%)
T32 : AV(1/2)+CS(1.00%)+CC(1.00%)
T33 : AV(1/1)+CS(1.50%)+CC(1.50%)
T34 : CS(0.50%)+CC(0.50%)+Chitosan(0.1%)
T35 : CS(1.00%)+CC(1.00%)+ Chitosan(0.2%)
T36 : CS(1.50%)+CC(1.50%)+Chitosan (0.3%)
T37 : AV (1/3) + CS (0.50%) + CC (0.50%) + Chitosan (0.1%)
T38 : AV (1/2) + CS (1.00%) + CC (1.00%) + Chitosan (0.2%)
T39 : AV (1/1) + CS (1.50%) + CC (1.50%) + Chitosan (0.3%)

CD(5%): Critical difference @ 5% level
AV- Aloe vera
CS - Corn starch
CC - Calcium Chloride

Graphical presentation of Experiment 1:

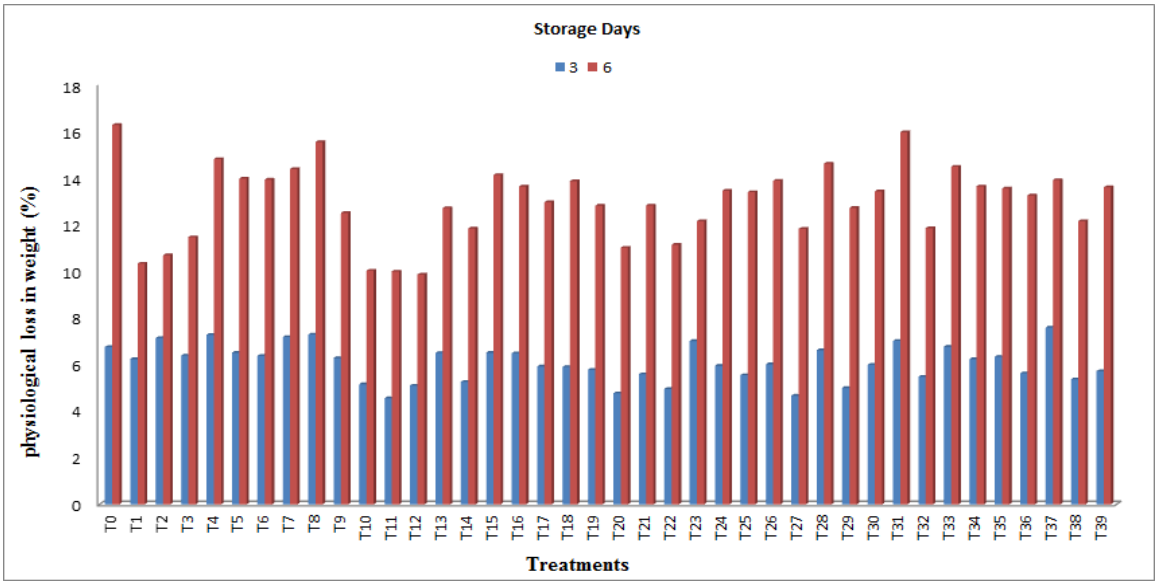

Fig. 1: Effect of various coating materials on PLW of guava *cv.* Allahabad Safeda under ambient conditions

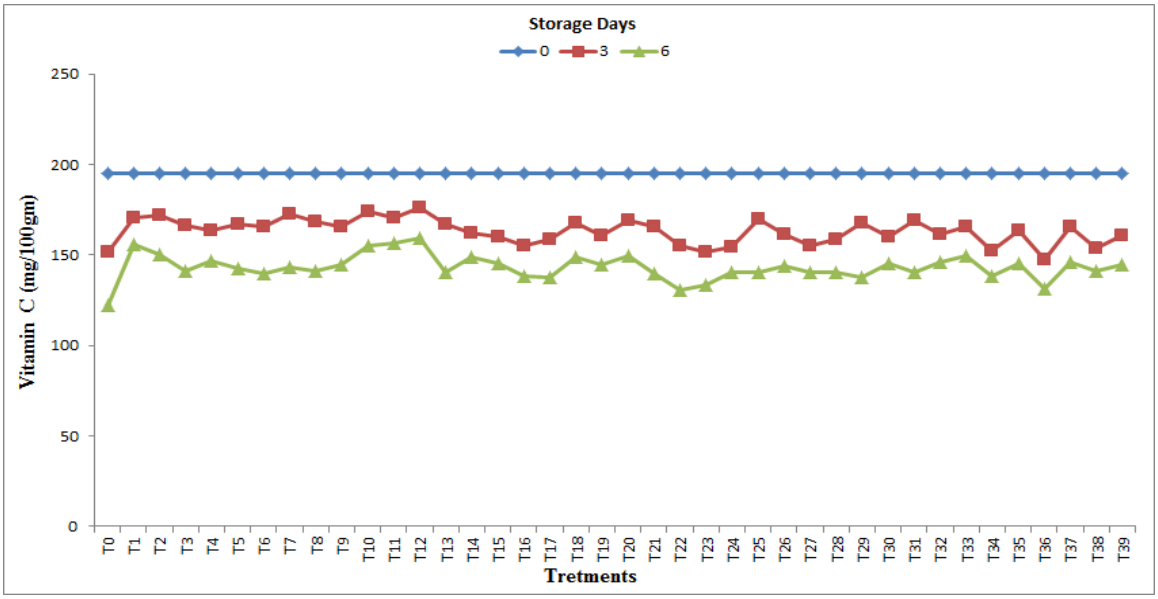

Fig. 2: Effect of various coating materials on vitamin C (mg/100gm) of guava *cv.* Allahabad Safeda under ambient conditions

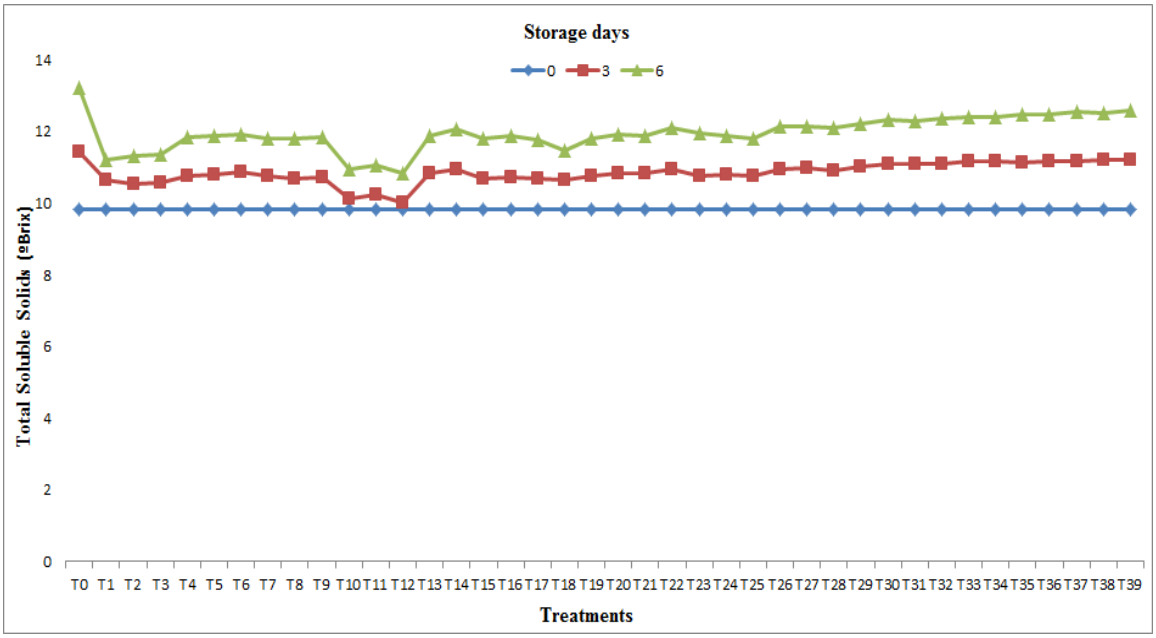

Fig. 3: Effect of various coating materials on TSS (ºBrix) of guava *cv.* Allahabad Safeda under ambient conditions

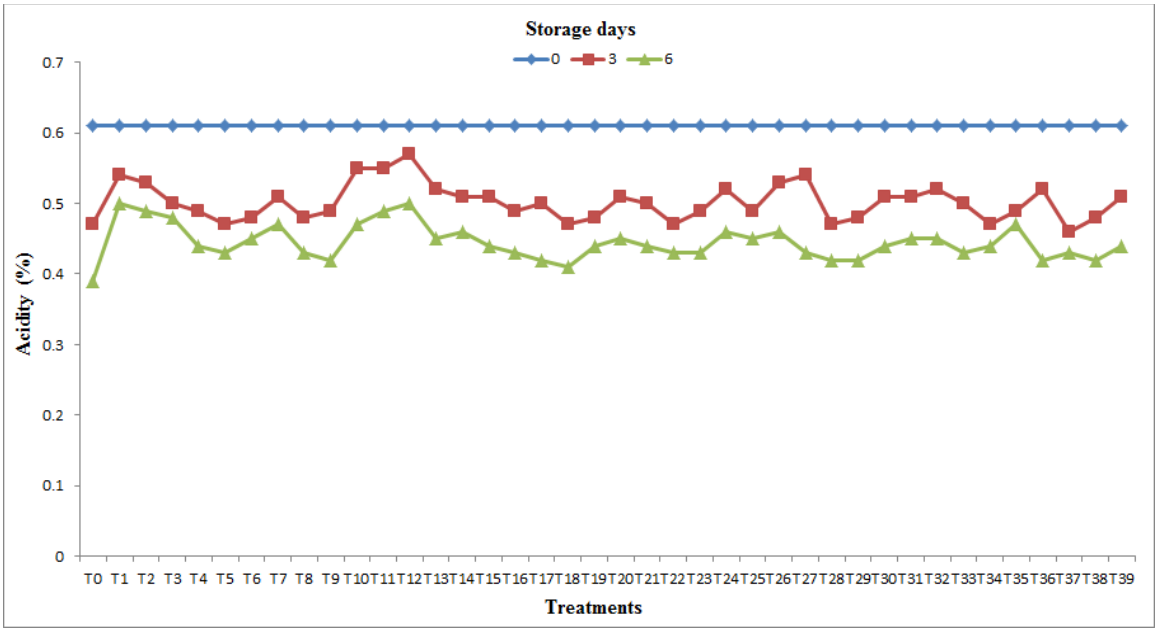

Fig. 4: Effect of various coating materials on acidity of guava *cv.* Allahabad Safeda under ambient conditions

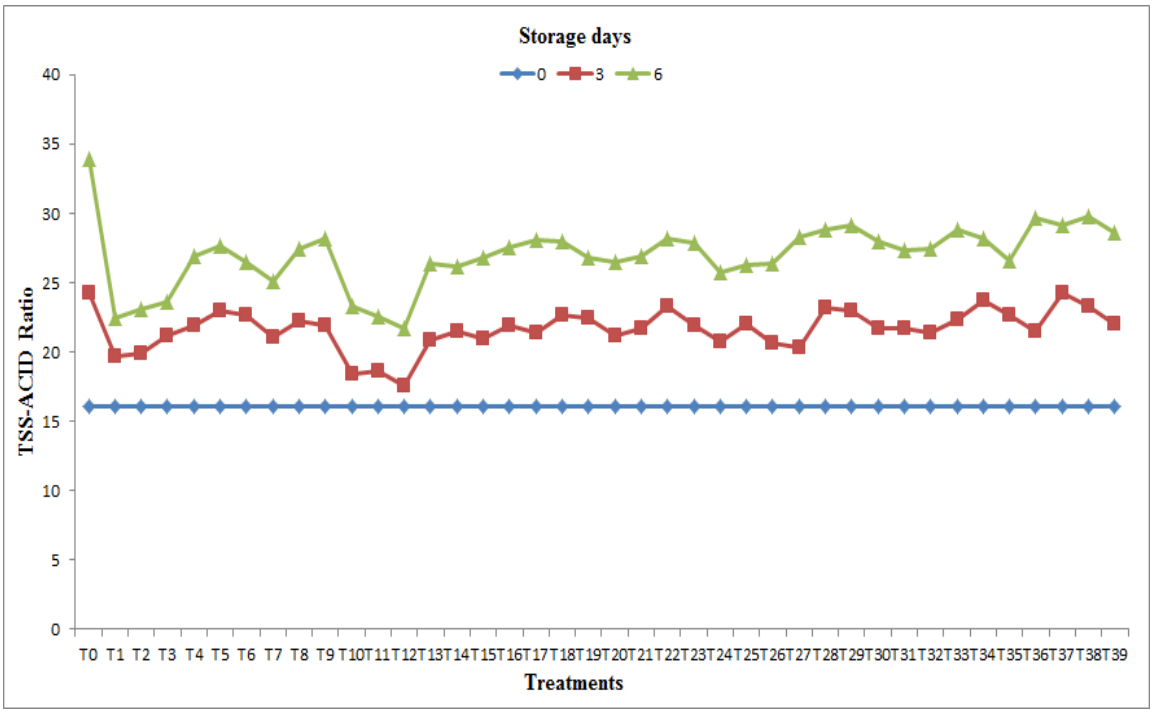

Fig. 5: Effect of various coating materials on TSS/Acid ratio of guava *cv.* Allahabad Safeda under ambient conditions

Experiment – 2(A) Effect of various coating materials on guava *cv.* Allahabad Safeda under cold conditions (7°C)

4.3. Physiological parameters

4.3.1. Physiological loss in weight (%)

Different coating materials had significant influence on PLW of guava fruit throughout storage according to the data given in Table 6 and Fig. 6 Among treatments, maximum PLW was observed in T_0 (15.20%) and minimum in T_5 (11.19%). PLW increase with duration of storage showing maximum PLW of weight on 21st DAS (24.05%) and minimum on 3rd DAS (3.68%). In general, fruit loss of weight of guava increases with increasing storage period with coating materials used.

Table 6: Effect of various coating materials on PLW (%) of guava *cv.* Allahabad Safeda under cold conditions (7°C)

Treatment Details	Storage Days							Mean
	3	6	9	12	15	18	21	
T_0	4.09	6.96	11.52	14.75	18.46	22.1	28.54	15.20
T_1	4.01	6.93	10.33	13.36	16.24	19.28	26.28	13.77
T_2	3.94	6.01	9.85	12.77	15.99	19.24	25.74	13.36
T_3	3.95	5.76	8.85	10.85	13.89	16.24	20.80	11.48
T_4	2.96	5.65	9.03	11.66	14.75	18.1	23.18	12.19
T_5	3.14	5.49	8.58	10.98	13.91	16.41	19.79	11.19
Mean	3.68	6.13	9.69	12.39	15.54	18.56	24.05	
C.D (at 5%)	0.782	1.093	1.863	2.531	1.943	1.510	1.551	

Treatments details:

T_0 : Control (cold temperature 7°C) T_3 : Chitosan 0.1 %
T_1 : Aloe Vera 1/3 T_4 : Chitosan 0.2 %
T_2 : Aloe Vera ½ T_5 : Chitosan 0.3 %
CD(5%): Critical difference @ 5% level

In the investigation, it was recorded that, with increase in the storage period there was rise in PLW due transpiration and reserved food material by respiration. During respiration process, various reserved food materials present in fruits are used. Also the process of transpiration from fruit surface continues even after harvest. These findings

resembles to those of **Joshi and Roy (1985)** in mango, **Aworth *et al.*, (1991)** on citrus, **Jitender *et al.*, (2000)** on kinnow and **Pandey *et al.*, (2006)** on apple.

Haard and Salunkhe (1975) reports that PLW occurs due to transpiration of water, respiration and various degradation processes that occurs during storage period. In this experimentation, the minimum PLW was observed in T_5 and the highest in T_0 (control). This might be because of restriction in dispersal of gases and reaction mechanism which results in slow transpiration and respiration rate. The outcomes were in covenant with the results of **Joshua and Sathiamoorthy (1993)** in sapota and **Venkatesha and Reddy (1994)** in guava.

4.4. Bio-chemical parameters

4.4.1 Vitamin C (mg/100gm)

Data depicted in Fig. 7 and table 7 shows that effect of various coating materials had significant effect on vitamin C of guava fruits throughout the storage. Among treatments, maximum value (182.38) was observed in T_5 followed by T_4 (179.18) and minimum value in T_0 (170.93). Generally, vitamin C of guava decreases with increase in storage period. Maximum vitamin C (198.30) quantity was observed on 3rd day of storage and minimum (141.98) vitamin C was observed on 21st day.

Vitamin C of fruit gradually reduced in all the treatments during storage period because of enzymatic oxidation of ascorbic acid to dehydro-ascorbic acid in the existence of ascorbinase enzyme which might contribute to the reduction of vitamin C content of fruit. In this study, the maximum vitamin C was observed in T_5 and the minimum in T_0 (control). These findings are in conformity with the reports given by **Das and Dash (1967)**. In comparison with control higher retention of vitamin C content was observed in fruits coated by different concentration of coating materials due to the low PLW accompanied by low respiration rate and transpirational losses. The results obtained from this investigation are in conformity with reports earlier given by **Venkatesha and Reddy (1994)** on guava and **Sudha *et al.* (2007)** on sapota.

Table 7: Effect of various coating materials on vitamin C (mg/100gm) of guava *cv.* Allahabad Safeda under cold conditions (7°C)

Treatment Details	Storage Days								Mean
	0	3	6	9	12	15	18	21	
T_0	208.65	193.55	180.29	178.14	169.45	158.91	148.27	130.24	170.93
T_1	208.65	195.25	188.29	182.16	170.50	163.85	155.14	142.30	175.77
T_2	208.65	197.45	190.45	180.21	172.15	161.26	150.50	140.65	175.17
T_3	208.65	201.84	193.54	184.51	174.21	165.37	153.70	144.20	178.25
T_4	208.65	197.20	192.25	187.20	178.34	168.28	155.67	145.85	179.18
T_5	208.65	204.54	197.14	189.51	180.87	170.21	159.49	148.65	182.38
Mean		198.30	190.32	183.62	174.25	164.64	153.79	141.98	
C.D (at 5%)		3.149	1.812	1.795	1.801	1.800	1.874	1.869	

Treatments details

T_0 : Control (cold temperature 7°C)
T_1 : Aloe Vera 1/3
T_2 : Aloe Vera ½
T_3 : Chitosan 0.1 %
T_4 : Chitosan 0.2 %
T_5 : Chitosan 0.3 %
CD(5%): Critical difference @ 5% level

4.4.2. Total soluble solids (ºBrix)

Data depicted in Fig. 8 and table 8 shows that effect of various coating materials had significant impact on total soluble solids of guava fruits throughout the storage period. Among treatments, the maximum value (10.04) was observed in T_0 and minimum value in T_4 (9.90). In general, TSS of guava increases with increasing storage period up to 15th days but after that the total soluble solids quantity decreases continuously in all treatments with increase in storage period. On 15th days of storage, highest value of total soluble solids (10.92) was observed and minimum (9.46) TSS was observed on 21st day.

It was observed that, there was rise in TSS of fruits up to 15th day of storage and thereafter, TSS decreased in all the treatments up to 21st day of storage. Increase in TSS of guava fruits till 15th day of storage was correlated with increase in PLW and then started decreasing up to 21st day because of consumption of sugars in respiration. The findings of this investigation are in conformation with the earlier findings of **Panwar (1980)** in ber. The maximum TSS was recorded in T_0 and the lowest TSS was observed in T_4. The coating materials used for fruits had less total soluble solids compared to

control. This might be due to the lesser PLW and slow conversion of starch into sugars. Findings of this investigation are in conformation with former reports by **Venkatesha and Reddy (1994)** on guava fruit and **Meena *et al*., (2009)** on ber.

Table 8: Effect of various coating materials on TSS (ºBrix) of guava *cv*. Allahabad Safeda under cold conditions (7°C)

Treatment Details	Storage Days								Mean
	0	3	6	9	12	15	18	21	
T_0	9.26	9.62	9.95	10.41	10.83	11.36	10.02	8.88	10.04
T_1	9.26	9.44	9.65	10.12	10.66	11.12	10.34	9.52	10.01
T_2	9.26	9.56	9.86	10.26	10.54	10.95	10.26	9.61	10.03
T_3	9.26	9.46	9.93	10.38	10.62	10.96	10.42	9.19	10.02
T_4	9.26	9.52	9.71	10.19	10.37	10.63	9.94	9.63	9.90
T_5	9.26	9.47	9.73	10.01	10.28	10.54	10.26	9.94	9.93
Mean		9.51	9.80	10.22	10.55	10.92	10.20	9.46	
C.D (at 5%)		0.076	0.079	0.102	0.093	0.108	0.099	0.082	

Treatments details

T_0 : Control (cold temperature 7°C) T_3 : Chitosan 0.1 %
T_1 : Aloe Vera 1/3 T_4 : Chitosan 0.2 %
T_2 : Aloe Vera ½ T_5 : Chitosan 0.3 %
CD(5%): Critical difference @ 5% level

4.4.3. Acidity (%)

Different coating materials had significant effect on acidity of guava fruit throughout storage according to the data given in Table 9 and Fig. 9 Among treatments, maximum value (0.47) was observed in T_5 followed by T_4 (0.46), and T_3 (0.46).while minimum in T_0 (0.40). In general, acidity of guava fruits decreases with increase in storage period regardless of coating materials used. The maximum value of acidity (0.53) was recorded on 3rd day and least acidity (0.33) on 21st day.

Table 9: Effect of various coating materials on acidity (%) of guava *cv.* Allahabad Safeda under cold conditions (7°C)

Treatment details	Storage Days								Mean
	0	3	6	9	12	15	18	21	
T_0	0.58	0.51	0.47	0.42	0.37	0.33	0.28	0.24	0.40
T_1	0.58	0.52	0.48	0.44	0.40	0.38	0.35	0.31	0.43
T_2	0.58	0.54	0.50	0.46	0.41	0.37	0.35	0.32	0.44
T_3	0.58	0.53	0.51	0.47	0.44	0.40	0.39	0.37	0.46
T_4	0.58	0.53	0.52	0.47	0.44	0.42	0.38	0.34	0.46
T_5	0.58	0.54	0.51	0.48	0.46	0.43	0.40	0.38	0.47
Mean		0.53	0.50	0.46	0.42	0.39	0.36	0.33	
C.D (at 5%)		0.018	0.028	0.027	0.031	0.032	0.032	0.036	

Treatments details

T_0 : Control (cold temperature 7°C)
T_1 : Aloe Vera 1/3
T_2 : Aloe Vera ½
T_3 : Chitosan 0.1 %
T_4 : Chitosan 0.2 %
T_5 : Chitosan 0.3 %
CD(5%): Critical difference @ 5% level

In all treatments, acidity of guava fruits observed to be decreased with the increasing period of storage. This is because of increased activity of invertase enzyme. This enzyme is responsible for transformation of acid into sugar and because of utilization of acids in metabolic activities. In this investigation, the highest recorded acidity value is in T_5 and the lowest in T_0 (control). The findings are similar with studies done by **Damodaran *et al*., (2001)** on sapota and **Yadav *et al*., (2010)** on kinnow. Fruits coated in coating material of different concentration retained more acidity in comparison with control. This is because of slow transformation of acids into sugars during ripening. These outcomes are in conformity with former reports of **Wavhal and Athale (1988)** in mango and **Nunes *et al*., (2006)** in strawberry.

4.4.4. Total Sugars (%)

Data presented in fig. 10 and table 10 showed that different coating materials had substantial impact during storage on total sugars of guava. Among treatments, highest value (13.40) was observed in T_0 and minimum value in T_4 (12.59) followed by T_5 (12.65). In general, total sugars of guava increased with increases storage period up to 15^{th} days but after that the total sugars quantity decreased continuously in all treatments with increase in storage period regardless of coating material used. Maximum total sugars (14.97) were observed on 15^{th} day of storage and least (11.85) on 3^{rd} day.

Table 10: Effect of various coating materials on total sugars (%) of guava *cv.* Allahabad Safeda under cold conditions (7°C)

Treatment Details	Storage Days								Mean
	0	3	6	9	12	15	18	21	
T_0	11.21	12.89	13.57	14.64	15.78	16.47	12.52	10.06	13.40
T_1	11.21	11.75	12.45	13.27	14.32	15.2	14.15	12.76	13.13
T_2	11.21	11.75	12.38	13.13	14.06	15.06	14.01	12.52	13.01
T_3	11.21	11.62	12.15	12.93	13.72	14.63	13.47	12.31	12.75
T_4	11.21	11.59	12.01	12.74	13.51	14.39	13.16	12.11	12.59
T_5	11.21	11.52	11.96	12.51	13.27	14.08	13.74	12.95	12.65
Mean		11.85	12.42	13.20	14.11	14.97	13.51	12.11	
C.D (at 5%)		0.104	0.127	0.147	0.160	0.206	0.223	0.182	

Treatments details

T_0 : Control (cold temperature 7°C)
T_1 : Aloe Vera 1/3
T_2 : Aloe Vera ½
T_3 : Chitosan 0.1 %
T_4 : Chitosan 0.2 %
T_5 : Chitosan 0.3 %
CD(5%): Critical difference @ 5% level

In the findings, there is significant rise in total sugars up to 15^{th} day of storage. This is because of accumulation of starch into sugars. It was found that total sugars started to decline because of degradative process. These findings are in conformity with previous reports by **Mohla *et al*. (2005)** in pear, and in mango by **Periyathambi (2006)**. Highest total sugars were recorded in T_0, whereas, the lowest total sugars were found in T_4 in different type of coating. The fruits coated in coating materials of different

concentration retained less total sugars as compared to control. This might be correlated with decrease in PLW in coated fruits as compared to control fruit. These observations are similar with those obtained by **Venkatesha and Reddy (1994)** in guava.

4.4.5. Reducing Sugars (%)

Data presented in Fig. 11 and Table 11 shows that during storage, there is significant impact of coating materials on reducing sugars of guava fruits. Among treatments, highest value (7.92) was observed in T_0 and minimum value in T_5 (7.60) followed by T_4 (7.63).In general, reducing sugars of guava increased up to 15^{th} days of storage and thereafter, the reducing sugars quantity decreases continuously in all treatments with increase in storage period regardless of coating material used. Maximum reducing sugars (8.94) were observed on 15^{th} day and minimum value (6.46) was observed on 21^{st} day.

Table 11: Effect of various coating materials on reducing sugars (%) of guava *cv.* Allahabad Safeda under cold conditions (7°C)

Treatment details	Storage Days								Mean
	0	3	6	9	12	15	18	21	
T_0	6.87	7.54	8.21	8.54	9.07	9.39	8.43	5.31	7.92
T_1	6.87	7.41	8.10	8.34	8.85	9.12	8.21	6.11	7.87
T_2	6.87	7.37	8.02	8.16	8.71	8.97	8.06	6.86	7.88
T_3	6.87	7.33	7.75	7.99	8.55	8.77	7.80	6.71	7.72
T_4	6.87	7.33	7.56	7.91	8.43	8.72	7.66	6.56	7.63
T_5	6.87	7.20	7.49	7.74	8.11	8.67	7.51	7.26	7.60
Mean		7.36	7.85	8.11	8.62	8.94	7.94	6.46	
C.D (at 5%)		0.167	0.151	0.163	0.152	0.162	0.167	0.161	

Treatments details

T_0 : Control (cold temperature 7°C)
T_1 : Aloe Vera 1/3
T_2 : Aloe Vera ½
T_3 : Chitosan 0.1 %
T_4 : Chitosan 0.2 %
T_5 : Chitosan 0.3 %
CD(5%): Critical difference @ 5% level

In the findings, there is significant rise in reducing sugars up to 15th day of storage. This is because of accumulation of starch into sugars. It was found that reducing sugars started to decline because of degradative process. The maximum value of reducing sugars was recorded in T_0 and the lowest value of reducing sugars was found in T_5 in different type of coating. The fruits coated in different concentration of coating materials retained less reducing sugars as compared to control. This might be correlated with decrease in PLW in coated fruits in comparison with control. The findings of investigation are in confirmation with reports of **Reddy *et al*., (2014), Dutta *et al*., (2017)** and **Yadav *et al*., (2010)** in guava fruits. The results are well supported by **Jagdeesh (1994)** in corn starch coated fruits, **Singh *et al*., (2017)** on kinnow fruits.

4.4.6. Non-Reducing Sugars (%)

Data presented in Table 12 and Fig. 12 shows that during storage, there is significant impact of coating materials on non-reducing sugars of guava fruits. Among treatments, highest value (5.08) was observed in T_0 and minimum value in T_5 (4.79) followed by T_4 (4.83). In general, non-reducing sugars of guava increased up to 15th day of storage and thereafter, the non-reducing sugars quantity decrease continuously in all treatments with an increase in storage period regardless of the coating material used. Highest non-reducing sugars (6.31) were observed on 21st DAS and lowest non-reducing sugars (4.11) were observed on 3rd day.

In the findings, non-reducing sugars increased till 15th day of storage and thereafter, fall in level of non-reducing sugars was observed till 21st day of storage. The reduction in non-reducing sugars is due to the hydrolysis of starch in the fruits at early stage and after that it is because of consumption of sugars in the process of respiration. The outcome of findings are in conformation with similar finding of **Kumar *et al*., (2012)** & **Yadav *et al*., (2010)** on guava and **Jholgiker and Reddy (2007)** in custard apple fruits. Lowest value of non-reducing sugars was recorded in T_5 and the maximum value was recorded in T_0 among different coating materials.

Table 12: Effect of various coating materials on non-reducing sugars (%) of guava *cv.* Allahabad Safeda under cold conditions (7°C)

Treatment Details	Storage Days								Mean
	0	3	6	9	12	15	18	21	
T_0	4.12	4.16	4.14	4.84	5.42	5.77	5.79	6.41	5.08
T_1	4.12	4.11	4.13	4.68	5.20	5.78	5.64	6.32	4.99
T_2	4.12	4.17	4.14	4.72	5.08	5.78	5.65	6.33	4.99
T_3	4.12	4.08	4.18	4.69	4.91	5.56	5.38	6.27	4.89
T_4	4.12	4.05	4.23	4.59	4.83	5.38	5.23	6.22	4.83
T_5	4.12	4.11	4.25	4.53	4.90	5.14	4.97	6.35	4.79
Mean		4.11	4.17	4.67	5.05	5.57	5.44	6.31	
C.D (at 5%)		N/A	0.037	0.183	0.130	0.162	0.165	N/A	

Treatments details

T_0 : Control (cold temperature 7°C)
T_1 : Aloe Vera 1/3
T_2 : Aloe Vera ½
T_3 : Chitosan 0.1 %
T_4 : Chitosan 0.2 %
T_5 : Chitosan 0.3 %
CD(5%): Critical difference @ 5% level

4.4.7. Sugar/Acid ratio

Data presented in Table 13 and Fig. 13 shows that different coating materials had significant impact on sugar-acid ratio of guava during storage. Among treatments, maximum value (35.94) was observed in T_0 and minimum value in T_5 (27.52). In general, sugar/acid ratio of guava increases up to 15^{th} day of storage and thereafter, the sugar-acid ratio decrease continuously in all treatments with an increase in storage period regardless of the coating material used. Highest sugar/acid ratio (39.03) was observed on 15^{th} days of storage and minimum sugar/acid ratio (22.46) was observed on 3^{rd} day.

In general, sugar/acid ratio of guava increases with increasing storage period up to 15^{th} day after that decreases, irrespective of coating material used. In this investigation, maximum sugar-acid ratio was observed in T_0 and the minimum in T_5 .The total sugar present in the fruit maintained the quantity of simple sugar due to this the ratio increase or decrease during the period of storage with respect to acid quantity.

Table 13: Effect of various coating materials on sugar/acid ratio of guava *cv.* Allahabad Safeda under cold conditions (7°C)

Treatment Details	Storage Days								Mean
	0	3	6	9	12	15	18	21	
T_0	19.33	25.27	28.87	34.86	42.65	49.91	44.71	41.92	35.94
T_1	19.33	22.60	25.94	30.16	35.80	40.00	40.43	41.16	31.93
T_2	19.33	21.76	24.76	28.54	34.29	40.70	40.03	39.13	31.07
T_3	19.33	21.92	23.82	27.51	31.18	36.58	34.54	33.27	28.52
T_4	19.33	21.87	23.10	27.11	30.70	34.26	34.63	35.62	28.33
T_5	19.33	21.33	23.45	26.06	28.85	32.74	34.35	34.08	27.52
Mean		22.46	24.99	29.04	33.91	39.03	38.12	37.53	
C.D (at 5%)		0.770	1.125	1.727	2.239	3.132	3.574	4.544	

Treatments details

T_0 : Control (cold temperature 7°C)
T_1 : Aloe Vera 1/3
T_2 : Aloe Vera ½
T_3 : Chitosan 0.1 %
T_4 : Chitosan 0.2 %
T_5 : Chitosan 0.3 %
CD(5%): Critical difference @ 5% level

4.4.8. TSS/Acid ratio

Data presented in table 14 and Fig. 14 shows that different coating materials had significant effect on TSS/acid ratio of guava during storage period. Among all the treatments, the maximum value (27.16) was observed in T_0 and minimum value in T_5 (21.51). In general, TSS/acid ratio of guava increases up to 21st day of storage but in certain treatments it has been following descending trend. Maximum TSS/acid ratio (29.51) was observed on 21st day of storage and minimum TSS/acid ratio (18.01) was observed on 3rd day.

The ratio of TSS/acid ratio of fruits increased or decreased according to the coating materials or treatments with increase in period of fruits storage. In this present study, highest TSS/acid ratio was recorded in T_0 and the minimum in T_5. Rise in TSS/acid ratio with respect to storage period was stated by **Joubert (1970)** in litchi and **Navjot (2005)** in peach.

Table 14: Effect of various coating materials on TSS/Acid ratio of guava *cv.* Allahabad Safeda under cold conditions (7°C)

Treatment Details	Storage Days								Mean
	0	3	6	9	12	15	18	21	
T_0	15.97	18.86	21.17	24.79	29.27	34.42	35.79	37.00	27.16
T_1	15.97	18.15	20.10	23.00	26.65	29.26	29.54	30.71	24.17
T_2	15.97	17.70	19.72	22.30	25.71	29.59	29.31	30.03	23.79
T_3	15.97	17.85	19.47	22.09	24.14	27.40	26.72	24.84	22.31
T_4	15.97	17.96	18.67	21.68	23.57	25.31	26.16	28.32	22.21
T_5	15.97	17.54	19.08	20.85	22.35	24.51	25.65	26.16	21.51
Mean		18.01	19.70	22.45	25.28	28.42	28.86	29.51	
C.D (at 5%)		0.636	1.133	1.384	1.640	2.373	2.826	3.874	

Treatments details

T_0 : Control (cold temperature 7°C)
T_1 : Aloe Vera 1/3
T_2 : Aloe Vera ½
T_3 : Chitosan 0.1 %
T_4 : Chitosan 0.2 %
T_5 : Chitosan 0.3 %
CD(5%): Critical difference @ 5% level

Graphical presentation of experiment 2 (A)

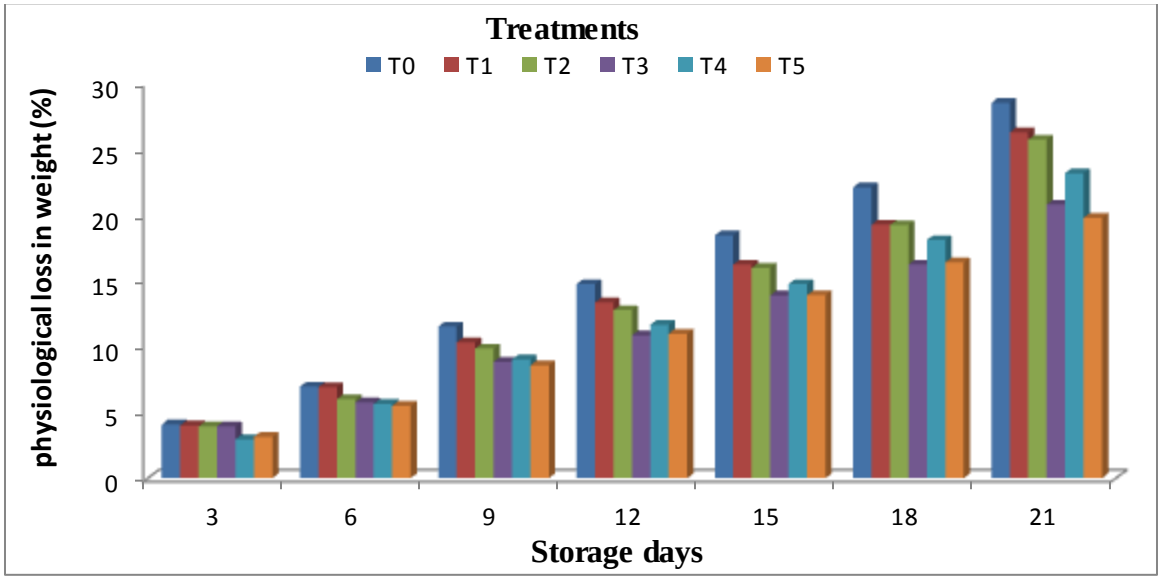

Fig. 6: Effect of various coating materials on PLW of guava *cv.* Allahabad Safeda under cold conditions (7°C)

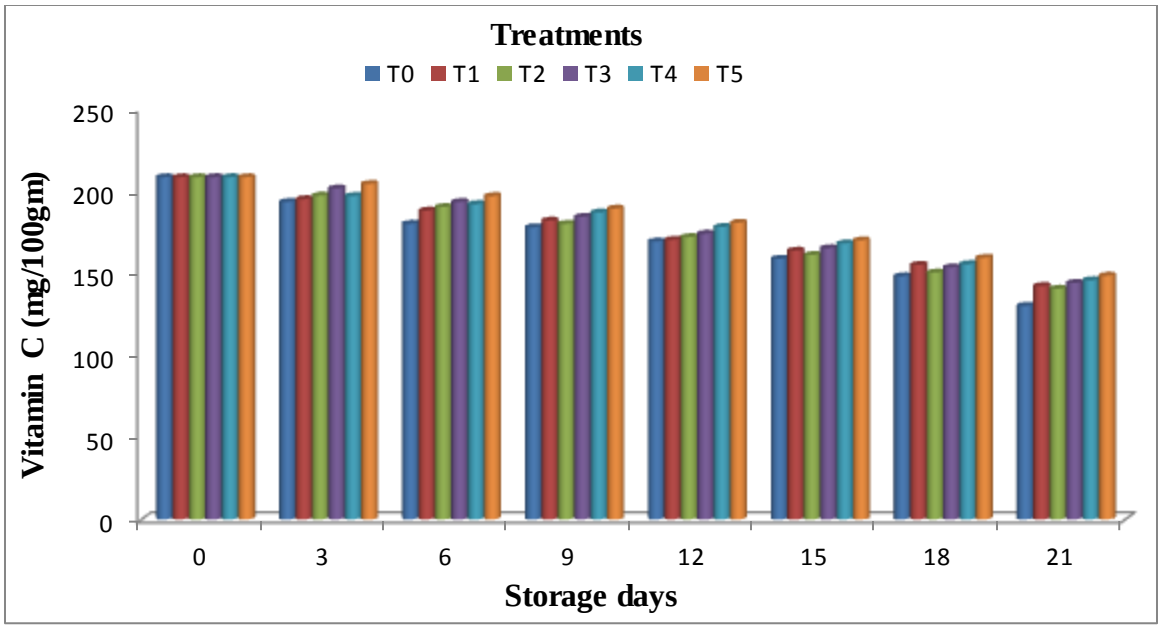

Fig. 7: Effect of various coating materials on vitamin C of guava *cv.* Allahabad Safeda under cold conditions (7°C)

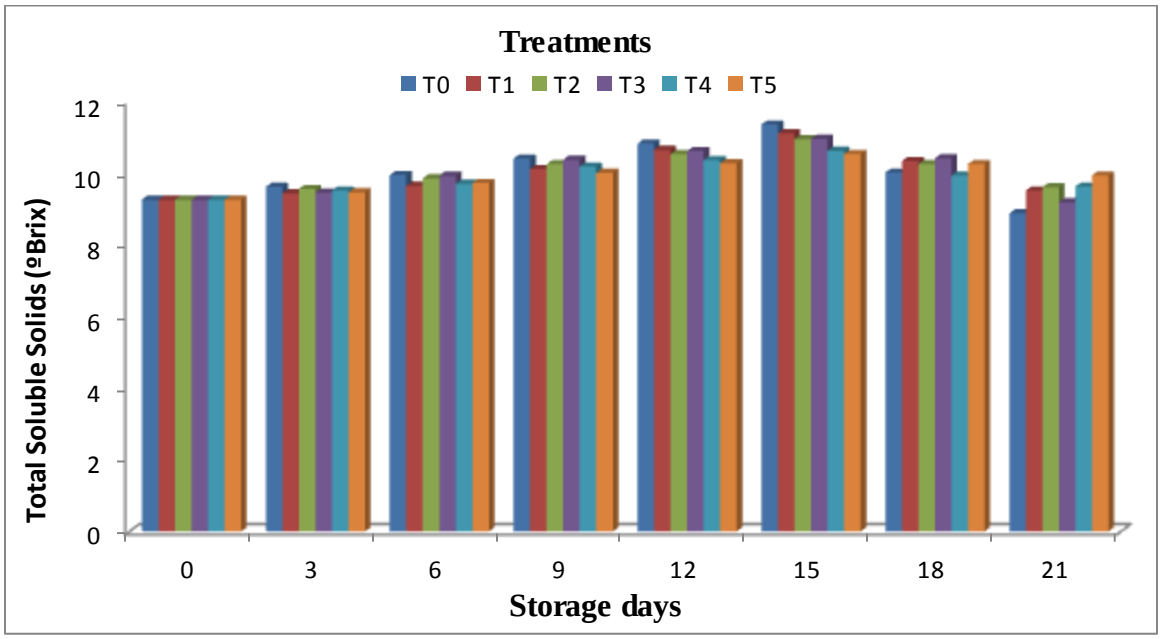

Fig. 8: Effect of various coating materials on TSS of guava *cv.* Allahabad Safeda under cold conditions (7°C)

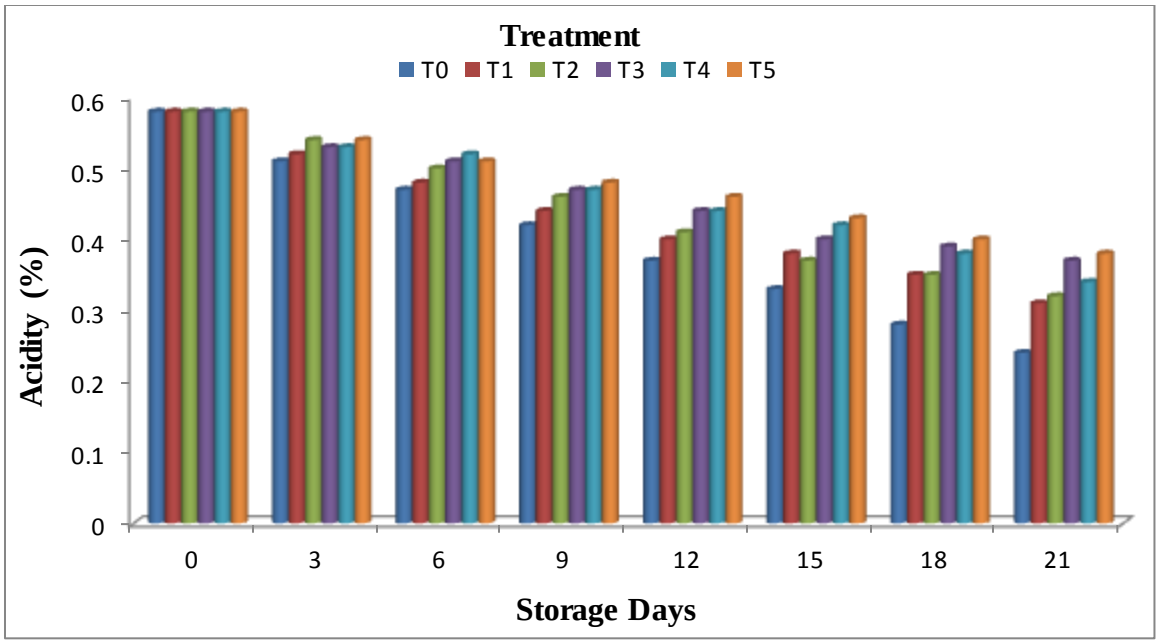

Fig. 9: Effect of various coating materials on acidity of guava *cv.* Allahabad Safeda under cold conditions (7°C)

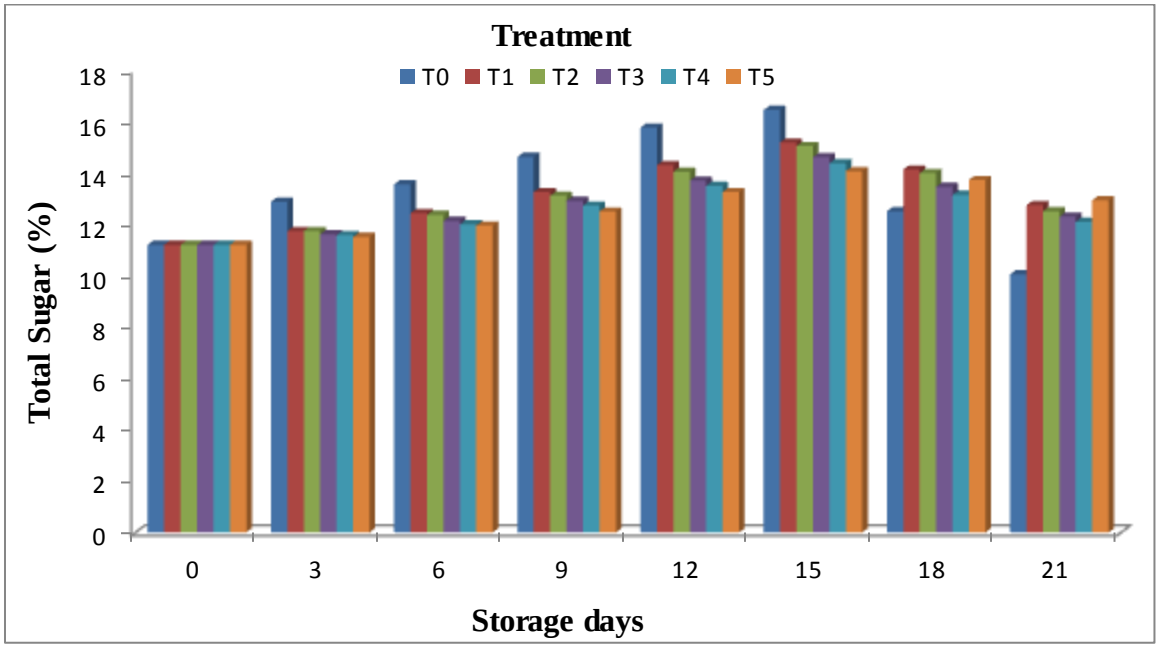

Fig. 10: Effect of various coating materials on total sugars of guava *cv.* Allahabad Safeda under cold conditions (7°C)

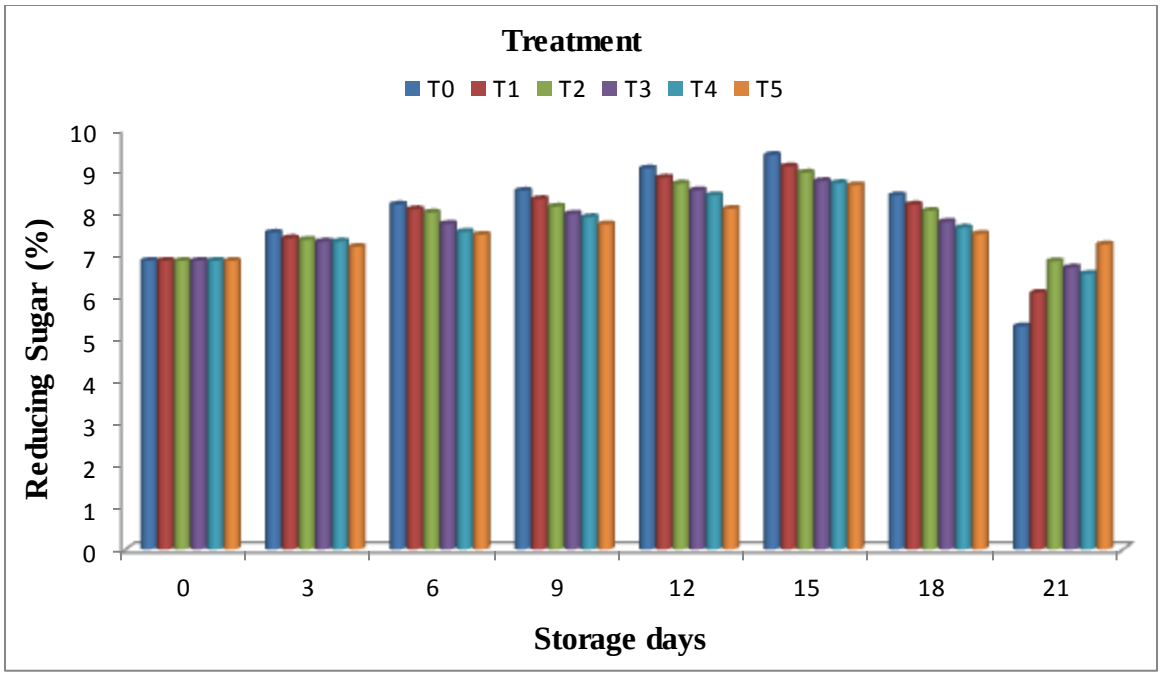

Fig. 11: Effect of various coating materials on reducing sugars of guava *cv.* Allahabad Safeda under cold conditions (7°C)

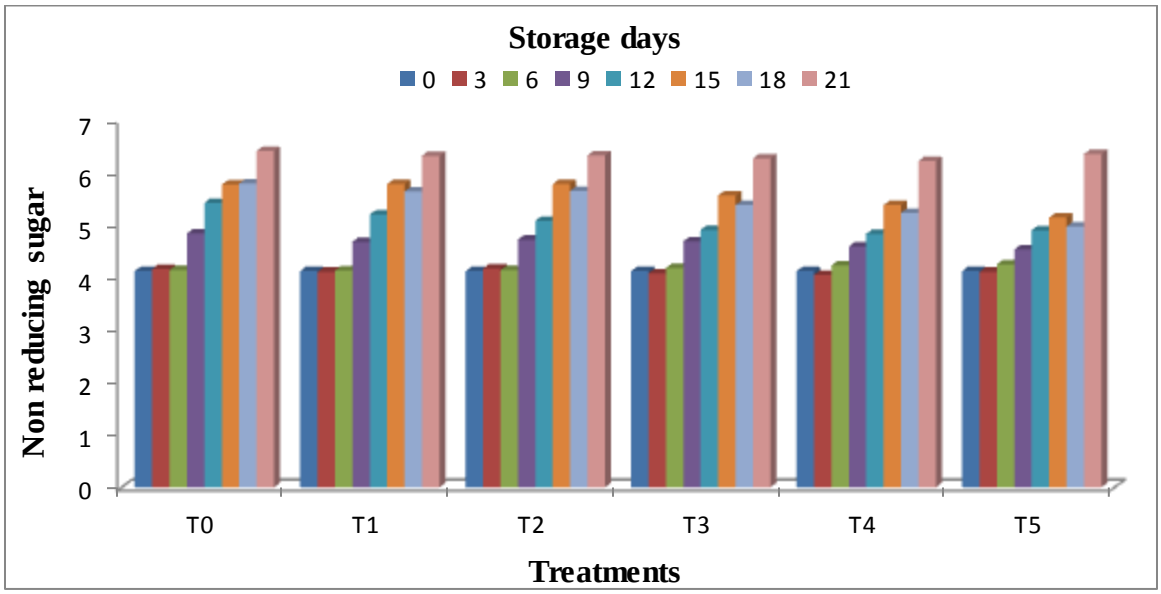

Fig. 12: Effect of various coating materials on non-reducing sugars of guava *cv.* Allahabad Safeda under cold conditions (7°C)

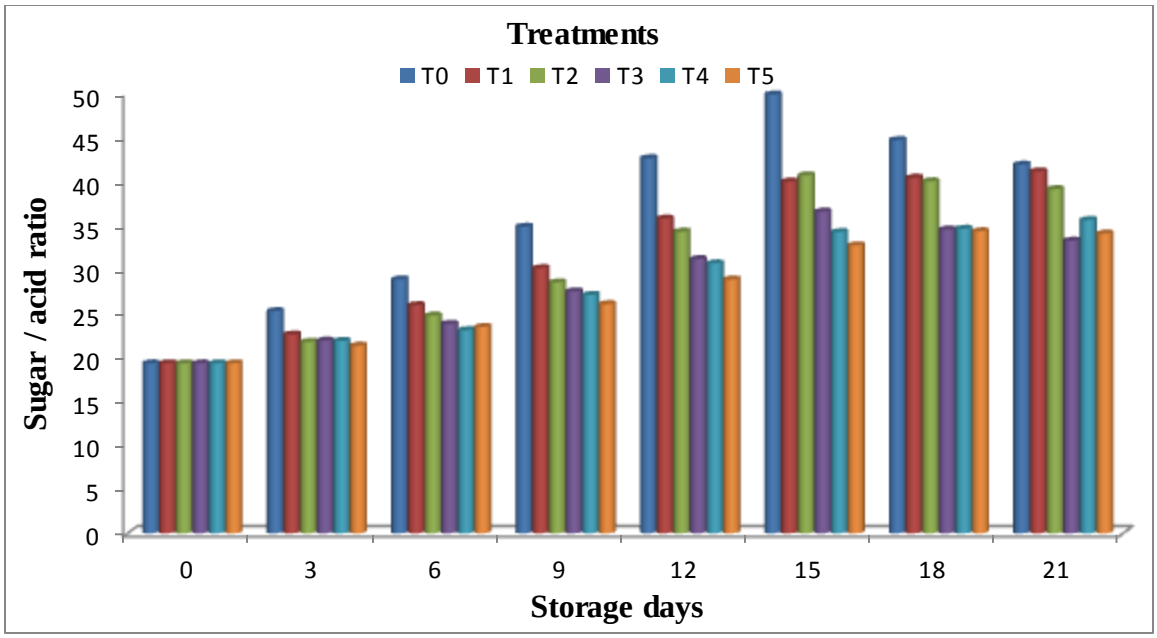

Fig. 13: Effect of various coating materials on sugar/acid ratio of guava *cv.* Allahabad Safeda under cold conditions (7°C)

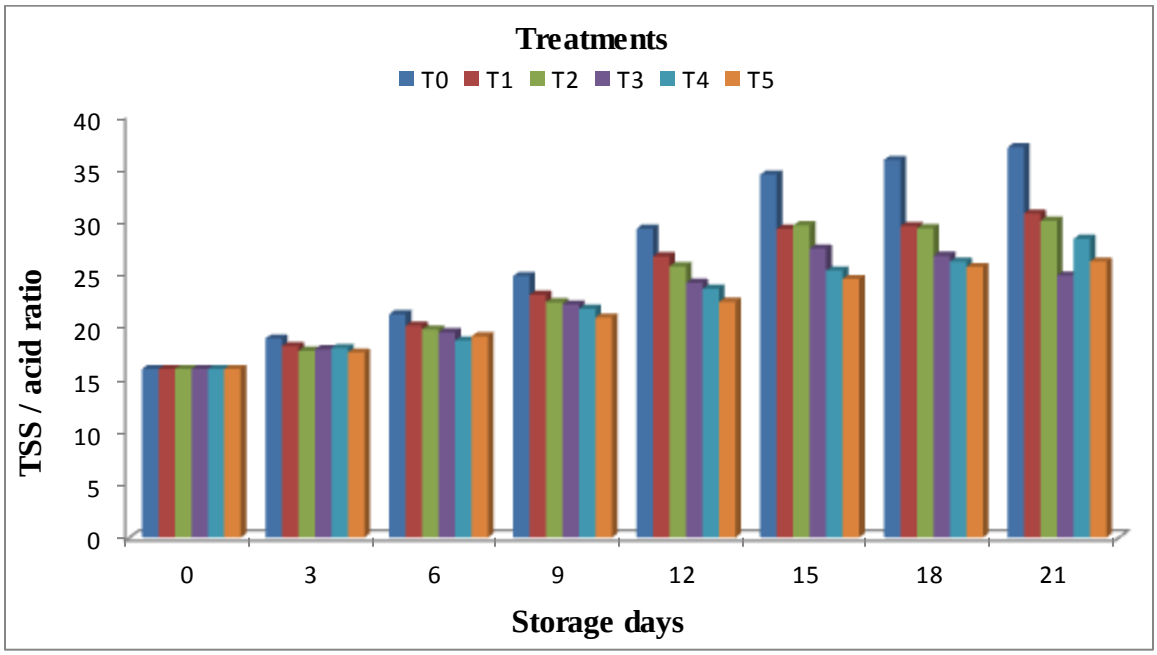

Fig. 14: Effect of various coating materials on TSS/Acid ratio of guava *cv.* Allahabad Safeda under cold conditions (7°C)

Experiment 2 (B) Effect of various edible coating on guava fruit *cv.* Allahabad Safeda under ambient conditions

4.5. Physiological parameters

4.5.1. Physiological loss in weight (%)

Different coating materials had significant effect on PLW of guava fruit throughout storage according to the data given in Table 15 and Fig. 15 Among treatments, maximum PLW was observed in T_0 (20.61%) and minimum in T_5 (16.42%). PLW increase with duration of storage showing highest PLW of weight on day 6 (23.09%) and lowest on day 3 (13.10%) In general, fruit loss of weight of guava increases with increasing storage period and coating materials used.

Table 15: Effect of various coating materials on PLW (%) of guava *cv.* Allahabad Safeda under ambient conditions

Treatment Details	Storage Days		Mean
	3	6	
T_0	15.14	26.09	20.61
T_1	13.58	25.82	19.70
T_2	13.38	23.25	18.32
T_3	12.99	23.01	18.00
T_4	11.67	21.42	16.55
T_5	11.87	20.96	16.42
Mean	13.10	23.09	
C.D (at 5%)	1.799	0.981	

Treatments details

T_0 : Control (Ambient temperature)
T_1 : Aloe Vera 1/3
T_2 : Aloe Vera ½
T_3 : Chitosan 0.1 %
T_4 : Chitosan 0.2 %
T_5 : Chitosan 0.3 %
CD(5%): Critical difference @ 5% level

In all the treatments, increased in PLW was observed with increase in storage period. This is because of moisture loss by transpiration and reserved food material by respiration. During respiration process, various reserved food materials present in fruits are used. Also the process of transpiration from fruit surface continues even after harvest.

Hence, due to respiration and transpiration of fruits, PLW increased with increase in storage period. The findings of investigations are in conformation with reports of **Joshi and Roy (1985)** in mango, **Aworth *et al.*, (1991)** in citrus, **Jitender *et al.*, (2000)** on kinnow & **Pandey *et al.*, (2006)** in apple.

In the report given by **Haard and Salunkhe (1975),** states that PLW is mainly because of the evaporation, respiration and various other degradation processes that occurs during storage of fruits. In this investigation, minimum PLW was observed in T_5 and the highest in T_0 (control). This might happened because of restriction in dispersal of various gases and reaction mechanism that results in slow transpiration and respiration rate of fruits. The results are in conformation with findings of **Joshua and Sathiamoorthy (1993)** on sapota and **Venkatesha and Reddy (1994)** on guava.

4.6. Bio-chemical parameters

4.6.1. Vitamin C (mg/100gm)

Data depicted in Table 16 and Fig. 16 shows, there is significant impact of coating materials on vitamin C of guava fruits during storage period. Among treatments, maximum value (187.22) was observed in T_5 followed by T_4 (185.47) and minimum value in T_0 (172.64). Generally, vitamin C of guava decreases with increase in storage period. Maximum vitamin C (180.59) quantity was observed on 3rd day of storage and minimum (156.53) vitamin C was observed on day 6.

Vitamin C of fruit gradually reduced in all the treatments during storage period because of enzymatic oxidation of ascorbic acid to dehydro-ascorbic acid in the existence of ascorbinase enzyme which might contribute to the reduction of vitamin C content of fruit. In this investigation, maximum vitamin C was observed in T_5 & T_2 and the minimum in T_0 (control). These findings are in conformity with the reports given by **Das and Dash (1967)**. In comparison with control higher retention of vitamin C content was observed in fruits coated by different concentration of coating materials due to the low PLW accompanied by low respiration rate and transpirational losses. The results obtained

from this investigation are in conformity with reports earlier given by **Venkatesha and Reddy (1994)** in guava and **Sudha et al. (2007)** in sapota.

Table 16: Effect of various coating materials on vitamin C (mg/100gm) of guava *cv.* Allahabad Safeda under ambient conditions

Treatment Details	Storage Days			Mean
	0	3	6	
T_0	208.65	168.37	140.89	172.64
T_1	208.65	178.12	155.54	180.77
T_2	208.65	183.45	158.52	183.54
T_3	208.65	181.41	155.68	181.91
T_4	208.65	187.70	165.32	185.47
T_5	208.65	184.53	163.24	187.22
Mean		180.59	156.53	
C.D (at 5%)		1.646	1.652	

Treatments details

T_0 : Control (Ambient temperature)
T_1 : Aloe Vera 1/3
T_2 : Aloe Vera ½
T_3 : Chitosan 0.1 %
T_4 : Chitosan 0.2 %
T_5 : Chitosan 0.3 %
CD(5%): Critical difference @ 5% level

4.6.2. Total soluble solids (ºBrix)

Data depicted in Table 17 and Fig. 17 shows that effect of various coating materials had significant impact on total soluble solids of guava fruits throughout the storage period. Among treatments, the maximum value (11.50) was observed in $T_0$and minimum value in T_5 (10.45). In general, TSS of guava increases with increase in storage period. Maximum total soluble solids (12.45) were observed on 6^{th} days of storage and minimum (10.69) were exhibited on 3^{rd} day.

It was observed that, there was rise in TSS of fruits up to 6^{th} day of storage but as after that the fruits had got rotten at ambient temperature hence afterwards reading has not been taken. Increase in TSS of guava fruits till 6th day of storage was correlated with increase in PLW. The findings of this investigation are in conformation with the earlier findings of **Panwar (1980)** in ber. The maximum TSS was recorded in T_0 and the lowest

TSS was observed in T_5. The coating materials used for fruits had less total soluble solids compared to control. This might be due to the lesser PLW and slow conversion of starch into sugars. Findings of this investigation are in conformation with former reports by **Venkatesha and Reddy (1994)** on guava fruit and **Meena *et al.*, (2009)** on ber.

Table 17: Effect of various coating materials on TSS (ºBrix) of guava *cv.* Allahabad Safeda under ambient conditions

Treatment Details	Storage Days			Mean
	0	3	6	
T_0	9.26	11.42	13.83	11.50
T_1	9.26	10.84	12.63	10.91
T_2	9.26	10.64	12.24	10.71
T_3	9.26	10.56	12.12	10.64
T_4	9.26	10.46	12.06	10.59
T_5	9.26	10.24	11.85	10.45
Mean		10.69	12.45	
C.D (at 5%)		0.089	0.123	

Treatments details

T_0 : Control (Ambient temperature)
T_1 : Aloe Vera 1/3
T_2 : Aloe Vera ½
T_3 : Chitosan 0.1 %
T_4 : Chitosan 0.2 %
T_5 : Chitosan 0.3 %
CD(5%): Critical difference @ 5% level

4.6.3. Acidity (%)

Data presented in Fig. 18 and Table 18 showed that different coating materials had significant impact on acidity of guava during storage period. Among treatments, maximum value (0.52) was observed in T_4 followed by T_5 (0.51).while minimum in T_0 (0.47). In general, acidity of guava fruits decreases with increase in storage period regardless of coating materials used. The highest acidity (0.50) was recorded on 3rd DAS and lowest acidity (0.42) on 6th day.

Table 18: Effect of various coating materials on acidity (%) of guava *cv.* Allahabad Safeda under ambient conditions

Treatment details	Storage Days			Mean
	0	3	6	
T_0	0.58	0.46	0.38	0.47
T_1	0.58	0.48	0.39	0.48
T_2	0.58	0.50	0.41	0.50
T_3	0.58	0.50	0.43	0.50
T_4	0.58	0.53	0.45	0.52
T_5	0.58	0.51	0.44	0.51
Mean		0.50	0.42	
C.D (at 5%)		0.037	0.045	

Treatments details

T_0 : Control (Ambient temperature)
T_1 : Aloe Vera 1/3
T_2 : Aloe Vera ½
T_3 : Chitosan 0.1 %
T_4 : Chitosan 0.2 %
T_5 : Chitosan 0.3 %
CD(5%): Critical difference @ 5% level

In all treatments, acidity of guava fruits observed to be decreased with the increasing period of storage. This is because of increased activity of invertase enzyme. This enzyme is responsible for transformation of acid into sugar and because of utilization of acids in metabolic activities. In this investigation, the highest recorded acidity value is in T_4 and the lowest in T_0 (control). The findings are similar with studies done by **Damodaran *et al*., (2001)** on sapota and **Yadav *et al*., (2010)** on kinnow. Fruits coated in coating material of different concentration retained more acidity in comparison with control. This is because of slow transformation of acids into sugars during ripening. These outcomes are in conformity with former reports of **Wavhal and Athale (1988)** in mango and **Nunes *et al*., (2006)** in strawberry.

4.6.4. Total sugars (%)

Data presented in Fig. 19 and Table 19 showed that different coating materials had substantial impact during storage on total sugars of guava. Among treatments, the

highest value (13.31) was observed in T_0 and minimum value in T_5 (12.25) followed by T_4 (12.34). In general, total sugars of guava increases with increases storage period up to 6th day but after that the total sugars quantity decreases continuously in all the treatments with increase in storage period regardless of coating material used. Maximum total sugars (13.30) were observed on 6th days and lowest (12.22) was observed on 3rd day.

Table 19: Effect of various coating materials on total sugars (%) of guava *cv.* Allahabad Safeda under ambient conditions

Treatment Details	Storage Days			Mean
	0	3	6	
T_0	11.21	12.46	14.15	13.31
T_1	11.21	12.3	13.57	12.94
T_2	11.21	12.12	13.42	12.77
T_3	11.21	12.86	13.12	12.99
T_4	11.21	11.83	12.84	12.34
T_5	11.21	11.76	12.73	12.25
Mean		12.22	13.30	
C.D (at 5%)		0.165	0.200	

Treatments details

T_0 : Control (Ambient temperature)
T_1 : Aloe Vera 1/3
T_2 : Aloe Vera ½
T_3 : Chitosan 0.1 %
T_4 : Chitosan 0.2 %
T_5 : Chitosan 0.3 %
CD(5%): Critical difference @ 5% level

In the findings, there is significant rise in total sugars up to 6th day but as after that the fruits had got rotten at ambient temperature hence afterwards reading have not been taken. Increasing total sugars of fruits up to 6th day this is because of accumulation of starch into sugars. These outcomes are in similar with former reports on mango fruit by **Upadhyay and Tripathi (1985)**, on pear fruit by **Mohla *et al*. (2005)** and on mango fruit by **Periyathambi (2006)**. The highest total sugars were recorded in T_0, whereas, the lowest total sugar was found in T_5 in different type of coating. The fruits coated in coating materials of different concentration retained less total sugars as compared to control. This might be correlated with decrease in PLW in coated fruits as compared to

control fruit. These observations are similar with those obtained by **Venkatesha and Reddy (1994)** in guava.

4.6.5. Reducing sugars (%)

Data presented in Fig. 20 and Table 20 showed that different coating materials had substantial impact on reducing sugars of guava fruits. Among treatments, the highest value (7.59) was observed in T_0 and minimum value in T_5 (7.17) followed by T_4 (7.21).In general, reducing sugars of guava increased with increasing period of storage up to 6th days. Highest reducing sugars (7.90) were observed on day 6 and lowest (7.33) were observed on day 3.

Table 20: Effect of various coating materials on reducing sugars (%) of guava *cv.* Allahabad Safeda under ambient conditions

Treatment Details	Storage Days			Mean
	0	3	6	
T_0	6.87	7.66	8.24	7.59
T_1	6.87	7.51	8.11	7.49
T_2	6.87	7.40	8.01	7.42
T_3	6.87	7.24	7.82	7.31
T_4	6.87	7.10	7.68	7.21
T_5	6.87	7.10	7.56	7.17
Mean		7.33	7.90	
C.D (at 5%)		0.130	0.137	

Treatments details

T_0 : Control (Ambient temperature)
T_1 : Aloe Vera 1/3
T_2 : Aloe Vera ½
T_3 : Chitosan 0.1 %
T_4 : Chitosan 0.2 %
T_5 : Chitosan 0.3 %
CD(5%): Critical difference @ 5% level

In the findings, there is significant rise in reducing sugars up to 6th day. This is because of accumulation of starch into sugars and then started decreasing due to degradative process which is not followed in this experiment as the fruits have rotten afterwards. The highest value of reducing sugars was exhibited in T_0 and lowest reducing

sugars were found in T_5 in different type of coating. The fruits coated in different concentration of coating materials retained less reducing sugars as compared to control. This might be correlated with decrease in PLW in coated fruits as compared to control fruit. The findings of investigation are in confirmation with reports of **Reddy *et al*., (2014), Dutta *et al*., (2017)** and **Yadav *et al*., (2010)** in guava fruits. The results are well supported by **Jagdeesh (1994)** in corn starch coated fruits, **Singh *et al*., (2017)** on kinnow fruits.

4.6.6. Non-Reducing sugars (%)

Data presented in Fig. 21 and Table no. 21 showed that different coating materials had significant impact on non-reducing sugars of guava fruits. Among treatments, the highest value (4.83) was observed in T_3 and minimum value in T_5 (4.48) followed by T_4 (4.50).In general, non-reducing sugars of guava increased with increasing storage period up to 6th day. Highest non-reducing sugars (5.13) were observed on day 6 and lowest non-reducing sugars (4.64) was observed on 3rd day.

Table 21: Effect of various coating materials on non-reducing sugars (%) of guava *cv.* Allahabad Safeda under ambient conditions

Treatment Details	Storage Days			Mean
	0	3	6	
T_0	4.12	4.56	5.61	4.76
T_1	4.12	4.55	5.19	4.62
T_2	4.12	4.48	5.14	4.58
T_3	4.12	5.34	5.04	4.83
T_4	4.12	4.49	4.90	4.5
T_5	4.12	4.43	4.91	4.48
Mean		4.64	5.13	
C.D (at 5%)		0.044	0.071	

Treatments details

T_0 : Control (Ambient temperature)
T_1 : Aloe Vera 1/3
T_2 : Aloe Vera ½
T_3 : Chitosan 0.1 %
T_4 : Chitosan 0.2 %
T_5 : Chitosan 0.3 %
CD(5%): Critical difference @ 5% level

In the findings, non-reducing sugars increased till 6th day of storage period and later on it was gradually decreased which are not followed in this experiment as the fruits have rotten afterwards. The reduction in non-reducing sugars is due to the hydrolysis of starch in the fruits at early stage and after that it is because of consumption of sugars in the process of respiration. The outcome of findings are in conformation with similar finding of **Kumar *et al*., (2012)** & **Yadav *et al*., (2010)** on guava and **Jholgiker and Reddy (2007)** in custard apple fruits. Lowest value of non-reducing sugars was recorded in T_5 and the maximum value was recorded in T_0 among different coating materials.

4.6.7. Sugar/Acid Ratio

Data depicted in Table 22 and Fig. 22 presented that different coating materials had substantial impact on sugar/acid ratio of guava during storage. Among treatments, maximum value (27.88) was observed in T_0 and minimum value in T_5 (23.77). In general, sugar/acid ratio of guava increases up to 6th day. Maximum sugar/acid ratio (32.12) was observed on 6th days of storage and minimum sugar/acid ratio (24.68) was observed on 3rd day.

Table 22: Effect of various coating materials on sugar/acid ratio of guava *cv.* Allahabad Safeda under ambient conditions

Treatment Details	Storage Days			Mean
	0	3	6	
T_0	19.33	27.09	37.24	27.88
T_1	19.33	25.63	34.79	26.58
T_2	19.33	24.24	32.73	25.43
T_3	19.33	25.72	30.51	25.19
T_4	19.33	22.32	28.53	23.39
T_5	19.33	23.06	28.93	23.77
Mean		24.68	32.12	
C.D (at 5%)		1.515	3.141	

Treatments details

T_0 : Control (Ambient temperature)
T_1 : Aloe Vera 1/3
T_2 : Aloe Vera ½
T_3 : Chitosan 0.1 %
T_4 : Chitosan 0.2 %
T_5 : Chitosan 0.3 %
CD(5%): Critical difference @ 5% level

In general, sugar/acid ratio of guava increases with increasing storage period up to 6th day. In the current study, highest sugar-acid ratio was recorded in T_0 and lowest in T_5. The total sugar present in the fruit maintained the quantity of simple sugar due to this the ratio increase or decrease during the period of storage with respect to acid quantity.

4.6.8. TSS/Acid Ratio

Data presented in Fig. 23 and Table no. 23 displayed that different coating materials had significant impact on TSS/acid ratio of guava fruits. Among the all treatments, the maximum value (25.73) was observed in T_0 and minimum value in T_4 (20.83). In general, TSS/acid ratio of guava increases up to 6th day. Maximum TSS/acid ratio (30.09) was observed on 6th day of storage and minimum TSS/acid ratio (21.60) was observed on 3rd day.

Table 23: Effect of various coating materials on TSS/Acid ratio of guava *cv.* Allahabad Safeda under ambient conditions

Treatment details	Storage Days			Mean
	0	3	6	
T_0	15.97	24.83	36.39	25.73
T_1	15.97	22.58	32.38	23.64
T_2	15.97	21.28	29.85	22.37
T_3	15.97	21.12	28.19	21.76
T_4	15.97	19.74	26.80	20.83
T_5	15.97	20.08	26.93	20.99
Mean		21.60	30.09	
C.D (at 5%)		1.480	2.932	

Treatments details

T_0 : Control (Ambient temperature)
T_1 : Aloe Vera 1/3
T_2 : Aloe Vera ½
T_3 : Chitosan 0.1 %
T_4 : Chitosan 0.2 %
T_5 : Chitosan 0.3 %
CD(5%): Critical difference @ 5% level

The TSS/acid ratio of fruits increased or decreased according to the coating materials or treatments with increase in period of fruits storage. In this present study, highest TSS/acid ratio was recorded in T_0 and the minimum in T_4. Rise in TSS/acid ratio

with respect to storage period was stated by **Joubert (1970)** in litchi and **Navjot (2005)** in peach.

Graphical presentation of experiment 2 (B)

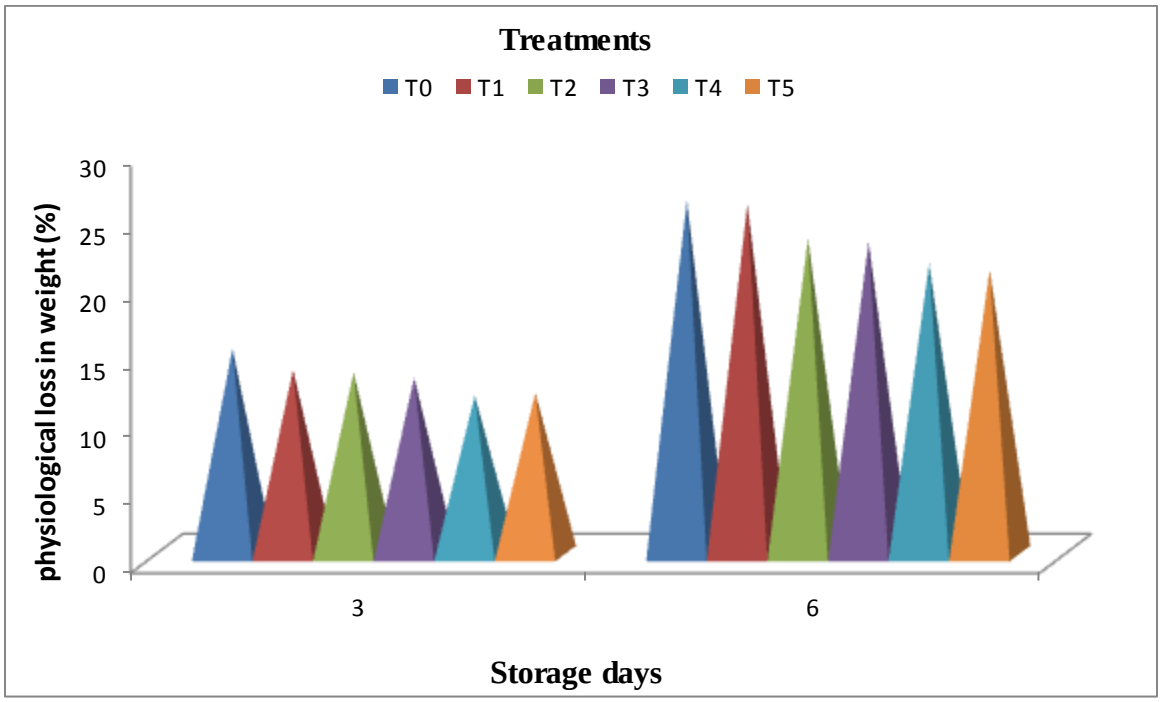

Fig. 15: Effect of various coating materials on PLW of guava *cv.* Allahabad Safeda under ambient conditions

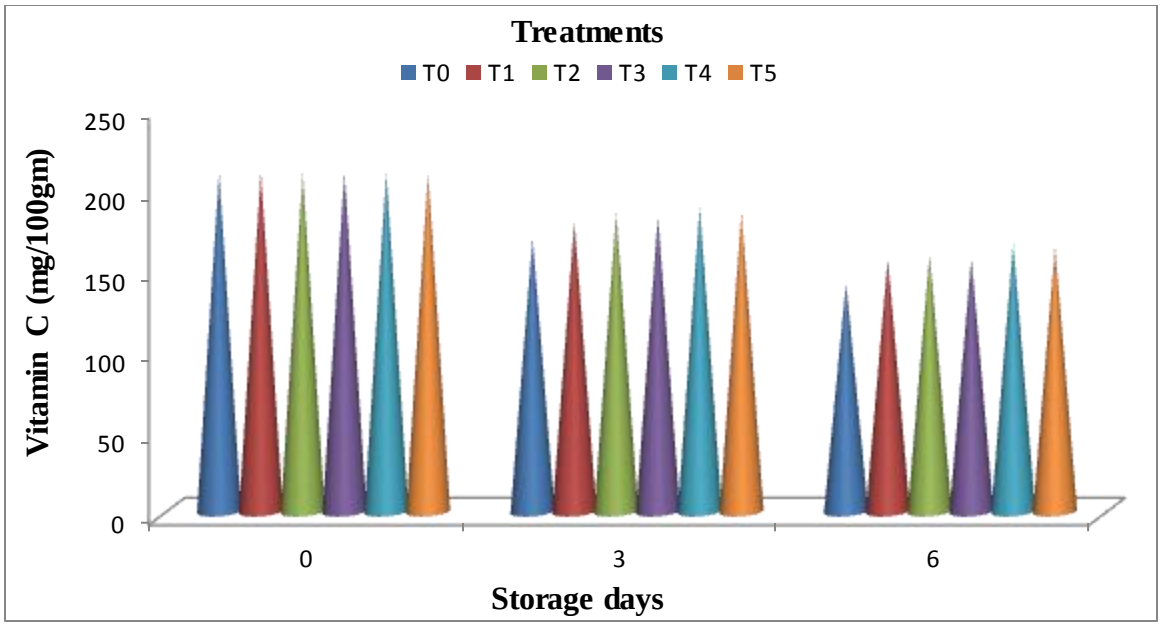

Fig. 16: Effect of various coating materials on vitamin C of guava *cv.* Allahabad Safeda under ambient conditions

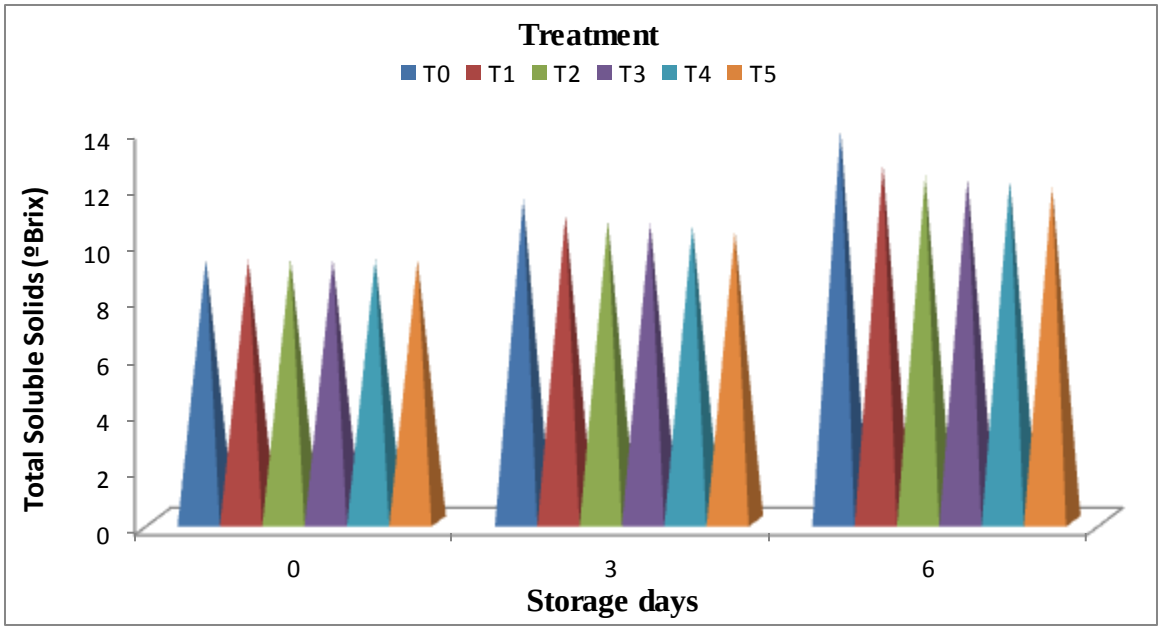

Fig. 17: Effect of various coating materials on TSS of guava *cv.* Allahabad Safeda under ambient conditions

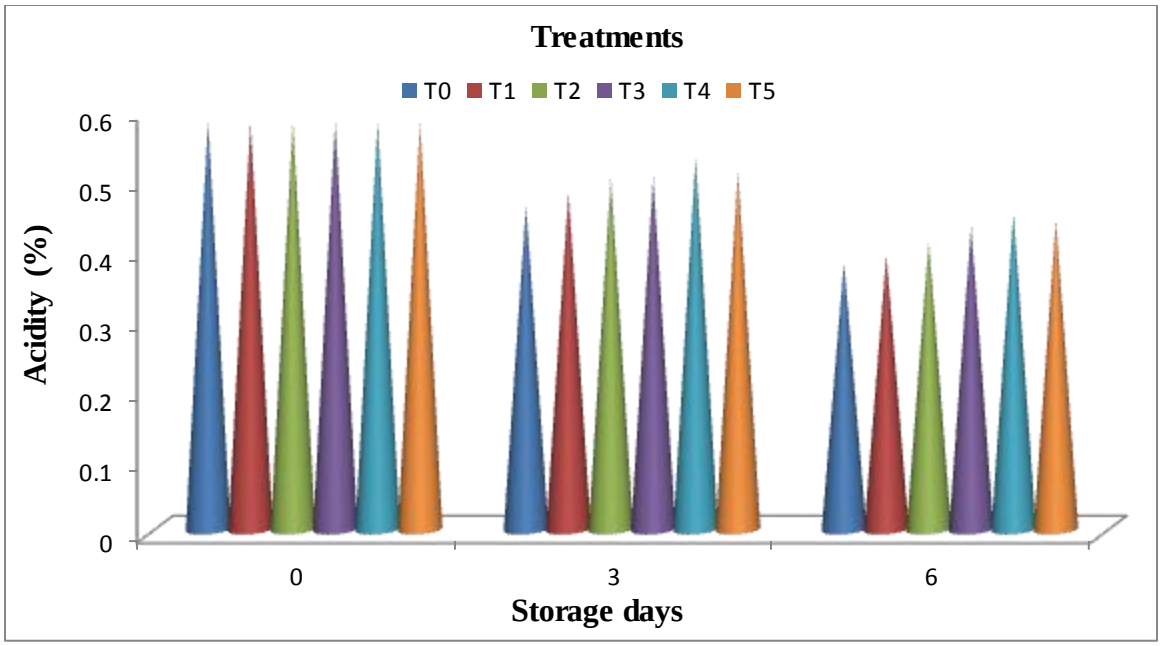

Fig. 18: Effect of various coating materials on acidity of guava *cv.* Allahabad Safeda under ambient conditions

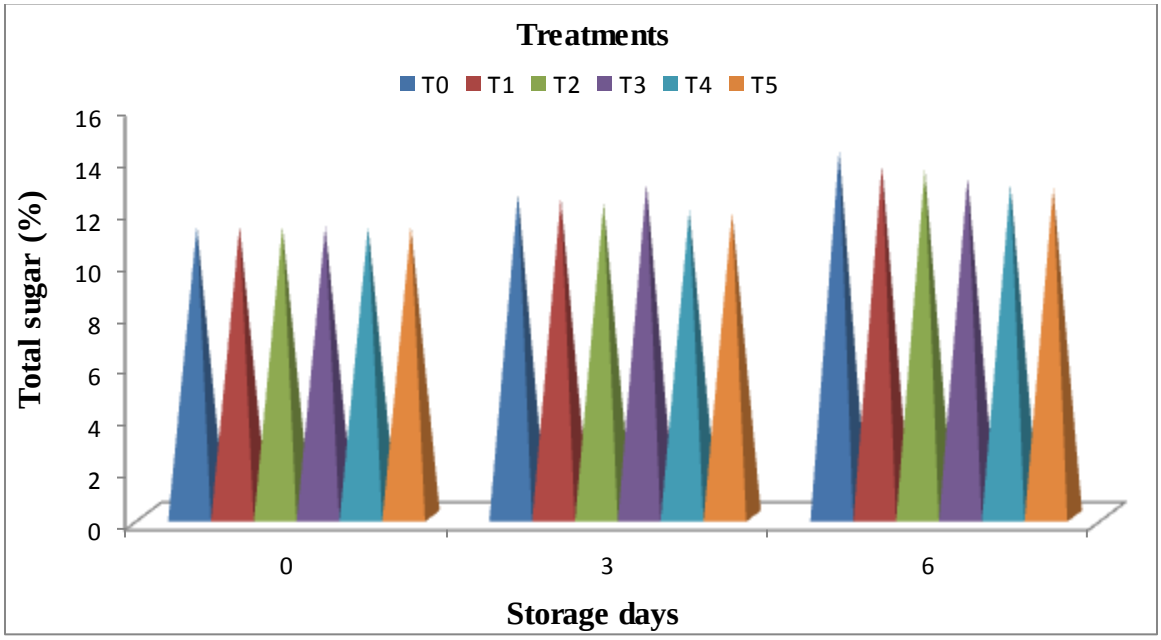

Fig. 19: Effect of various coating materials on total sugars of guava *cv.* Allahabad Safeda under ambient conditions

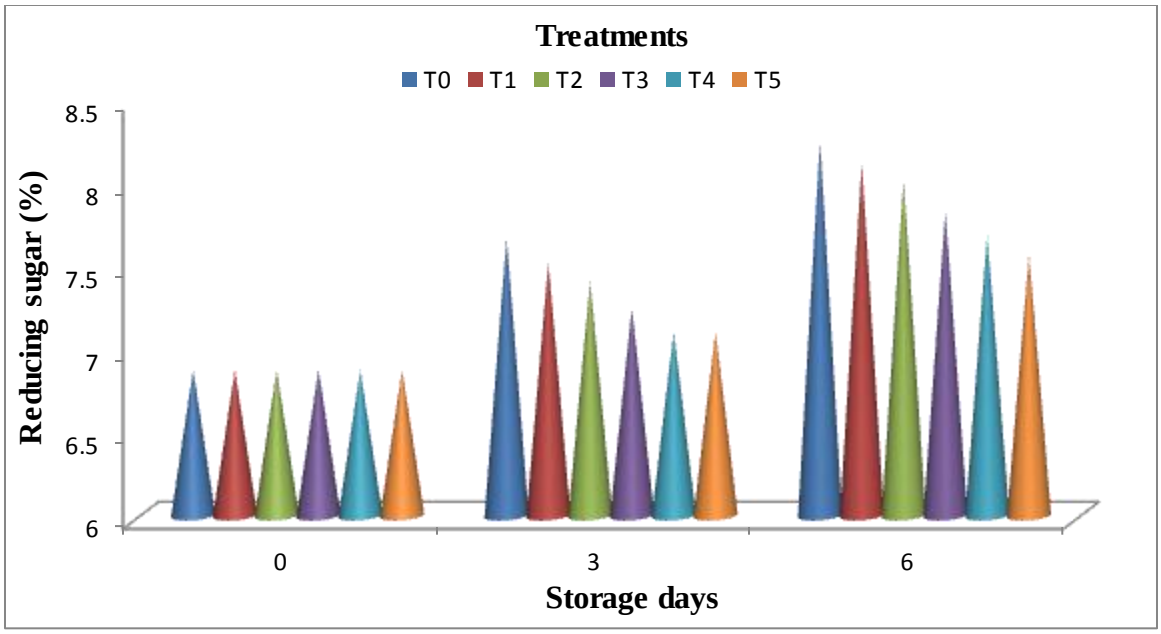

Fig. 20: Effect of various coating materials on reducing sugars of guava *cv.* Allahabad Safeda under ambient conditions

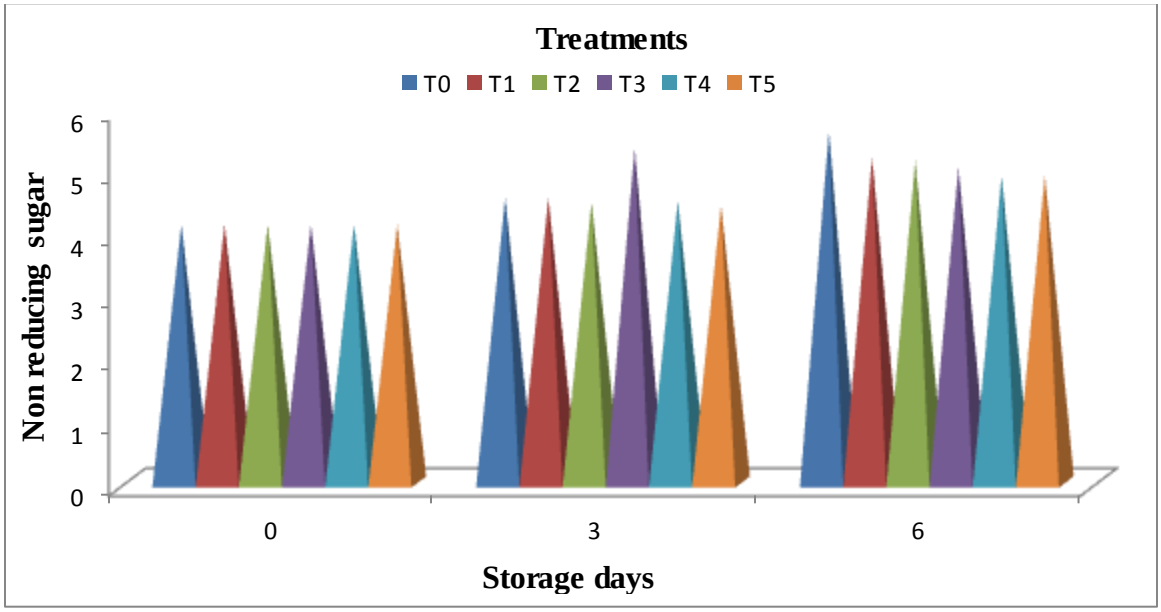

Fig. 21: Effect of various coating materials on non-reducing sugars of guava *cv.* Allahabad Safeda under ambient conditions

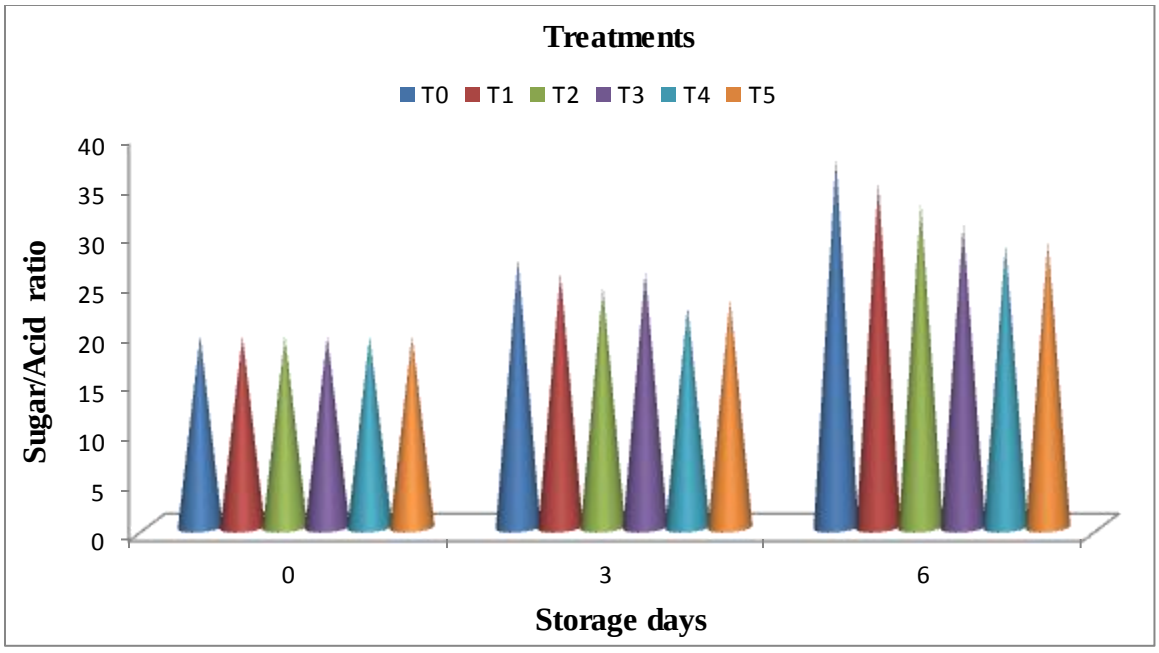

Fig. 22: Effect of various coating materials on sugar/acid ratio of guava *cv.* Allahabad Safeda under ambient conditions

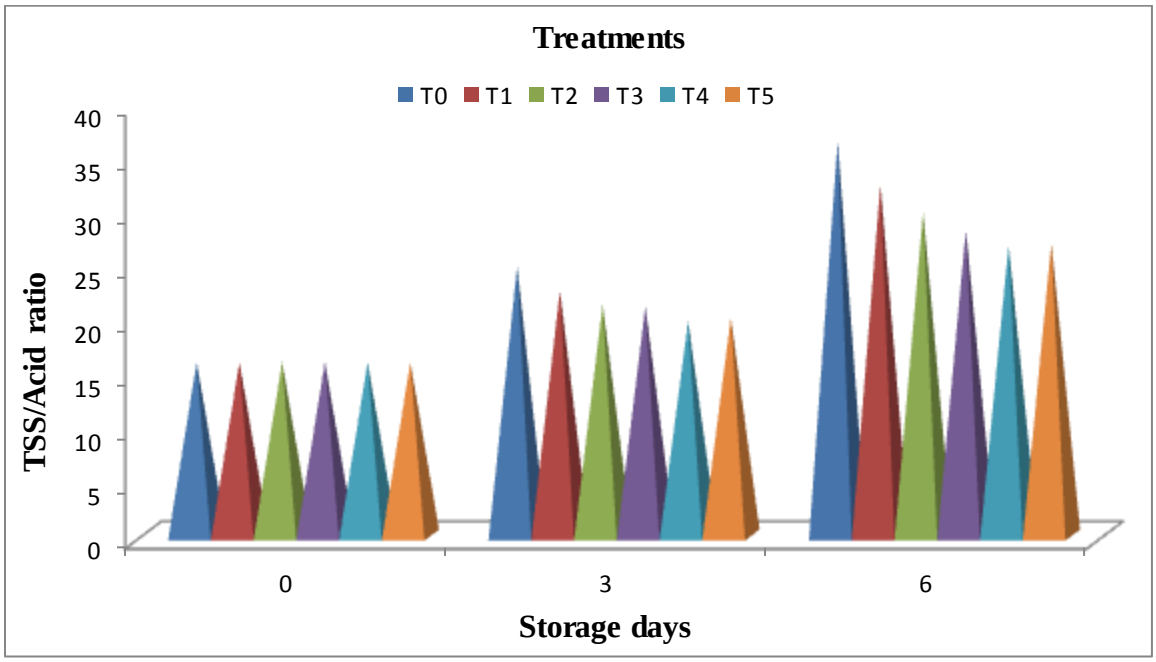

Fig. 23: Effect of various coating materials on TSS/Acid ratio of guava *cv.* Allahabad Safeda under ambient conditions

Experiment 3 (A) Effect of various edible coating & packaging on guava fruit *cv.* Allahabad Safeda under cold conditions (7°C)

4.7. Physiological parameters

4.7.1. Physiological loss in weight (%)

Data depicted in Table 24 and Fig. 24 showed that different packaging & coating materials had significant effect on PLW of guava fruit during storage. Among treatments, maximum PLW was observed in T_0 (6.57%) and minimum in T_5 (0.68%). PLW increase with increasing duration of storage showing maximum PLW of weight on 30^{th} day of storage (3.37%) and minimum on 3^{rd} day of storage (0.31%).

In general, fruit loss of weight of guava increases with increasing period of storage irrespective of coating & packaging materials used.

Table 24: Effect of various coating & packaging materials on PLW (%) of guava cv. Allahabad Safeda under cold condition (7°C)

Treatment Details	Storage Days										Mean
	3	6	9	12	15	18	21	24	27	30	
T_0	1.14	2.19	3.08	4.19	5.76	6.97	8.79	10.01	11.13	12.45	6.57
T_1	0.15	0.33	0.41	0.42	0.63	0.69	0.84	0.96	1.17	1.36	0.70
T_2	0.15	0.41	0.56	0.67	0.84	1.09	1.29	1.50	1.69	1.88	1.01
T_3	0.16	0.35	0.50	0.61	0.79	0.99	1.18	1.29	1.55	1.75	0.92
T_4	0.12	0.23	0.37	0.50	0.65	0.91	1.06	1.18	1.22	1.52	0.78
T_5	0.14	0.24	0.36	0.49	0.61	0.71	0.85	0.99	1.11	1.27	0.68
Mean	0.31	0.62	0.88	1.14	1.54	1.89	2.33	2.65	2.97	3.37	
C.D (at 5%)	0.039	0.158	0.154	0.233	0.200	0.358	0.393	0.451	0.401	0.511	

Treatments details

T_0 : Control (Chitosan 0.3% at cold temp. 7°C)
T_1 : Chitosan 0.3% + Cling (10µ)
T_2 : Chitosan 0.3% + HDPE (20µ)
T_3 : Chitosan 0.3% + PP (40µ)
T_4 : Chitosan 0.3% + PP (60µ)
T_5 : Chitosan 0.3% + LDPE (100µ)

CD(5%): Critical difference @ 5% level

In all the treatments, increase in PLW was observed with increase in storage period. This is because of moisture loss by transpiration and reserved food material by respiration. During respiration process, various reserved food materials present in fruits

are used. Also the process of transpiration from fruit surface continues even after harvest. Hence, due to respiration and transpiration of fruits, PLW increased with increase in storage period. The findings of investigations are in conformation with reports of **Joshi and Roy (1985)** in mango, **Aworth *et al.*, (1991)** in citrus, **Jitender *et al.*, (2000)** on kinnow & **Pandey *et al.*, (2006)** in apple.

In the report given by **Haard and Salunkhe (1975),** PLW is mainly because of the evaporation, respiration and various other degradation processes that occur during storage of fruits. In this investigation, minimum PLW was observed in T_5 and the highest in T_0 (control). This might happened because of restriction in dispersal of various gases and reaction mechanism that results in slow transpiration and respiration rate of fruits. The results are in conformation with findings of **Joshua and Sathiamoorthy (1993)** on sapota and **Venkatesha and Reddy (1994)** on guava.

4.8. Bio-chemical parameters

4.8.1 Vitamin C (mg/100gm)

Data depicted in Table 25 and Fig. 25 showed that different packaging & coating materials had major impact on vitamin C of guava fruits. Among treatments, maximum value (169.95) was observed in T_5 followed by T_4 (166.63) and minimum value in T_0 (157.85). Generally, vitamin C of guava decreases with increase in storage period. Maximum vitamin C (201.77) quantity was observed on 3rd day of storage and minimum (115.15) vitamin C was observed on 30th day.

Vitamin C of fruit gradually reduced in all the treatments during storage period because of enzymatic oxidation of ascorbic acid to dehydro-ascorbic acid in the existence of ascorbinase enzyme which might contribute to the reduction of vitamin C content of fruit. In this investigation, maximum vitamin C was observed in T_5 and the minimum in T_0 (control). These findings are in conformity with the reports given by **Das and Dash (1967)**. In comparison with control higher retention of vitamin C content was observed in fruits coated by different concentration of coating materials due to the low PLW accompanied by low respiration rate and transpirational losses. The results obtained from

this investigation are in conformity with reports earlier given by **Venkatesha and Reddy (1994)** in guava and **Sudha *et al*., (2007)** in sapota.

Table 25: Effect of various coating & packaging materials on vitamin C (mg/100gm) of guava *cv.* Allahabad Safeda under cold condition (7°C)

Treatment Details	Storage Days											Mean
	0	3	6	9	12	15	18	21	24	27	30	
T_0	212.56	197.25	188.11	176.56	168.54	156.50	144.26	136.56	128.26	120.18	107.58	157.85
T_1	212.56	201.46	194.86	185.97	176.15	166.12	155.27	143.16	133.64	125.61	115.25	163.12
T_2	212.56	201.56	191.52	180.26	170.26	162.26	149.36	138.96	130.26	123.60	112.91	161.23
T_3	212.56	203.48	194.20	183.50	172.78	164.12	150.89	141.48	133.01	123.94	114.37	164.55
T_4	212.56	202.25	193.61	186.78	178.90	169.78	158.36	147.47	135.65	128.69	118.90	166.63
T_5	212.56	204.63	196.14	188.61	181.54	174.63	162.78	155.17	141.25	130.29	121.90	169.95
Mean		201.77	193.07	183.61	174.69	165.56	153.48	143.80	133.67	125.38	115.15	
C.D (at 5%)		1.922	1.895	1.800	1.871	1.861	1.743	1.823	1.629	1.740	1.840	

Treatments details

T_0 : Control (Chitosan 0.3% at cold temp. 7°C)
T_1 : Chitosan 0.3% + Cling (10µ)
T_2 : Chitosan 0.3% + HDPE (20µ)
T_3 : Chitosan 0.3% + PP (40µ)
T_4 : Chitosan 0.3% + PP (60µ)
T_5 : Chitosan 0.3% + LDPE (100µ)

CD(5%): Critical difference @ 5% level

4.8.2. Total soluble solids (ºBrix)

Data presented in Fig. 26 and Table 26 shows the different packaging & coating materials had substantial effect on TSS of guava during storage period. Among treatments, the maximum value (10.02) was observed in T_0 and minimum value in T_4 (9.84) followed by T_5 (9.85). In general, TSS of guava increased up to 18th day but after that the TSS quantity decreased continuously with increase in storage period, irrespective of coating & packaging material used. Maximum total soluble solids (11.37) were observed on 18th days of storage and minimum (8.95) TSS was exhibited on 3rd day.

It was observed that, there was rise in TSS of fruits up to 18th day of storage and thereafter, TSS decreased in all the treatments up to 30th day of storage. Increase in TSS of guava fruits till 18th day of storage was correlated with increase in PLW and then

started decreasing up to 30th day because of consumption of sugars in respiration. The findings of this investigation are in conformation with the earlier findings of **Panwar (1980)** in ber. The maximum TSS was recorded in T_0 and the lowest TSS was observed in T_4. The coating materials used for fruits had less total soluble solids compared to control. This might be due to the lesser PLW and slow conversion of starch into sugars. Findings of this investigation are in conformation with former reports by **Venkatesha and Reddy (1994)** on guava fruit and **Meena *et al*., (2009)** on ber.

Table 26: Effect of various coating & packaging materials on TSS (ºBrix) of guava *cv*. Allahabad Safeda under cold condition (7°C)

Treatment Details	Storage Days											Mean
	0	3	6	9	12	15	18	21	24	27	30	
T_0	8.74	9.10	9.46	9.89	10.39	10.85	11.71	11.38	10.96	9.56	8.24	10.02
T_1	8.74	9.00	9.24	9.61	10.22	10.8	11.66	10.90	10.41	10.04	9.59	10.00
T_2	8.74	8.88	9.14	9.54	10.16	10.74	11.58	10.91	10.54	9.98	9.57	9.98
T_3	8.74	8.97	9.20	9.59	10.01	10.58	11.26	10.76	10.40	9.92	9.43	9.89
T_4	8.74	8.89	9.11	9.42	9.94	10.37	10.94	10.72	10.36	10.05	9.75	9.84
T_5	8.74	8.91	9.17	9.46	9.98	10.50	11.12	10.81	10.45	9.86	9.35	9.85
Mean		8.95	9.22	9.58	10.11	10.64	11.37	10.91	10.52	9.90	9.32	
C.D (at 5%)		0.086	0.091	0.091	0.082	0.089	0.098	0.091	0.092	0.089	0.089	

Treatments details

T_0 : Control (Chitosan 0.3% at cold temp. 7°C)
T_1 : Chitosan 0.3% + Cling (10µ)
T_2 : Chitosan 0.3% + HDPE (20µ)
T_3 : Chitosan 0.3% + PP (40µ)
T_4 : Chitosan 0.3% + PP (60µ)
T_5 : Chitosan 0.3% + LDPE (100µ)

CD(5%): Critical difference @ 5% level

4.8.3. Acidity (%)

Data presented in Fig. 27 and table 27 showed that different coating & packaging materials had substantial effect on acidity of guava during storage period. Among treatments, maximum value (0.50) was observed in T_5 followed by T_4 (0.48), and T_3 (0.47).While minimum in T_0 (0.43). In general, acidity of guava decreases with increasing period of storage irrespective of coating & packaging materials used. Maximum acidity (0.61) was recorded on day 3 and lowest acidity (0.27) on day 30.

In all treatments, acidity of guava fruits observed to be decreased with the increasing period of storage. This is because of increased activity of invertase enzyme. This enzyme is responsible for transformation of acid into sugar and because of utilization of acids in metabolic activities. In this investigation, the highest recorded acidity value is in T_5 and the lowest in T_0 (control). The findings are similar with studies done by **Damodaran *et al*., (2001)** on sapota and **Yadav *et al*., (2010)** on kinnow. Fruits coated in coating material of different concentration retained more acidity in comparison with control. This is because of slow transformation of acids into sugars during ripening. These outcomes are in conformity with former reports of **Wavhal and Athale (1988)** in mango and **Nunes *et al*., (2006)** in strawberry.

Table 27: Effect of various coating & packaging materials on acidity (%) of guava *cv.* Allahabad Safeda under cold condition (7°C)

Treatment Details	Storage Days											Mean
	0	3	6	9	12	15	18	21	24	27	30	
T_0	0.65	0.59	0.55	0.49	0.45	0.41	0.38	0.34	0.31	0.28	0.22	0.43
T_1	0.65	0.61	0.57	0.52	0.48	0.44	0.40	0.36	0.32	0.28	0.24	0.44
T_2	0.65	0.60	0.57	0.53	0.48	0.44	0.41	0.36	0.33	0.30	0.25	0.45
T_3	0.65	0.62	0.59	0.56	0.51	0.48	0.44	0.38	0.37	0.31	0.28	0.47
T_4	0.65	0.63	0.60	0.56	0.53	0.49	0.46	0.40	0.36	0.33	0.31	0.48
T_5	0.65	0.63	0.60	0.57	0.55	0.51	0.48	0.45	0.41	0.37	0.31	0.50
Mean		0.61	0.58	0.54	0.50	0.46	0.43	0.38	0.35	0.31	0.27	
C.D (at 5%)		0.018	0.031	0.032	0.039	0.047	0.044	0.065	0.061	0.056	0.058	

Treatments details

T_0 : Control (Chitosan 0.3% at cold temp. 7°C)
T_1 : Chitosan 0.3% + Cling (10µ)
T_2 : Chitosan 0.3% + HDPE (20µ)
T_3 : Chitosan 0.3% + PP (40µ)
T_4 : Chitosan 0.3% + PP (60µ)
T_5 : Chitosan 0.3% + LDPE (100µ)
CD(5%): Critical difference @ 5% level

4.8.4. Total sugars (%)

Data presented in Fig. 28 and table 28 displayed that different coating & packaging materials had substantial effect on total sugars of guava fruits. Among treatments, the highest value (12.05) was observed in T_0 and minimum value in T_3

(11.80) followed by T_5 (11.81). In general, total sugars of guava increases up to 18th days but after that the total sugars quantity decreased continuously with increasing storage period irrespective of packaging & coating material used. Maximum total sugars (13.82) were observed on 18th day and lowest (13.75) on 30th day.

Table 28: Effect of various coating & packaging materials on total sugars (%) of guava *cv.* Allahabad Safeda under cold condition (7°C)

Treatment Details	Storage Days											Mean
	0	3	6	9	12	15	18	21	24	27	30	
T_0	10.78	10.94	11.12	12.43	13.06	13.43	14.86	13.88	12.14	10.14	09.77	12.05
T_1	10.78	10.9	11.03	11.66	12.18	13.23	14.06	13.36	12.43	11.85	10.74	12.02
T_2	10.78	10.85	10.97	11.51	12.11	13.1	13.81	13.4	12.62	11.72	10.83	11.97
T_3	10.78	10.9	11.2	11.52	12.03	12.72	13.48	12.83	12.4	11.32	10.72	11.80
T_4	10.78	10.98	11.13	11.74	11.98	12.85	13.65	13.1	12.32	11.58	10.92	11.91
T_5	10.78	10.84	11.02	11.4	11.85	12.46	13.11	12.88	12.29	11.76	11.53	11.81
Mean		10.90	11.07	11.71	12.20	12.96	13.82	13.24	12.36	11.39	10.75	
C.D (at 5%)		0.049	0.148	0.130	0.145	0.133	0.158	0.167	0.138	0.144	0.155	

Treatments details

T_0 : Control (Chitosan 0.3% at cold temp. 7°C)
T_1 : Chitosan 0.3% + Cling (10µ)
T_2 : Chitosan 0.3% + HDPE (20µ)
T_3 : Chitosan 0.3% + PP (40µ)
T_4 : Chitosan 0.3% + PP (60µ)
T_5 : Chitosan 0.3% + LDPE (100µ)

CD(5%): Critical difference @ 5% level

In the findings, there is significant rise in total sugars up to 18th day. This is because of accumulation of starch into sugars. It was found that total sugars started to decline because of degradative process. These findings are in conformity with previous reports in pear by **Mohla *et al*. (2005),** on mango fruits by **Upadhyay and Tripathi (1985)**, and on mango by **Periyathambi (2006)**. Highest total sugars were recorded in T_0, whereas, the least total sugar was found in T_3 in different type of wrapping and coating. The fruits wrapped and coated retained less total sugars as compared to control. This might be correlated with decrease in PLW in polythene wrapped and coated fruits as

compared to control fruit. These observations are similar with those obtained by **Venkatesha and Reddy (1994)** in guava.

4.8.5. Reducing sugars (%)

Data presented in Fig. 29 and Table 29 showed that different coating materials had substantial impact on reducing sugars of guava fruits. Among treatments, the highest value (7.12) was observed in T_0 and minimum value in T_5 (6.72) followed by T_3 (6.77). In general, reducing sugars of guava increased up to 18^{th} days but after that the reducing sugars quantity decreased continuously in all the treatments with increase in storage period irrespective of coating & packaging material used. Maximum reducing sugars (8.40) were observed on 18^{th} days of storage and minimum reducing sugars (4.65) were observed on 30^{th} day.

Table 29: Effect of various coating & packaging materials on reducing sugars (%) of guava *cv.* Allahabad Safeda under cold condition (7°C)

Treatment Details	Storage Days											Mean
	0	3	6	9	12	15	18	21	24	27	30	
T_0	6.12	6.61	7.11	7.56	8.04	8.51	8.97	8.24	7.25	5.98	3.95	7.12
T_1	6.12	6.60	6.95	7.34	7.96	8.31	8.71	8.10	7.11	6.77	4.16	7.10
T_2	6.12	6.55	6.84	7.26	7.84	8.13	8.49	7.86	6.98	6.41	4.51	7.09
T_3	6.12	6.35	6.56	7.80	7.12	7.56	8.04	7.61	6.74	5.83	4.84	6.77
T_4	6.12	6.52	6.72	7.02	7.51	7.88	8.24	7.77	6.91	6.13	4.88	6.88
T_5	6.12	6.28	6.45	6.68	6.94	7.21	7.96	7.38	6.95	6.41	5.54	6.72
Mean		6.48	6.77	7.27	7.56	7.93	8.40	7.82	6.99	6.25	4.65	
C.D (at 5%)		0.113	0.115	0.125	0.120	0.125	0.123	0.121	0.131	0.128	0.125	

Treatments details

T_0 : Control (Chitosan 0.3% at cold temp. 7°C)
T_1 : Chitosan 0.3% + Cling (10µ)
T_2 : Chitosan 0.3% + HDPE (20µ)
T_3 : Chitosan 0.3% + PP (40µ)
T_4 : Chitosan 0.3% + PP (60µ)
T_5 : Chitosan 0.3% + LDPE (100µ)

CD(5%): Critical difference @ 5% level

In the findings, there is significant rise in reducing sugars up to 18^{th} day. This is because of accumulation of starch into sugars. It was found that reducing sugars started to

decline because of degradative process. The maximum reducing sugars was exhibited in T_0 & lowest reducing sugars was found in T_5 in different type of coating. The fruits coated in different concentration of coating materials retained less reducing sugars in comparison to control. This might be correlated with decrease in PLW in coated fruits as compared to control. The findings of investigation are in confirmation with reports of **Reddy *et al*., (2014), Dutta *et al*., (2017)** and **Yadav *et al*., (2010)** on guava fruits. The results are well supported by **Jagdeesh (1994)** on corn starch coated fruits, **Singh *et al*., (2017)** on kinnow fruits.

4.8.6. Non-reducing sugars (%)

Data presented in Fig. 30 and Table 30 showed that different coating materials had substantial impact on non-reducing sugars of guava fruits. Among treatments, the highest value (4.95) was observed in T_5 and minimum value in T_1 (4.63). Highest non-reducing sugars (6.14) were observed on 30th days and lowest non-reducing sugars (4.09) were observed on day 6.

Table 30: Effect of various coating & packaging materials on non-reducing sugars (%) of guava *cv.* Allahabad Safeda under cold condition (7°C)

Treatment Details	Storage Days											Mean
	0	3	6	9	12	15	18	21	24	27	30	
T_0	4.43	4.11	3.81	4.63	4.77	4.67	5.04	5.36	5.37	5.89	5.72	4.89
T_1	4.43	4.09	3.88	4.11	4.01	4.67	5.08	5.00	5.05	4.83	5.78	4.63
T_2	4.43	4.09	3.92	4.04	4.06	4.72	5.06	5.26	5.36	5.04	6.00	4.72
T_3	4.43	4.24	4.19	4.49	4.25	4.72	5.14	5.06	5.14	5.18	6.25	4.83
T_4	4.43	4.32	4.41	3.54	4.66	4.91	5.17	4.96	5.38	5.22	6.50	4.86
T_5	4.43	4.34	4.34	4.49	4.66	4.99	4.89	5.03	5.36	5.38	6.64	4.95
Mean		4.2	4.09	4.21	4.4	4.78	5.06	5.11	5.27	5.25	6.14	
C.D (at 5%)		0.063	0.108	0.033	0.139	0.111	0.161	0.149	0.109	0.207	0.042	

Treatments details

T_0 : Control (Chitosan 0.3% at cold temp. 7°C)
T_1 : Chitosan 0.3% + Cling (10µ)
T_2 : Chitosan 0.3% + HDPE (20µ)
T_3 : Chitosan 0.3% + PP (40µ)
T_4 : Chitosan 0.3% + PP (60µ)
T_5 : Chitosan 0.3% + LDPE (100µ)

CD(5%): Critical difference @ 5% level

In general, non-reducing sugars of guava increased with increase in storage period up to 18th day after that decreased irrespective of coating and packaging material used. The reduction in non-reducing sugars is due to the hydrolysis of starch in the fruits at early stage and after that it is because of consumption of sugars in the process of respiration. The outcome of findings are in conformation with similar finding of **Kumar *et al*., (2012)** & **Yadav *et al*., (2010)** on guava and **Jholgiker and Reddy (2007)** in custard apple fruits. Lowest value of non-reducing sugars was recorded in T_1 and the maximum value was recorded in T_5 among different coating materials.

4.8.7. Sugar/Acid ratio

Data presented in Fig. 31 and table 31 displayed that different packaging and coating materials had substantial impact on sugar/acid ratio of guava during storage. Among treatments, the maximum value (31.11) was observed in T_0 and minimum value in T_5 (24.82). In general, sugar/acid ratio of guava increases with increasing storage period irrespective of coating and packaging material used. Maximum sugar/acid ratio (40.53) was observed on 30th days of storage and minimum sugar/acid ratio (17.79) was observed on 3rd day.

Table 31: Effect of various coating & packaging materials on sugar/acid ratio of guava *cv.* Allahabad Safeda under cold condition (7°C)

Treatment Details	Storage Days											Mean
	0	3	6	9	12	15	18	21	24	27	30	
T_0	16.58	18.54	20.22	25.37	29.02	32.76	39.11	40.82	39.16	36.21	44.41	31.11
T_1	16.58	17.87	19.35	22.42	25.38	30.07	35.15	37.11	38.84	42.32	44.75	29.99
T_2	16.58	18.08	19.25	21.72	25.23	29.77	33.68	37.22	38.24	39.07	43.32	29.29
T_3	16.58	17.58	18.98	20.57	23.59	26.50	30.64	33.76	33.51	36.52	38.29	26.96
T_4	16.58	17.43	18.55	20.96	22.60	26.22	29.67	32.75	34.22	35.09	35.23	26.30
T_5	16.58	17.21	18.37	20.00	21.55	24.43	27.31	28.62	29.98	31.78	37.19	24.82
Mean		17.79	19.12	21.84	24.56	28.29	32.59	35.05	35.66	36.83	40.53	
C.D (at 5%)		0.445	0.887	1.182	1.797	2.649	3.102	5.567	5.996	6.637	8.903	

Treatments details

T_0 : Control (Chitosan 0.3% at cold temp. 7°C)
T_1 : Chitosan 0.3% + Cling (10µ)
T_2 : Chitosan 0.3% + HDPE (20µ)
T_3 : Chitosan 0.3% + PP (40µ)
T_4 : Chitosan 0.3% + PP (60µ)
T_5 : Chitosan 0.3% + LDPE (100µ)

CD(5%): Critical difference @ 5% level

In the current study, the highest sugar-acid ratio was observed in T_0 and the minimum in T_5. The total sugars present in the fruit maintained the quantity of simple sugar due to this the ratio increase or decrease during the period of storage with respect to acid quantity.

4.8.8 TSS/Acid ratio

Data presented in Fig. 32 and Table no. 32 showed that different packaging and coating materials had substantial effect on TSS/acid ratio of guava fruits. Among treatments, the maximum value (26.09) was observed in T_0 and minimum value in T_5 (20.70). In general, TSS/acid ratio of guava increases with increasing period of storage up to 30th days but in certain treatments it has been following descending trend. Maximum TSS/acid ratio (35.16) was observed on 30th DAS and least TSS/acid ratio (14.62) was recorded on 3rd day.

Table 32: Effect of various coating & packaging materials on TSS/Acid ratio of guava *cv.* Allahabad Safeda under cold condition (7°C)

Treatment Details	Storage Days											Mean
	0	3	6	9	12	15	18	21	24	27	30	
T_0	13.45	15.42	17.20	20.18	23.09	26.46	30.82	33.47	35.35	34.14	37.45	26.09
T_1	13.45	14.75	16.21	18.48	21.29	24.55	29.15	30.28	32.53	35.86	39.96	25.14
T_2	13.45	14.80	16.04	18.00	21.17	24.41	28.24	30.31	31.94	33.27	38.28	24.54
T_3	13.45	14.47	15.59	17.13	19.63	22.04	25.59	28.32	28.11	32.00	33.68	22.73
T_4	13.45	14.11	15.18	16.82	18.75	21.16	23.78	26.80	28.78	30.45	31.45	21.89
T_5	13.45	14.14	15.28	16.60	18.15	20.59	23.17	24.02	25.49	26.65	30.16	20.7
Mean		14.62	15.92	17.87	20.35	23.20	26.79	28.87	30.37	32.06	35.16	
C.D (at 5%)		0.455	0.835	1.084	1.508	2.414	2.839	4.913	5.438	5.913	7.997	

Treatments details

T_0	:	Control (Chitosan 0.3% at cold temp. 7°C)	T_3	:	Chitosan 0.3% + PP (40µ)
T_1	:	Chitosan 0.3% + Cling (10µ)	T_4	:	Chitosan 0.3% + PP (60µ)
T_2	:	Chitosan 0.3% + HDPE (20µ)	T_5	:	Chitosan 0.3% + LDPE (100µ)

CD(5%): Critical difference @ 5% level

The TSS/acid ratio of fruit increases or decreased according to the coating and packaging materials or treatments with an increase in period of fruit storage. In this present study, highest TSS/acid ratio was recorded in T_0 and the minimum in T_5. Rise in TSS/acid ratio with respect to storage period was stated by **Joubert (1970)** in litchi and **Navjot (2005)** in peach.

4.8.9. Phenol (mg TAE g-1 DW)

Data presented in Fig. 33 and table 33 showed that different coating and packaging materials had substantial effect on phenol content of guava during storage period. Among treatments, the maximum value (25.34) was observed in T_5 followed by T_4 (25.06) and minimum value in T_0 (23.59). In general, phenol content of guava decreases with increase of storage period up to 30^{th} days, irrespective of coating and packaging material used. Maximum phenol value (27.68) was observed on 3^{rd} day of storage and minimum phenol value (18.07) was observed on 30^{th} day.

In the findings, there is significant decrease in phenol content during the storage period. In fruits, phenols act as antioxidants (**Heinonen *et al*., 1998**). Several factors during storage of fruits may affect the phenol content in fruits. Those factors include the stress due to temperature and carbon dioxide. The highest phenol content was exhibited in T_5 & lowest phenol was found in T_0. During storage, the phenol content of fruit decreases and this may be influenced by storage conditions. Packed fruits resulted with better phenol content than control fruits. The results are in agreement with the study of **Kim *et al*., (2007)** on mango.

Table 33: Effect of various coating & packaging materials on phenol (mg TAE g-1 DW) of guava *cv.* Allahabad Safeda under cold condition (7°C)

Treatment Details	Storage Days											Mean
	0	3	6	9	12	15	18	21	24	27	30	
T_0	28.08	27.44	27.11	26.71	25.22	24.38	23.11	22.32	20.37	18.59	16.22	23.59
T_1	28.08	27.69	27.32	26.84	25.99	25.42	24.27	23.17	21.89	20.06	17.42	24.38
T_2	28.08	27.64	27.22	26.80	25.78	25.12	23.94	22.68	21.26	19.76	17.03	24.12
T_3	28.08	27.75	27.34	26.87	26.24	25.75	24.71	23.57	22.24	20.41	18.56	24.68
T_4	28.08	27.80	27.45	26.92	26.36	25.86	25.19	24.03	23.12	21.68	19.14	25.06
T_5	28.08	27.80	27.51	27.02	26.59	26.06	25.61	24.48	23.36	22.19	20.07	25.34
Mean		27.68	27.32	26.86	26.03	25.43	24.47	23.37	22.06	20.44	18.07	
C.D (at 5%)		0.240	0.257	0.173	0.185	0.191	0.206	0.224	0.199	0.228	0.203	

Treatments details

T_0 : Control (Chitosan 0.3% at cold temp. 7°C)
T_1 : Chitosan 0.3% + Cling (10µ)
T_2 : Chitosan 0.3% + HDPE (20µ)
T_3 : Chitosan 0.3% + PP (40µ)
T_4 : Chitosan 0.3% + PP (60µ)
T_5 : Chitosan 0.3% + LDPE (100µ)

CD(5%): Critical difference @ 5% level

4.8.10. DPPH (%)

Data presented in Fig. 34 and Table 34 displayed that different coating and packaging materials had substantial effect on DPPH content of guava during storage period. Among treatments, the maximum value (3.78) was observed in T_5 followed by T_4 (3.69) and minimum value in T_0 (3.29). In general, DPPH content of guava decreased with increase in storage period up to 30^{th} days, irrespective of coating and packaging material used. Maximum DPPH value (4.70) was observed on 3^{rd} day of storage and minimum DPPH value (1.77) was observed on 30^{th} day.

In the findings, there is significant decrease in DPPH content during the storage period. In fruits, DPPH act as antioxidants (**Heinonen *et al*., 1998**). Several factors during storage of fruits may affect the DPPH content in fruits. Those factors include the stress due to temperature and carbon dioxide. The highest DPPH content was exhibited in T_5 & lowest DPPH was found in T_0. During storage, the DPPH content of fruit decreases and this may be influenced by storage conditions. Therefore, packed fruits resulted in

more DPPH content than control fruits. The results are in agreement with the study of **Kim *et al.*, (2007)** on mango.

Table 34: Effect of various coating & packaging materials on DPPH (%) of guava *cv.* Allahabad Safeda under cold condition (7°C)

Treatment Details	Storage Days											Mean
	0	3	6	9	12	15	18	21	24	27	30	
T_0	4.86	4.57	4.33	4.06	3.8	3.41	3.07	2.69	2.31	1.77	1.34	3.29
T_1	4.86	4.68	4.44	4.18	3.98	3.55	3.22	2.95	2.65	2.22	1.67	3.49
T_2	4.86	4.74	4.51	4.24	4.02	3.61	3.34	3.05	2.78	2.37	1.84	3.58
T_3	4.86	4.65	4.40	4.12	3.91	3.48	3.17	2.87	2.52	2.14	1.51	3.42
T_4	4.86	4.75	4.58	4.34	4.09	3.77	3.51	3.18	2.92	2.58	2.01	3.69
T_5	4.86	4.78	4.63	4.40	4.17	3.93	3.65	3.26	3.04	2.66	2.25	3.78
Mean		4.70	4.48	4.22	3.99	3.63	3.33	3.00	2.70	2.29	1.77	
C.D (at 5%)		0.092	0.125	0.096	0.098	0.102	0.093	0.099	0.109	0.114	0.112	

Treatments details

T_0 : Control (Chitosan 0.3% at cold temp. 7°C)
T_1 : Chitosan 0.3% + Cling (10µ)
T_2 : Chitosan 0.3% + HDPE (20µ)
T_3 : Chitosan 0.3% + PP (40µ)
T_4 : Chitosan 0.3% + PP (60µ)
T_5 : Chitosan 0.3% + LDPE (100µ)

CD(5%): Critical difference @ 5% level

Graphical presentation of experiment 3 (A)

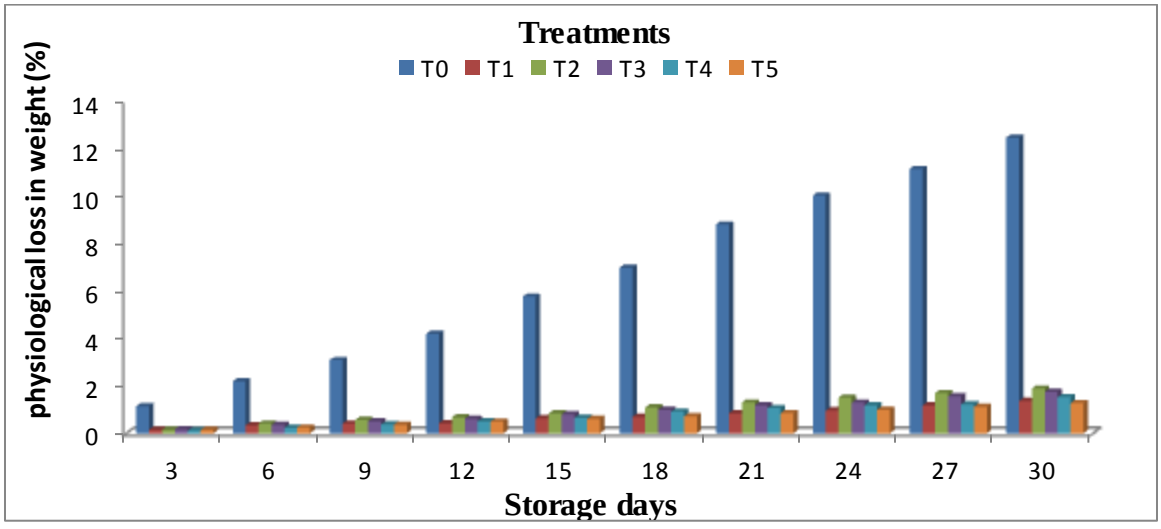

Fig. 24: Effect of various coating & packaging materials on PLW of guava *cv.* Allahabad Safeda under cold condition (7°C)

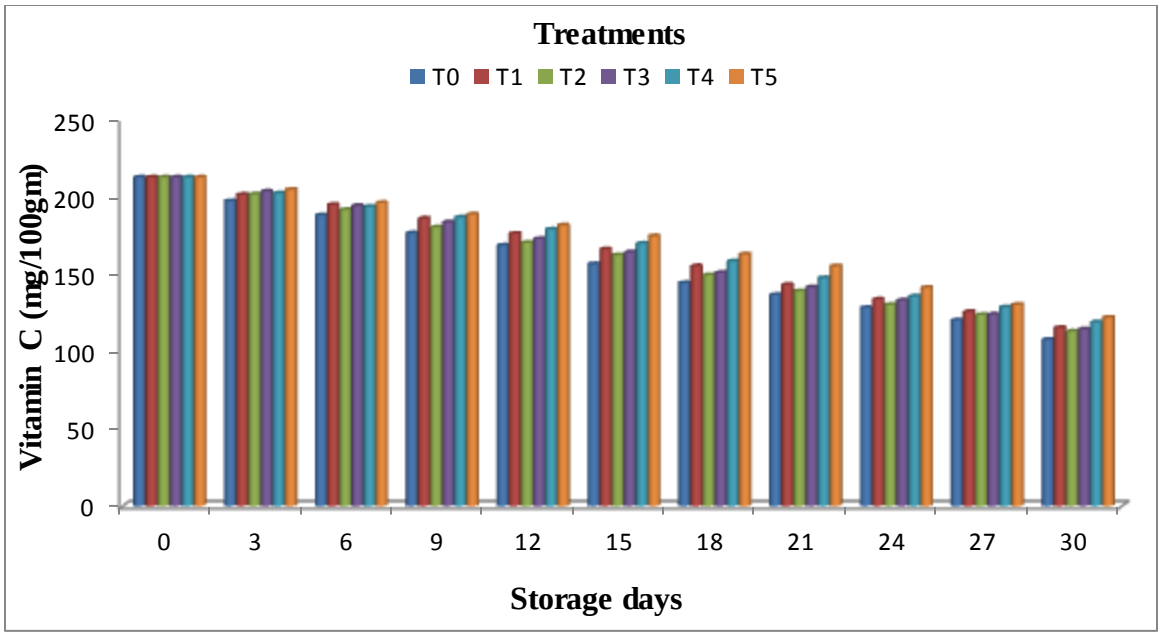

Fig. 25: Effect of various coating & packaging materials on vitamin C of guava *cv.* Allahabad Safeda under cold condition (7°C)

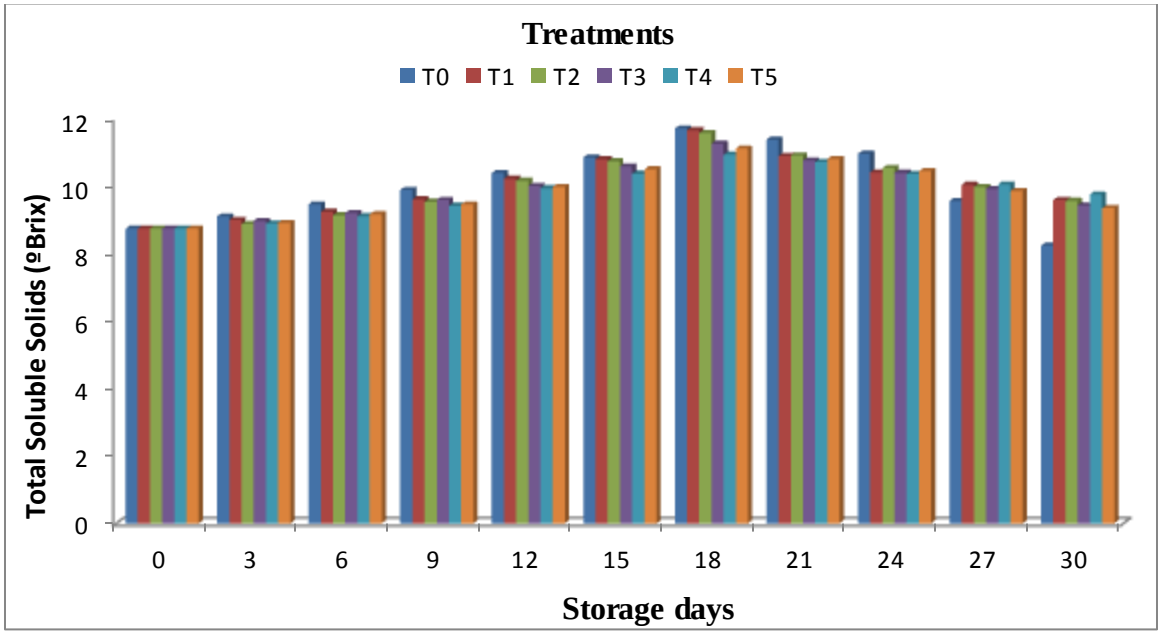

Fig. 26: Effect of various coating & packaging materials on TSS of guava *cv.* Allahabad Safeda under cold condition (7°C)

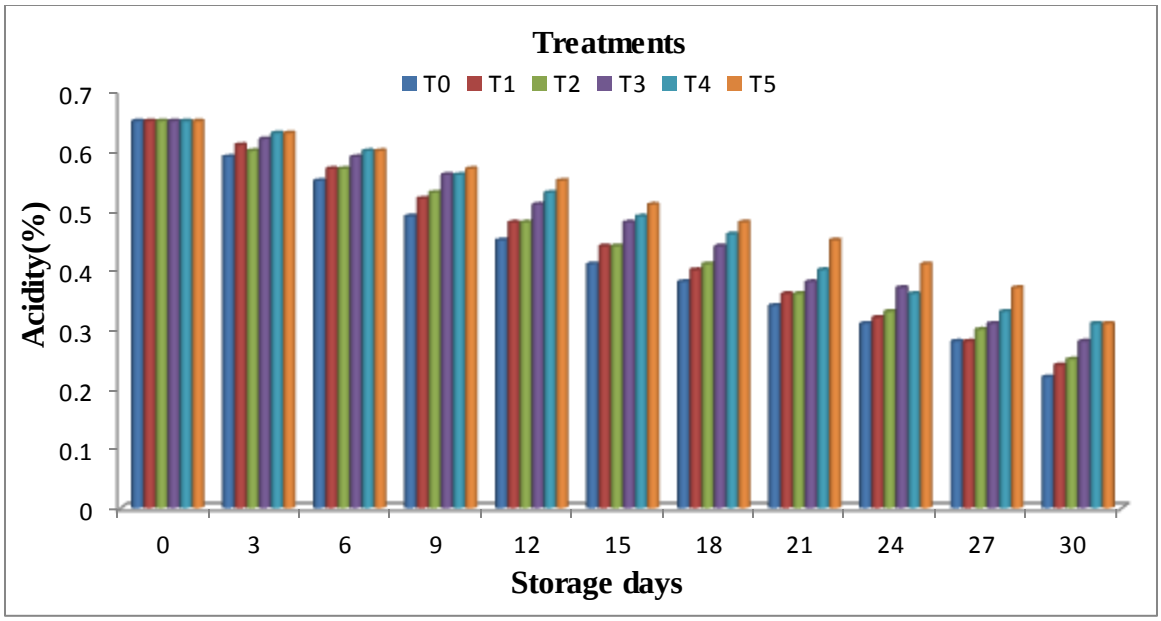

Fig. 27: Effect of various coating & packaging materials on acidity of guava *cv.* Allahabad Safeda under cold condition (7°C)

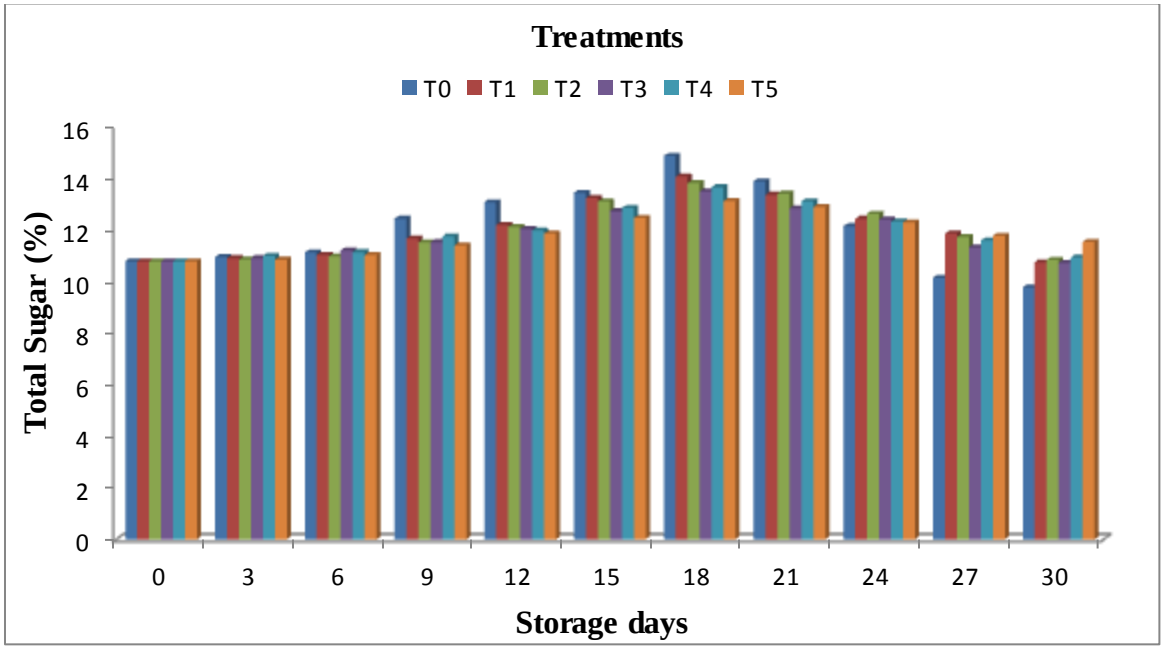

Fig. 28: Effect of various coating & packaging materials on total sugars of guava *cv.* Allahabad Safeda under cold condition (7°C)

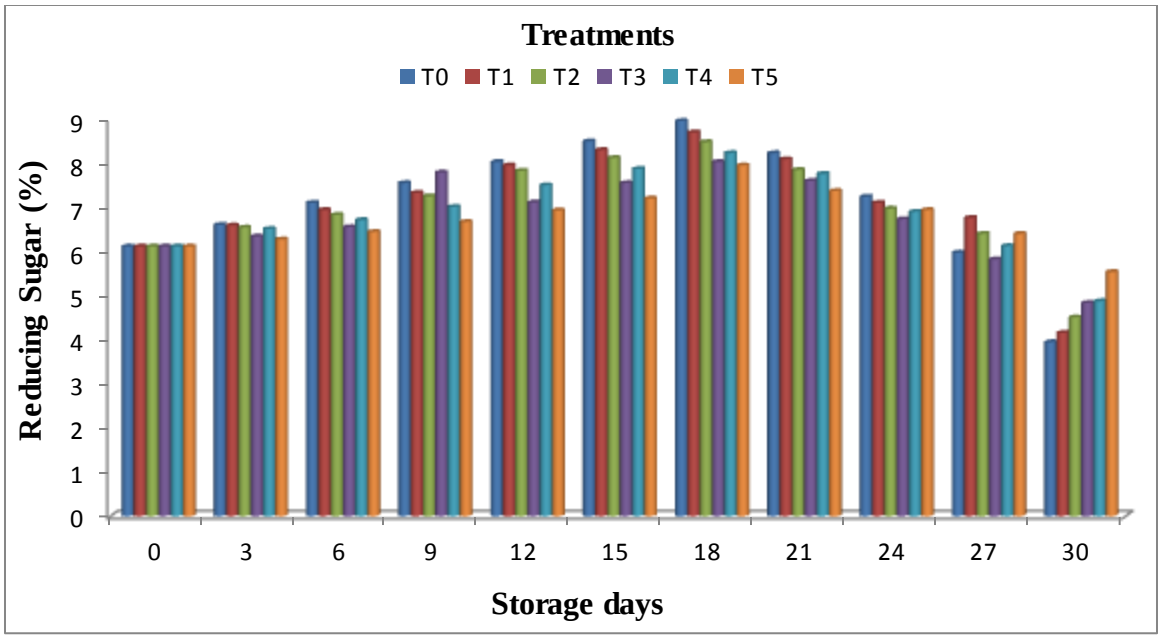

Fig. 29: Effect of various coating & packaging materials on reducing sugars of guava *cv.* Allahabad Safeda under cold condition (7°C)

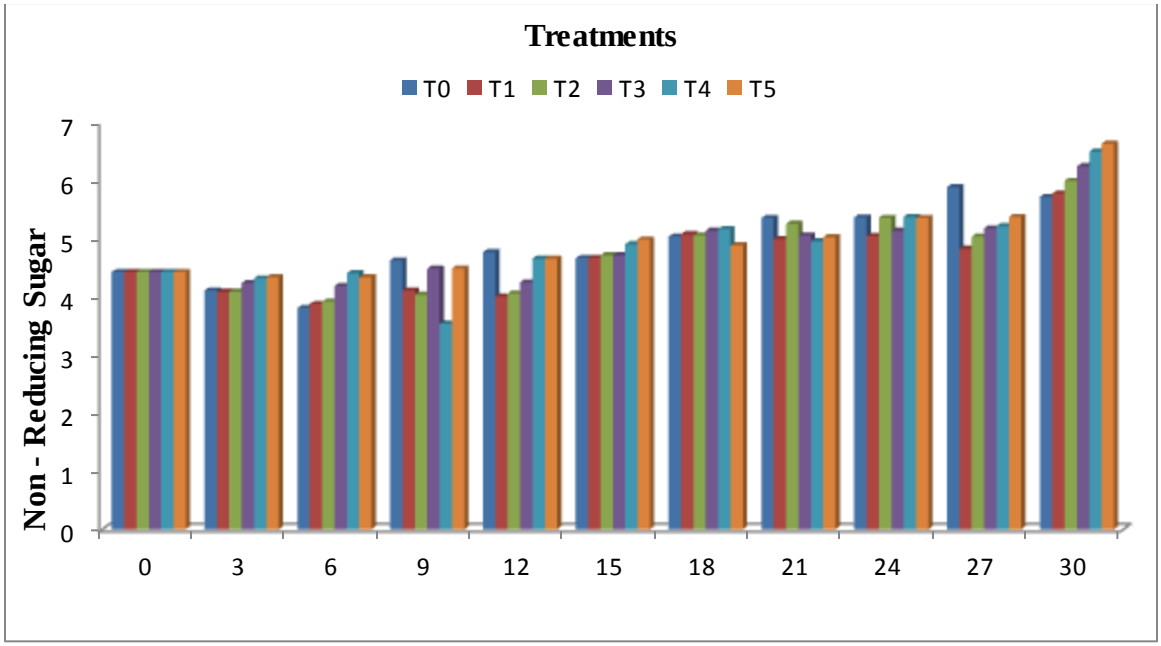

Fig. 30: Effect of various coating & packaging materials on non-reducing sugars of guava *cv.* Allahabad Safeda under cold condition (7°C)

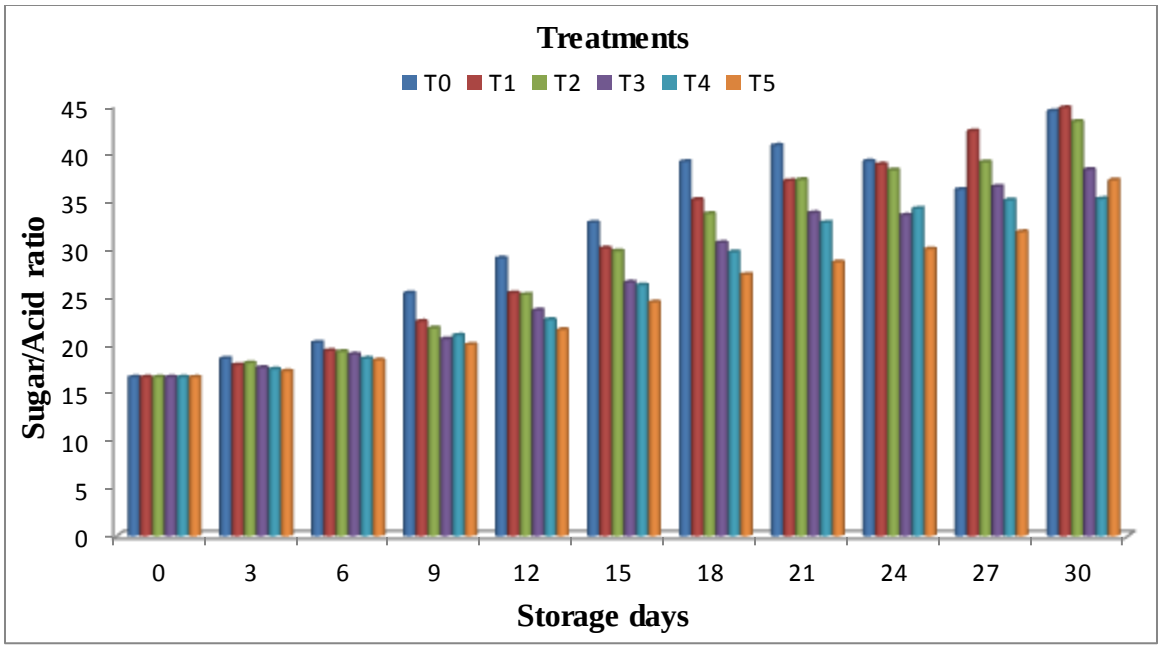

Fig. 31: Effect of various coating & packaging materials on sugar/acid ratio of guava *cv.* Allahabad Safeda under cold condition (7°C)

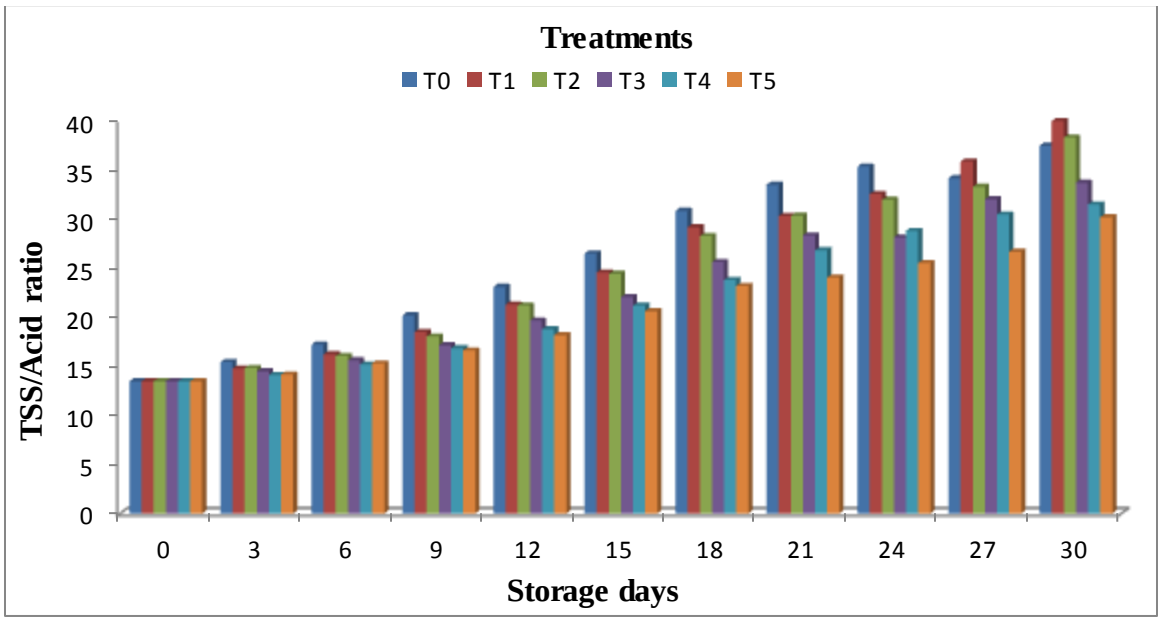

Fig. 32: Effect of various coating & packaging materials on TSS/Acid ratio of guava *cv.* Allahabad Safeda under cold condition (7°C)

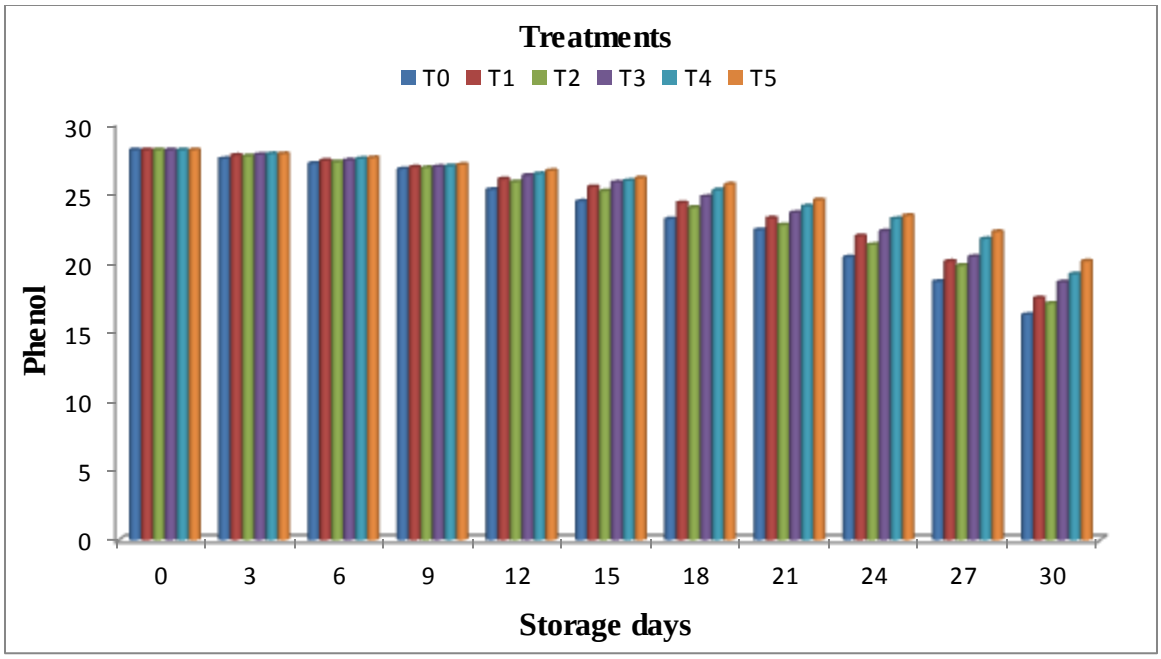

Fig. 33: Effect of various coating & packaging materials on phenol of guava *cv.* Allahabad Safeda under cold condition (7°C)

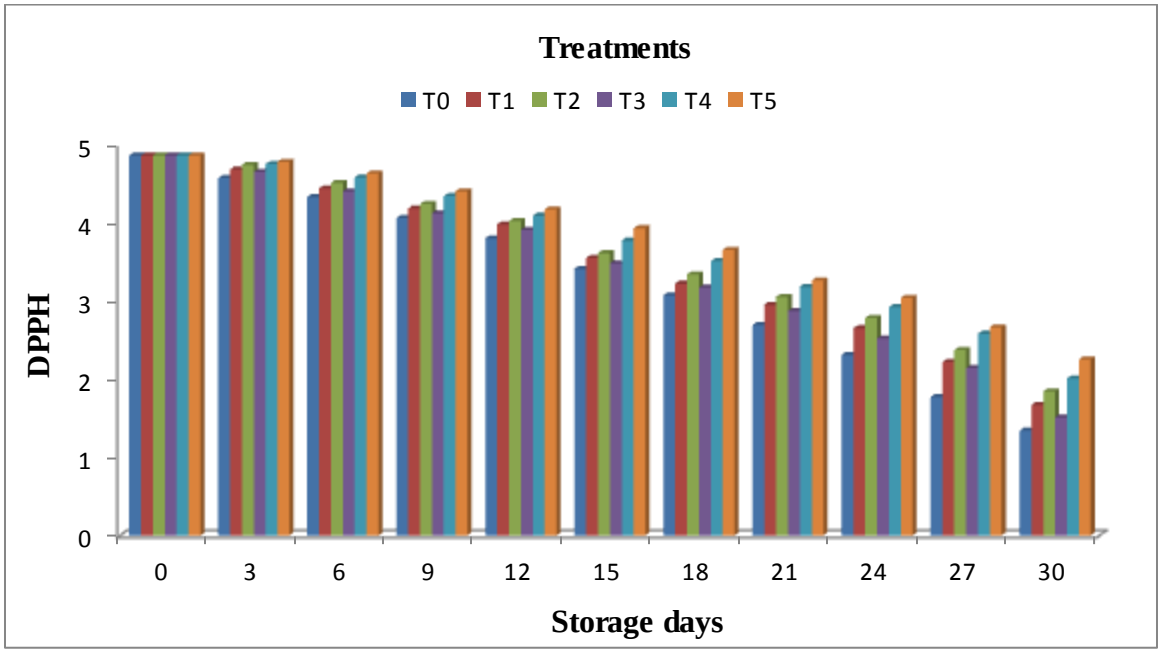

Fig. 34: Effect of various coating & packaging materials on DPPH of guava *cv.* Allahabad Safeda under cold condition (7°C)

Experiment 3 (B) Effect of various edible coating & packaging on guava fruit *cv.* Allahabad Safeda under ambient conditions

4.9. Physiological parameters

4.9.1. Physiological loss in weight (%)

Data depicted in Table 35 and Fig. 35 showed that different packaging & coating materials had significant effect on PLW of guava fruit during storage. Among treatments, maximum PLW was observed in T_0 (5.96%) and minimum in T_5 (1.10%). PLW increase with increasing duration of storage showing maximum PLW on day 21 (5.37%) and minimum on day 3 (0.35%).In general, fruit loss of weight of guava increased with increasing period of storage irrespective of coating & packaging materials used.

In all the treatments, increase in PLW was observed with increase in storage period. This is because of moisture loss by transpiration and reserved food material by respiration. During respiration process, various reserved food materials present in fruits are used. Also the process of transpiration from fruit surface continues even after harvest. Hence, due to respiration and transpiration of fruits, PLW increased with increase in storage period. The findings of investigations are in conformation with reports of **Joshi and Roy (1985)** in mango, **Aworth *et al.*, (1991)** in citrus, **Jitender *et al.*, (2000)** on kinnow & **Pandey *et al.*, (2006)** in apple.

In the report given by **Haard and Salunkhe (1975),** PLW is mainly because of the transpiration, respiration and various other degradation processes that occur during storage of fruits. In this investigation, minimum PLW was observed in T_5 and the highest in T_0 (control). This might happened because of restriction in dispersal of various gases and reaction mechanism that results in slow transpiration and respiration rate of fruits. The results are in conformation with findings of **Joshua and Sathiamoorthy (1993)** on sapota and **Venkatesha and Reddy (1994)** on guava.

Table 35: Effect of various coating & packaging materials on PLW (%) of guava *cv.* Allahabad Safeda under ambient conditions

Treatment Details	Storage Days							Mean
	3	6	9	12	15	18	21	
T_0	0.73	2.26	3.76	6.03	7.81	9.07	12.09	5.96
T_1	0.6	1.49	2.15	3.38	4.41	5.49	6.04	3.37
T_2	0.21	0.87	1.29	1.96	2.93	3.29	4.56	2.16
T_3	0.12	0.75	1.18	1.61	2.17	2.76	3.52	1.73
T_4	0.26	1.09	1.52	2.01	2.46	2.95	3.98	2.04
T_5	0.19	0.62	0.84	1.05	1.37	1.62	2.02	1.10
Mean	0.35	1.18	1.79	2.67	3.52	4.19	5.37	
C.D (at 5%)	0.142	0.901	1.173	1.427	0.945	0.110	0.253	

Treatments details

T_0 : Control (Chitosan 0.3% at ambient temp.)
T_1 : Chitosan 0.3% + Cling (10µ)
T_2 : Chitosan 0.3% + HDPE (20µ)
T_3 : Chitosan 0.3% + PP (40µ)
T_4 : Chitosan 0.3% + PP (60µ)
T_5 : Chitosan 0.3% + LDPE (100µ)

CD(5%): Critical difference @ 5% level

4.10. Bio-chemical parameters

4.10.1. Vitamin C (mg/100gm)

Data depicted in Table 36 and Fig. 36 showed that different packaging & coating materials had major impact on vitamin C of guava fruits. Among treatments, maximum value (181.51) was observed in T_5 followed by T_4 (179.83) and minimum value in T_0 (165.46). In general, vitamin C of guava decreases with increasing period of storage. Maximum vitamin C (201.59) quantity was observed on 3rd day of storage and minimum (134.46) vitamin C was observed on 21st day.

Vitamin C of fruit gradually reduced in all the treatments during storage period because of enzymatic oxidation of ascorbic acid to dehydro-ascorbic acid in the existence of ascorbinase enzyme which might contribute to the reduction of vitamin C content of fruit. In this investigation, maximum vitamin C was observed in T_5 and the minimum in T_0 (control). These findings are in conformity with the reports given by **Das and Dash (1967)**. In comparison with control higher retention of vitamin C content was observed in

fruits coated by different concentration of coating materials due to the low PLW accompanied by low respiration rate and transpirational losses. The results obtained from this investigation are in conformity with reports earlier given by **Venkatesha and Reddy (1994)** in guava and **Sudha *et al*., (2007)** in sapota.

Table 36: Effect of various coating & packaging materials on vitamin C (mg/100gm) of guava *cv.* Allahabad Safeda under ambient conditions

Treatment Details	Storage Days								Mean
	0	3	6	9	12	15	18	21	
T_0	212.56	196.54	187.85	173.32	157.68	149.17	130.90	115.68	165.46
T_1	212.56	200.65	193.49	180.15	168.51	161.60	149.18	130.12	174.53
T_2	212.56	203.64	192.40	177.69	165.18	158.18	148.60	133.65	173.99
T_3	212.56	201.64	197.60	185.64	174.14	169.35	154.98	142.69	177.21
T_4	212.56	202.49	196.48	180.54	171.15	163.52	150.69	140.22	179.83
T_5	212.56	204.61	199.61	187.61	176.22	170.94	156.10	144.45	181.51
Mean		201.59	194.57	180.82	168.81	162.12	148.40	134.46	
C.D (at 5%)		1.844	1.752	1.802	1.845	1.788	1.873	1.800	

Treatments details

T_0 : Control (Chitosan 0.3% at ambient temp.)
T_1 : Chitosan 0.3% + Cling (10µ)
T_2 : Chitosan 0.3% + HDPE (20µ)
T_3 : Chitosan 0.3% + PP (40µ)
T_4 : Chitosan 0.3% + PP (60µ)
T_5 : Chitosan 0.3% + LDPE (100µ)

CD(5%): Critical difference @ 5% level

4.10.2. Total soluble solids of (ºBrix)

Data presented in Fig. 37 and Table no. 37 shows that different packaging& coating materials had substantial effect on TSS of guava during storage period. Among treatments, the maximum value (10.10) was observed in T_0 and minimum value in T_4 & T_5 (9.66). In general, TSS of guava increased up to 15^{th} day but after that the TSS quantity decreased continuously with increasing storage period, irrespective of packaging & coating material used. Maximum total soluble solids (11.24) were observed on 15^{th} days of storage and minimum (9.06) TSS was exhibited on 3^{rd} day.

It was observed that, there was rise in TSS of fruits up to 15th day of storage and thereafter, TSS decreased in all the treatments up to 21st day of storage. Increase in TSS of guava fruits till 15th day of storage was correlated with increase in PLW and then started decreasing up to 21st day because of consumption of sugars in respiration. The findings of this investigation are in conformation with the earlier findings of **Panwar (1980)** in ber. The maximum TSS was recorded in T_0 and the lowest TSS was observed in T_4 & T_5. The coating materials used for fruits had less total soluble solids compared to control. This might be due to the lesser PLW and slow conversion of starch into sugars. Findings of this investigation are in conformation with former reports by **Venkatesha and Reddy (1994)** on guava fruit and **Meena *et al*., (2009)** on ber.

Table 37: Effect of various coating & packaging materials on TSS (ºBrix) of guava *cv*. Allahabad Safeda under ambient conditions

Treatment details	Storage Days								Mean
	0	3	6	9	12	15	18	21	
T_0	8.74	9.27	9.92	10.54	11.38	12.23	10.18	8.58	10.10
T_1	8.74	9.15	9.80	10.26	10.96	11.54	10.80	9.34	10.07
T_2	8.74	9.08	9.71	10.10	10.82	11.38	10.51	9.13	9.93
T_3	8.74	9.02	9.40	9.81	10.43	11.00	10.46	9.86	9.84
T_4	8.74	8.96	9.21	9.56	10.12	10.74	10.27	9.72	9.66
T_5	8.74	8.91	9.12	9.44	9.96	10.58	10.41	10.13	9.66
Mean		9.06	9.52	9.95	10.61	11.24	10.43	9.46	
C.D (at 5%)		0.086	0.092	0.106	0.110	0.438	0.095	0.100	

Treatments details

T_0 : Control (Chitosan 0.3% at ambient temp.)
T_1 : Chitosan 0.3% + Cling (10µ)
T_2 : Chitosan 0.3% + HDPE (20µ)
T_3 : Chitosan 0.3% + PP (40µ)
T_4 : Chitosan 0.3% + PP (60µ)
T_5 : Chitosan 0.3% + LDPE (100µ)

CD(5%): Critical difference @ 5% level

4.10.3. Acidity (%)

Data presented in Fig. 38 and Table 38 showed that different coating & packaging materials had substantial effect on acidity of guava during storage period. Among

treatments, maximum value (0.49) was observed in T_5 followed by T_4 (0.46), and T_3 (0.45).while minimum in T_0 (0.38). In general, acidity of guava decreased with increasing period of storage irrespective of coating & packaging materials used. Maximum acidity (0.55) was recorded on day 3 and lowest acidity (0.26) was observed on 21st day.

Table 38: Effect of various coating & packaging materials on acidity (%) of guava *cv.* Allahabad Safeda under ambient conditions

Treatment Details	Storage Days								Mean
	0	3	6	9	12	15	18	21	
T_0	0.65	0.57	0.51	0.43	0.39	0.31	0.26	0.21	0.38
T_1	0.65	0.59	0.55	0.49	0.44	0.37	0.32	0.25	0.43
T_2	0.65	0.59	0.52	0.46	0.41	0.35	0.30	0.23	0.41
T_3	0.65	0.61	0.56	0.51	0.45	0.40	0.33	0.27	0.45
T_4	0.65	0.62	0.56	0.53	0.47	0.41	0.36	0.30	0.46
T_5	0.65	0.62	0.58	0.55	0.50	0.45	0.39	0.33	0.49
Mean		0.55	0.5	0.44	0.38	0.33	0.27	0.26	
C.D (at 5%)		0.031	0.031	0.044	0.045	0.051	0.052	0.051	

Treatments details

T_0 : Control (Chitosan 0.3% at ambient temp.)
T_1 : Chitosan 0.3% + Cling (10µ)
T_2 : Chitosan 0.3% + HDPE (20µ)
T_3 : Chitosan 0.3% + PP (40µ)
T_4 : Chitosan 0.3% + PP (60µ)
T_5 : Chitosan 0.3% + LDPE (100µ)

CD(5%): Critical difference @ 5% level

In all treatments, acidity of guava fruits observed to be decreased with the increasing period of storage. This is because of increased activity of invertase enzyme. This enzyme is responsible for transformation of acid into sugar and because of utilization of acids in metabolic activities. In this investigation, the highest recorded acidity value is in T_5 and the lowest in T_0 (control). The findings are similar with studies done by **Damodaran *et al*., (2001)** on sapota and **Yadav *et al*., (2010)** on kinnow. Fruits coated in coating material of different concentration retained more acidity in comparison with control. This is because of slow transformation of acids into sugars during ripening.

These outcomes are in conformity with former reports of **Wavhal and Athale (1988)** in mango and **Nunes *et al.*, (2006)** in strawberry.

4.10.4. Total sugars (%)

Data presented in Fig. 39 and Table 39 displayed that different coating & packaging materials had substantial effect on total sugars of guava fruits. Among treatments, the highest value (12.54) was observed in T_0 and minimum value in T_5 (12.34) followed by T_3 (12.40). In general, total sugars of guava increased up to 15th day but after that the total sugars quantity decreased continuously with increase in storage period. Highest total sugars (14.36) were observed on 15th day and lowest (11.25) were observed on 3rd day.

Table 39: Effect of various coating & packaging materials on total sugars (%) of guava *cv.* Allahabad Safeda under ambient conditions

Treatment Details	Storage Days								Mean
	0	3	6	9	12	15	18	21	
T_0	10.78	11.46	12.61	13.24	14.03	15.14	12.47	10.6	12.54
T_1	10.78	11.27	12.31	12.78	13.42	14.44	12.85	11.67	12.44
T_2	10.78	11.34	12.44	12.94	13.65	14.59	13.06	11.15	12.49
T_3	10.78	11.24	12.1	12.64	13.69	14.28	12.81	11.72	12.40
T_4	10.78	11.08	11.85	12.54	13.21	13.8	13.39	12.76	12.42
T_5	10.78	11.13	11.96	12.69	13.77	13.92	12.72	11.81	12.34
Mean		11.25	12.21	12.80	13.62	14.36	12.88	11.61	
C.D (at 5%)		0.148	0.154	0.167	0.177	0.182	0.149	0.142	

Treatments details

T_0 : Control (Chitosan 0.3% at ambient temp.)
T_1 : Chitosan 0.3% + Cling (10µ)
T_2 : Chitosan 0.3% + HDPE (20µ)
T_3 : Chitosan 0.3% + PP (40µ)
T_4 : Chitosan 0.3% + PP (60µ)
T_5 : Chitosan 0.3% + LDPE (100µ)

CD(5%): Critical difference @ 5% level

In the findings, there is significant rise in total sugars with increase in storage period up to 15th day. This is because of accumulation of starch into sugars. It was found that total sugars started to decline because of degradative process. These findings are in

conformity with previous reports in pear by **Mohla *et al*. (2005),** on mango by **Upadhyay and Tripathi (1985)**, and on mango by **Periyathambi (2006)**. Highest total sugar was recorded in T_0, whereas, the lowest total sugars were found in T_5 in different type of coating & packaging. The fruits coated & packed retained less total sugars as compared to control. This might be correlated with decrease in PLW in coated fruits as compared to control fruit. These observations are similar with those obtained by **Venkatesha and Reddy (1994)** in guava.

4.10.5. Reducing sugars (%)

Data described in Fig. 40 and Table 40 displayed that different coating and packaging materials had substantial impact on reducing sugars of guava fruits. Among treatments, the highest value (7.19) was observed in T_0 and minimum value in T_5 (6.79) followed by T_3 (6.90). In general, reducing sugars of guava increased up to 15th day but after that the reducing sugars quantity decreased continuously with increasing storage period irrespective of packaging & coating material used. Maximum reducing sugars (8.77) was observed on 15th days of storage and minimum reducing sugars (4.93) was observed on 21st day.

Table 40: Effect of various coating & packaging materials on reducing sugars (%) of guava *cv.* Allahabad Safeda under ambient conditions

Treatment Details	Storage Days								Mean
	0	3	6	9	12	15	18	21	
T_0	6.12	6.75	7.33	7.86	8.41	9.52	7.12	4.42	7.19
T_1	6.12	6.41	6.96	7.16	7.98	8.24	7.78	6.62	7.15
T_2	6.12	6.60	7.20	7.67	8.34	8.88	6.40	4.20	6.92
T_3	6.12	6.55	7.15	7.44	8.24	8.72	6.10	4.95	6.90
T_4	6.12	6.49	7.06	7.33	8.16	8.58	7.56	5.20	7.06
T_5	6.12	6.54	7.14	7.59	7.96	8.71	6.12	4.16	6.79
Mean		6.55	7.14	7.50	8.18	8.77	6.85	4.93	
C.D (at 5%)		0.123	0.133	0.130	0.131	0.134	0.130	0.131	

Treatments details

T_0	:	Control (Chitosan 0.3% at ambient temp.)	T_3	:	Chitosan 0.3% + PP (40µ)
T_1	:	Chitosan 0.3% + Cling (10µ)	T_4	:	Chitosan 0.3% + PP (60µ)
T_2	:	Chitosan 0.3% + HDPE (20µ)	T_5	:	Chitosan 0.3% + LDPE (100µ)

CD(5%): Critical difference @ 5% level

In the findings, there is significant rise in reducing sugars up to 15th day. This is because of accumulation of starch into sugars. It was found that reducing sugars started to decline because of degradative process. The highest reducing sugars were exhibited in T_0 & lowest reducing sugars was found in T_5 in different type of coating & packaging. The fruits coated & packed retained less reducing sugars as compared to control. This might be correlated with decrease in PLW in coated fruits in comparison to control. The findings of investigation are in confirmation with reports of **Reddy *et al*., (2014), Dutta *et al*., (2017)** and **Yadav *et al*., (2010)** in guava fruits. The results are well supported by **Jagdeesh (1994)** in corn starch coated fruits, **Singh *et al*., (2017)** on kinnow fruits.

4.10.6. Non-reducing sugars (%)

Data described in Fig. 41 and Table no. 41 showed that different coating and packaging materials had substantial impact on non-reducing sugars of guava fruits. Among treatments, the highest value (5.58) was recorded in T_0 followed by T_1 (5.40) and lowest value in T_4 (5.27). Highest non-reducing sugars (7.42) were observed on 21st day and lowest non-reducing sugars (4.46) were observed on 3rd day.

In general, non-reducing sugars of guava increase up to 15th day after that decreases, irrespective of coating and packaging materials used. The reduction in non-reducing sugars is due to the hydrolysis of starch in the fruits at early stage and after that it is because of consumption of sugars in the process of respiration. The outcome of findings are in conformation with similar finding of **Kumar *et al*., (2012)** & **Yadav *et al*., (2010)** on guava and **Jholgiker and Reddy (2007)** in custard apple fruits. Lowest value of non-reducing sugars was recorded in T_4 and the maximum value was recorded in T_0 among different coating materials.

Table 41: Effect of various coating & packaging materials on non-reducing sugars (%) of guava *cv.* Allahabad Safeda under ambient conditions

Treatment Details	Storage Days								Mean
	0	3	6	9	12	15	18	21	
T_0	4.43	4.47	5.02	5.11	5.34	5.91	6.56	7.77	5.58
T_1	4.43	4.50	4.98	5.00	5.04	5.42	6.32	7.55	5.4
T_2	4.43	4.49	4.91	4.93	5.19	5.44	6.39	7.27	5.38
T_3	4.43	4.46	4.70	4.94	5.18	5.28	6.37	7.38	5.34
T_4	4.43	4.41	4.66	5.09	5.33	4.35	6.52	7.40	5.27
T_5	4.43	4.43	4.65	5.11	4.97	5.28	6.28	7.13	5.28
Mean		4.46	4.82	5.03	5.17	5.28	6.41	7.42	
C.D (at 5%)		N/A	0.131	0.056	0.125	0.149	0.038	0.121	

Treatments details

T_0 : Control (Chitosan 0.3% at ambient temp.)
T_1 : Chitosan 0.3% + Cling (10µ)
T_2 : Chitosan 0.3% + HDPE (20µ)
T_3 : Chitosan 0.3% + PP (40µ)
T_4 : Chitosan 0.3% + PP (60µ)
T_5 : Chitosan 0.3% + LDPE (100µ)

CD(5%): Critical difference @ 5% level

4.10.7. Sugar/Acid ratio

Data described in Fig. 42 and Table 42 displayed that different packaging and coating materials had substantial impact on sugar/acid ratio of guava during storage. Among treatments, the maximum value (34.43) was observed in T_0 and minimum value in T_5 (25.64) In general, sugar/acid ratio of guava increased with increase in storage period irrespective of coating and packaging material used. Maximum sugar/acid ratio (44.56) was observed on 21st days of storage and minimum sugar/acid ratio (18.78) was observed on 3rd day.

In the present study, the highest sugar/acid ratio was observed in T_0 & the least in T_5. The total sugar present in the fruit maintained the quantity of simple sugar due to this the ratio increase or decrease during the period of storage with respect to acid quantity.

Table 42: Effect of various coating & packaging materials on sugar/acid ratio of guava *cv.* Allahabad Safeda under ambient conditions

Treatment Details	Storage Days								Mean
	0	3	6	9	12	15	18	21	
T_0	16.58	20.11	24.73	30.79	35.97	48.84	47.96	50.48	34.43
T_1	16.58	19.10	22.38	26.08	30.50	39.03	40.16	46.68	30.06
T_2	16.58	19.22	23.92	28.13	33.29	41.69	43.53	48.48	31.86
T_3	16.58	18.43	21.61	24.78	30.42	35.70	38.82	43.41	28.72
T_4	16.58	17.87	21.16	23.66	28.11	33.66	37.19	42.53	27.60
T_5	16.58	17.95	20.62	23.07	27.54	30.93	32.62	35.79	25.64
Mean		18.78	22.4	26.09	30.97	38.31	40.05	44.56	
C.D (at 5%)		0.782	0.984	2.101	2.734	4.886	5.884	8.072	

Treatments details

T_0 : Control (Chitosan 0.3% at ambient temp.)
T_1 : Chitosan 0.3% + Cling (10µ)
T_2 : Chitosan 0.3% + HDPE (20µ)
T_3 : Chitosan 0.3% + PP (40µ)
T_4 : Chitosan 0.3% + PP (60µ)
T_5 : Chitosan 0.3% + LDPE (100µ)

CD(5%): Critical difference @ 5% level

4.10.8. TSS/Acid ratio

Data presented in Fig. 43 and Table 43 showed that different packaging and coating materials had substantial impact on TSS/acid ratio of guava fruits. Among treatments, the maximum value (27.79) was observed in T_0 and minimum value in T_5 (20.19). In general, TSS/acid ratio of guava increases up to 21st day. Maximum TSS/acid ratio (36.25) was observed on 21st day of storage and minimum TSS/acid ratio (15.13) was observed on 3rd day.

The increases or decreases in TSS/acid ratio of fruits depend on the coating & packaging materials or treatments with increasing storage period. In the current study, the highest TSS/acid ratio was observed in T_0 & the least in T_5. The rise in TSS/acid ratio with respect to storage period has also been stated by **Joubert (1970)** in litchi and **Navjot (2005)** in peach during storage.

Table 43: Effect of various coating & packaging materials on TSS/Acid ratio of guava *cv.* Allahabad Safeda under ambient conditions

Treatment Details	Storage Days								Mean
	0	3	6	9	12	15	18	21	
T_0	13.45	16.26	19.45	24.51	29.18	39.45	39.15	40.86	27.79
T_1	13.45	15.51	17.82	20.94	24.91	31.19	33.75	37.36	24.36
T_2	13.45	15.39	18.67	21.96	26.39	32.51	35.03	39.70	25.39
T_3	13.45	14.79	16.79	19.24	23.18	27.50	31.70	36.52	22.89
T_4	13.45	14.45	16.45	18.04	21.53	26.20	28.53	32.40	21.38
T_5	13.45	14.37	15.72	17.16	19.92	23.51	26.69	30.70	20.19
Mean		15.13	17.48	20.31	24.18	30.06	32.48	36.25	
C.D (at 5%)		0.735	0.862	1.692	2.362	3.855	4.900	6.921	

Treatments details

T_0 : Control (Chitosan 0.3% at ambient temp.)
T_1 : Chitosan 0.3% + Cling (10µ)
T_2 : Chitosan 0.3% + HDPE (20µ)
T_3 : Chitosan 0.3% + PP (40µ)
T_4 : Chitosan 0.3% + PP (60µ)
T_5 : Chitosan 0.3% + LDPE (100µ)

CD(5%): Critical difference @ 5% level

4.10.9. Phenol (mg TAE g-1 DW)

Data presented in Fig. 44 and Table 44 showed that different coating and packaging materials had substantial effect on phenol content of guava during storage period. Among treatments, the maximum value (24.89) was observed in T_5 followed by T_3 (24.84) and minimum value in T_0 (23.44). In general, phenol content of guava decreased with increase in storage period up to 21st days, irrespective of coating and packaging material used. Maximum phenol value (27.24) was observed on 3rd day of storage and minimum phenol value (19.16) was observed on 21th day.

In the findings, there is significant decrease in phenol content during the storage period. In fruits, phenols act as antioxidants (**Heinonen *et al.*, 1998**). Several factors during storage of fruits may affect the phenol content in fruits. Those factors include the stress due to temperature and carbon dioxide. The highest phenol content was exhibited in T_5 & lowest phenol was found in T_0. During storage, the phenol content of fruit

decreases and this may be influenced by storage conditions. Packed fruits resulted with better phenol content than control fruits. The results are in agreement with the study of **Kim *et al.*, (2007)** on mango.

Table 44: Effect of various coating & packaging materials on phenol (mg TAE g-1 DW) of guava *cv.* Allahabad Safeda under ambient conditions

Treatment Details	Storage Days								Mean
	0	3	6	9	12	15	18	21	
T_0	28.08	26.8	25.72	24.52	23.10	21.85	19.47	17.98	23.44
T_1	28.08	26.94	25.98	25.36	23.56	22.28	20.16	18.27	23.83
T_2	28.08	27.12	26.15	25.28	24.09	22.61	20.59	18.82	24.09
T_3	28.08	27.5	26.54	25.82	25.14	23.46	22.02	20.13	24.84
T_4	28.08	27.34	26.42	25.04	24.63	23.13	21.06	19.28	24.37
T_5	28.08	27.78	26.86	25.19	24.74	23.94	22.12	20.46	24.89
Mean		27.24	26.27	25.20	24.21	22.87	20.90	19.16	
C.D (at 5%)		0.417	0.215	0.219	0.218	0.223	0.238	0.250	

Treatments details

T_0 : Control (Chitosan 0.3% at ambient temp.)
T_1 : Chitosan 0.3% + Cling (10µ)
T_2 : Chitosan 0.3% + HDPE (20µ)
T_3 : Chitosan 0.3% + PP (40µ)
T_4 : Chitosan 0.3% + PP (60µ)
T_5 : Chitosan 0.3% + LDPE (100µ)

CD(5%): Critical difference @ 5% level

4.10.10. DPPH (%)

Data presented in Fig. 45 and Table 45 showed that different coating and packaging materials had substantial impact on DPPH content of guava during storage period. Among treatments, the maximum value (4.00) was observed in T_5 followed by T_2 (3.83) and minimum value in T_0 (3.15). In general, DPPH content of guava decreased with increase in storage period up to 21st days, irrespective of coating and packaging material used. Maximum DPPH value (4.59) was observed on 3rd day and lowest DPPH value (2.25) was reported on 21st day.

In the findings, there is significant decrease in DPPH content during the storage period. In fruits, DPPH act as antioxidants (**Heinonen *et al*., 1998**). Several factors during storage of fruits may affect the DPPH content in fruits. Those factors include the stress due to temperature and carbon dioxide. The highest DPPH content was exhibited in T_5 & lowest DPPH was found in T_0. During storage, the DPPH content of fruit decreases and this may be influenced by storage conditions. Therefore, packed fruits resulted in more DPPH content than control fruits. The results are in agreement with the study of **Kim *et al*., (2007)** on mango.

Table 45: Effect of various coating & packaging materials on DPPH (%) of guava *cv*. Allahabad Safeda under ambient conditions

Treatment Details	Storage Days								Mean
	0	3	6	9	12	15	18	21	
T_0	4.86	4.48	4.02	3.56	3.02	2.24	1.88	1.16	3.15
T_1	4.86	4.52	4.12	3.81	3.41	2.99	2.43	1.98	3.51
T_2	4.86	4.65	4.41	4.12	3.61	3.26	2.99	2.76	3.83
T_3	4.86	4.56	4.24	3.98	3.58	3.15	2.57	2.25	3.64
T_4	4.86	4.62	4.4	4.17	3.82	3.38	2.74	2.47	3.81
T_5	4.86	4.71	4.52	4.27	3.95	3.64	3.21	2.87	4.00
Mean		4.59	4.29	3.99	3.57	3.11	2.64	2.25	
C.D (at 5%)		0.109	0.117	0.132	0.159	0.166	0.147	0.165	

Treatments details

T_0 : Control (Chitosan 0.3% at ambient temp.)
T_1 : Chitosan 0.3% + Cling (10µ)
T_2 : Chitosan 0.3% + HDPE (20µ)
T_3 : Chitosan 0.3% + PP (40µ)
T_4 : Chitosan 0.3% + PP (60µ)
T_5 : Chitosan 0.3% + LDPE (100µ)

CD(5%): Critical difference @ 5% level

Graphical presentation of experiment 3 (B)

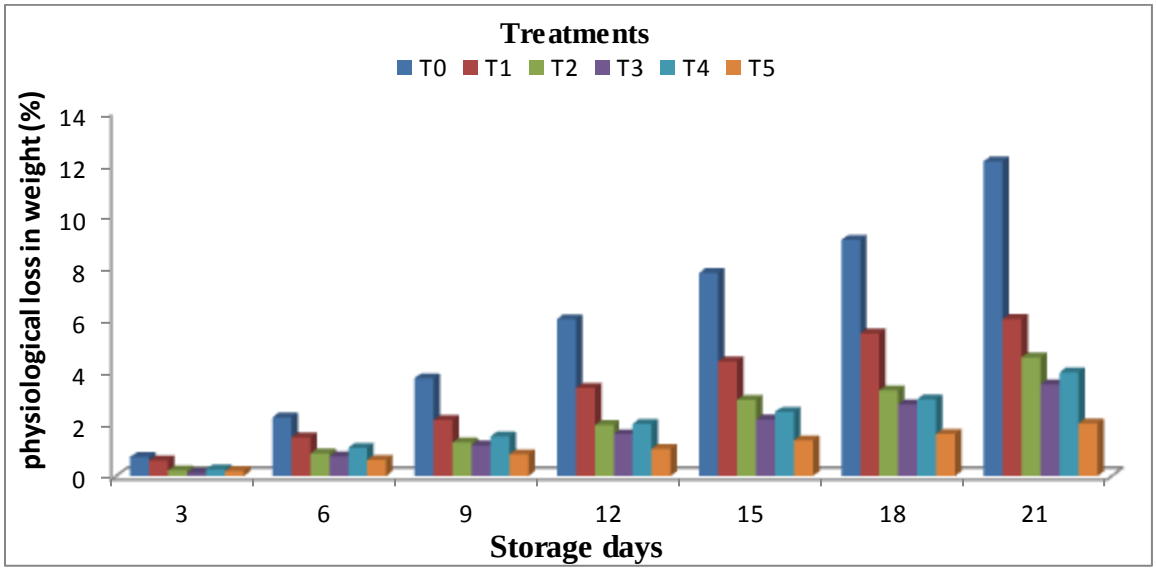

Fig. 35: Effect of various coating & packaging materials on PLW of guava *cv.* Allahabad Safeda under ambient conditions

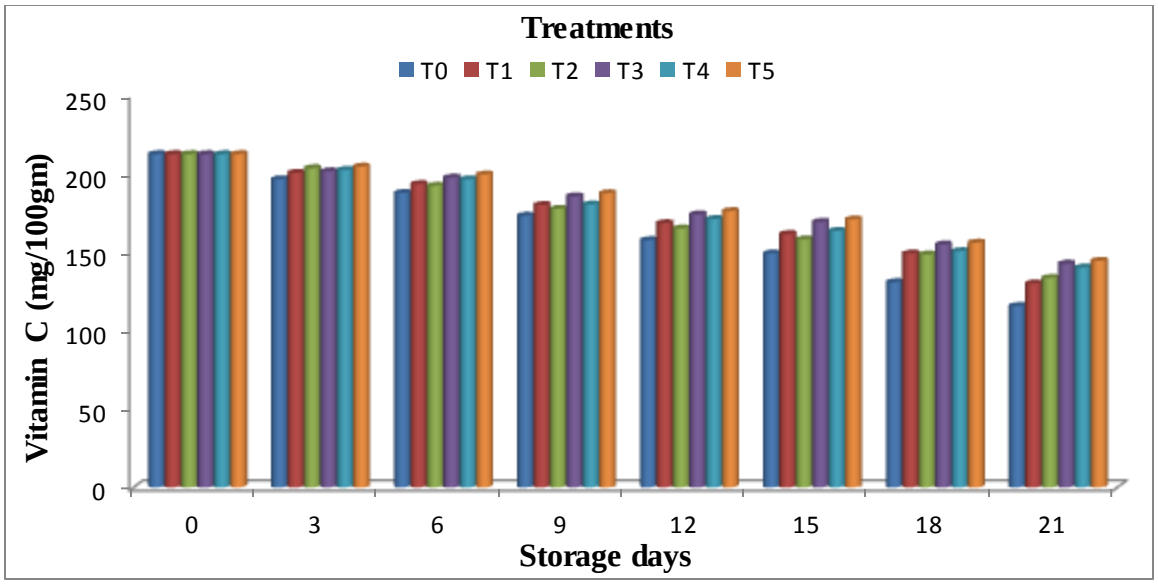

Fig. 36: Effect of various coating & packaging materials on vitamin C of guava *cv.* Allahabad Safeda under ambient conditions

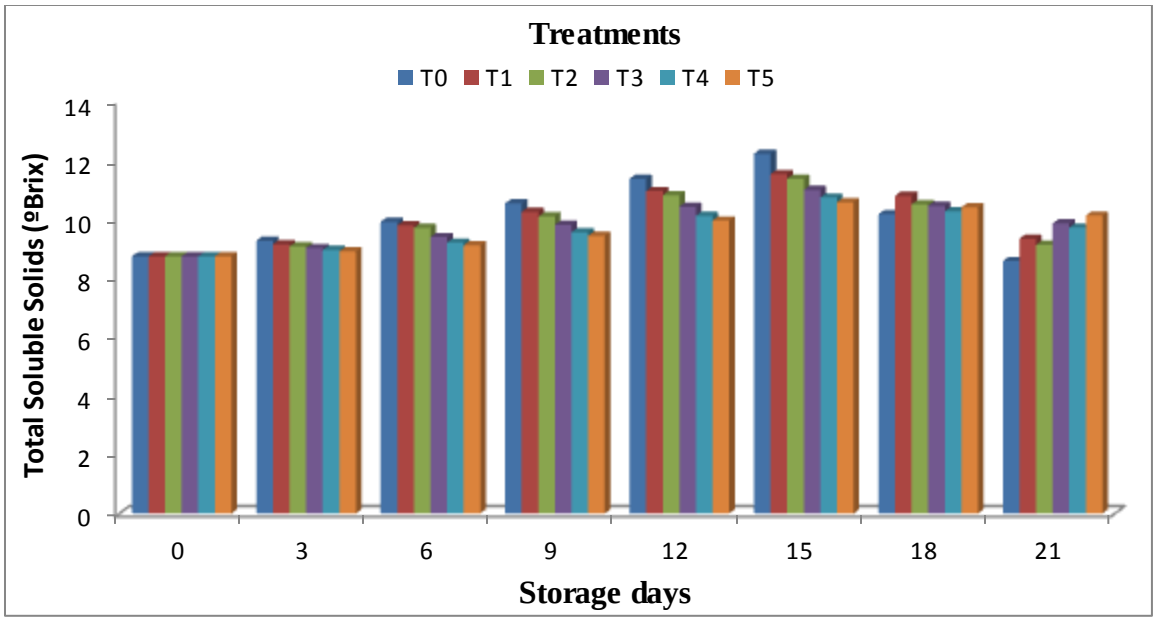

Fig. 37: Effect of various coating & packaging materials on TSS of guava *cv.* Allahabad Safeda under ambient conditions

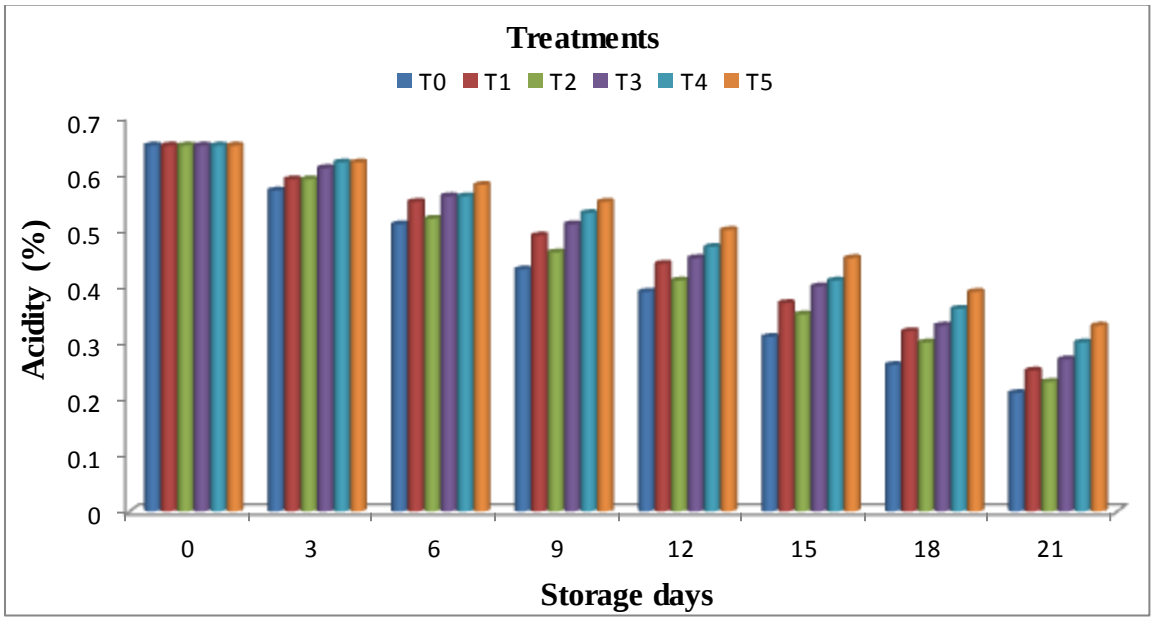

Fig. 38: Effect of various coating & packaging materials on acidity of guava *cv.* Allahabad Safeda under ambient conditions

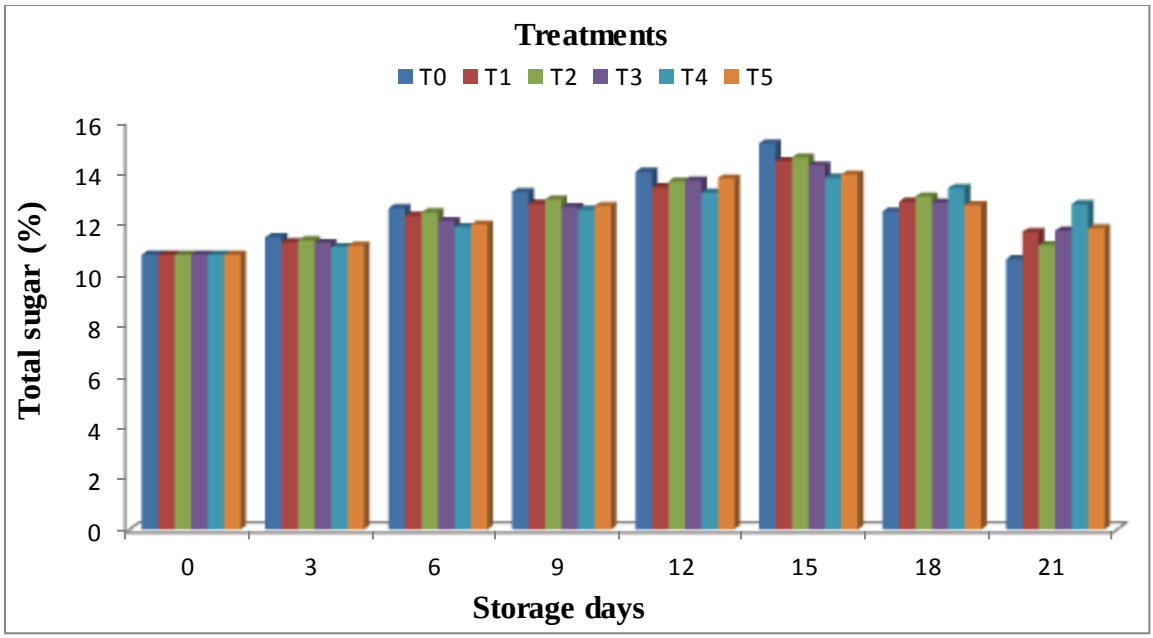

Fig. 39: Effect of various coating & packaging materials on total sugars of guava *cv.* Allahabad Safeda under ambient conditions

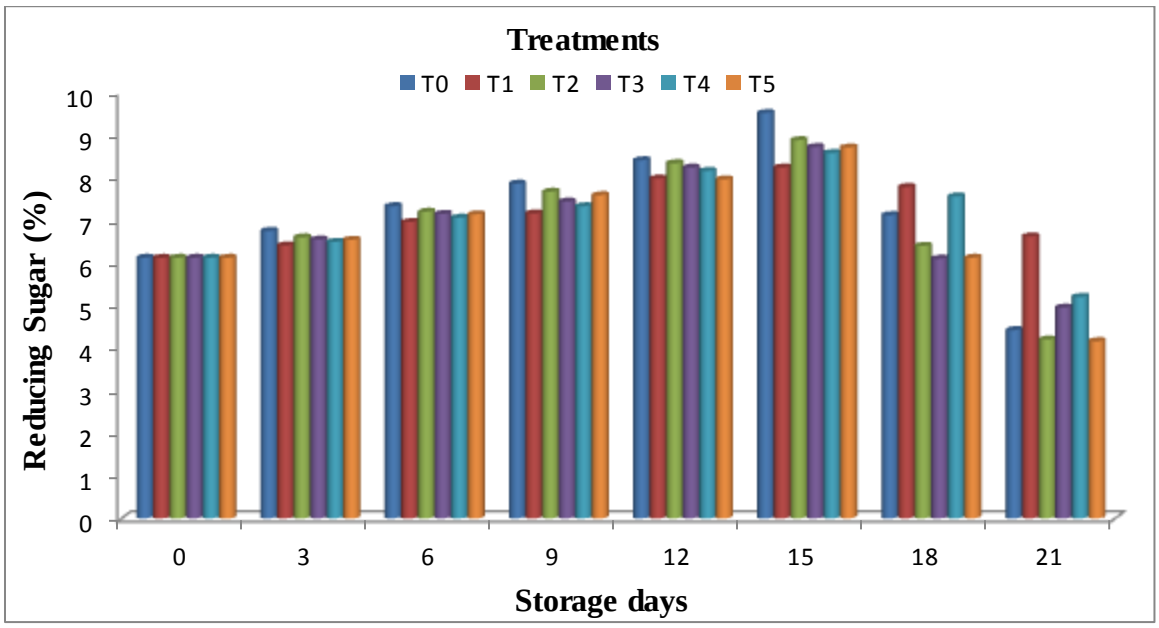

Fig. 40: Effect of various coating & packaging materials on reducing sugars of guava *cv.* Allahabad Safeda under ambient conditions

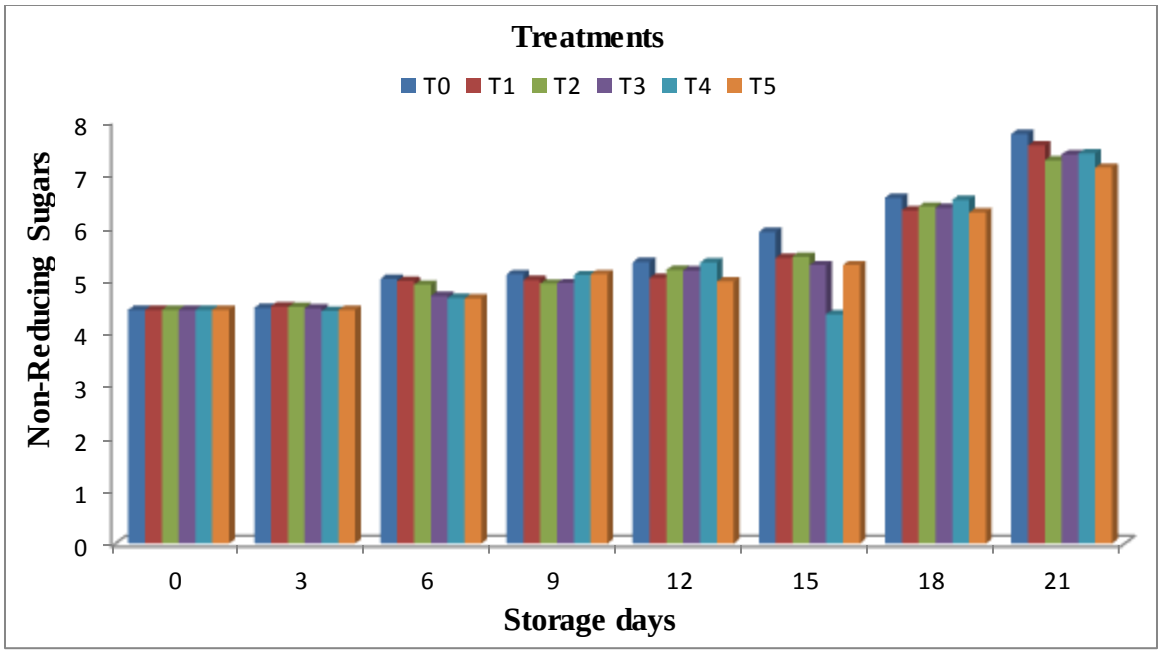

Fig. 41: Effect of various coating & packaging materials on non-reducing sugars of guava *cv.* Allahabad Safeda under ambient conditions

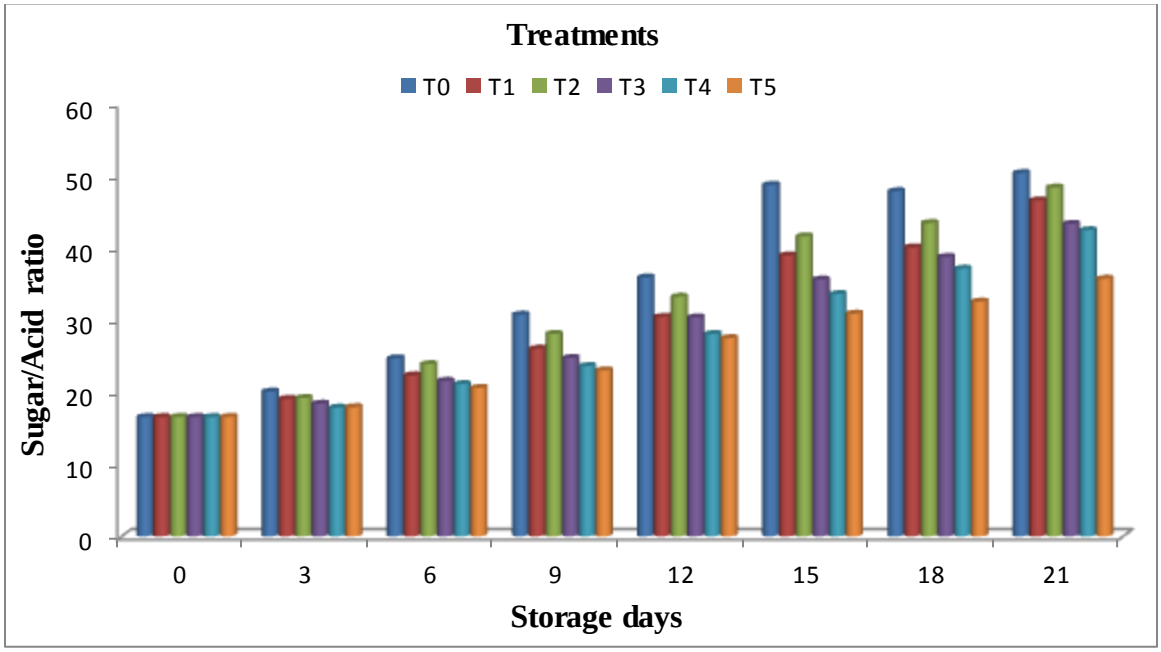

Fig. 42: Effect of various coating & packaging materials on sugar/acid ratio of guava *cv.* Allahabad Safeda under ambient conditions

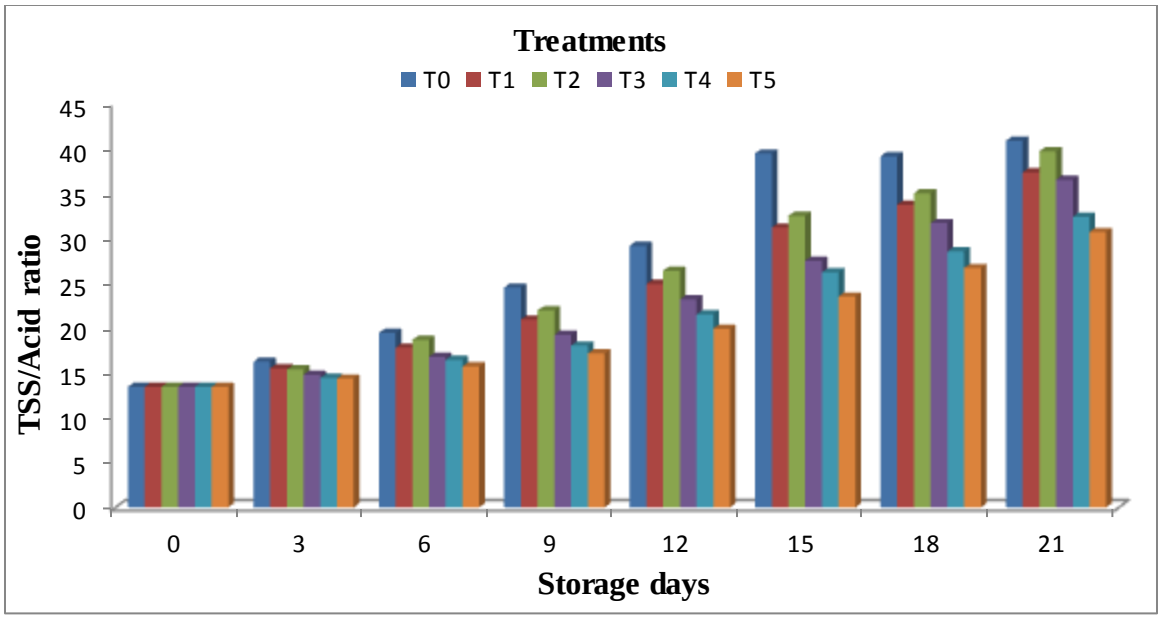

Fig. 43: Effect of various coating & packaging materials on TSS/Acid ratio of guava *cv.* Allahabad Safeda under ambient conditions

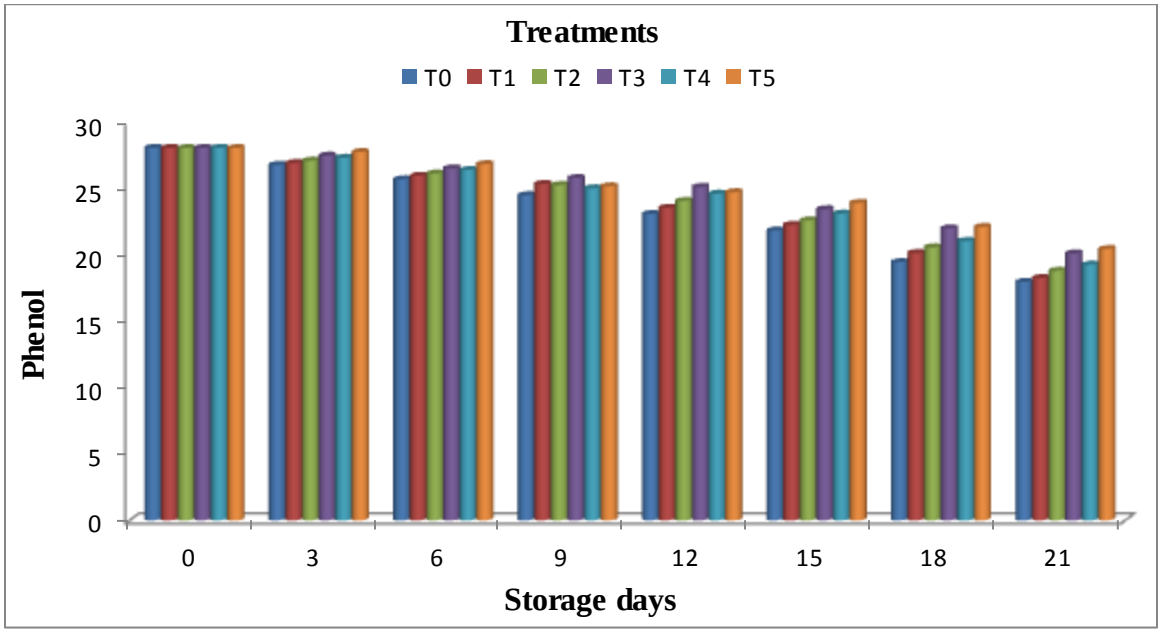

Fig. 44: Effect of various coating & packaging materials on phenol of guava *cv.* Allahabad Safeda under ambient conditions

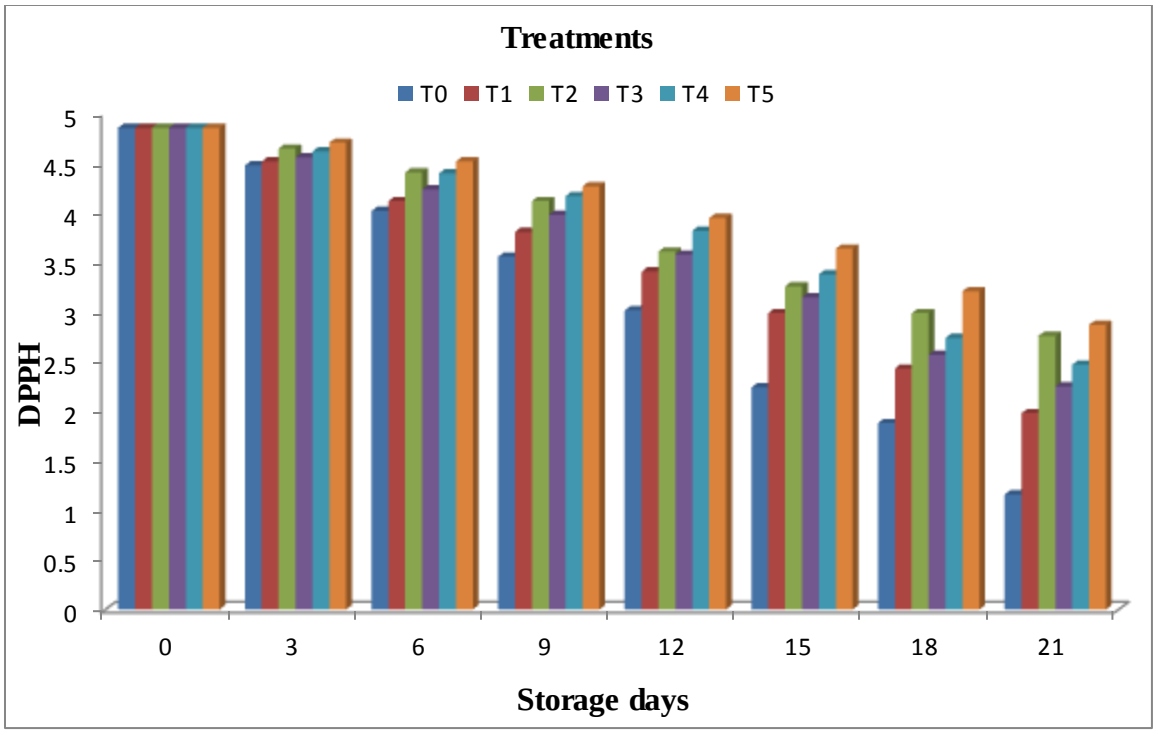

Fig. 45: Effect of various coating & packaging materials on DPPH of guava *cv.* Allahabad Safeda under ambient conditions

CHAPTER-V

SUMMARY AND CONCLUSION

Experiment – 1 was conducted to study the effect of various edible coating on guava fruit *cv*. Allahabad Safeda under ambient conditions. The summary is given as below:

- The physiological loss in weight (%), maximum PLW was observed in T_0 (11.51%) and minimum in T_{11} (7.26%) followed by T_{12} (7.47%), T_{10} (7.59%), T_1 (8.28%), T_2 (8.90%). PLW increased with duration of storage showing maximum PLW of weight on 6^{th} DAS (12.95%) and least on 3^{rd} DAS (6.06%).
- Vitamin C (mg/100g pulp), maximum value (177.10) was observed in T_{12} followed by T_{10} (174.90), T_{11} (174.10), T_1 (173.90) and T_2 (172.60) and minimum value in T_0 (156.40). Generally, vitamin C of guava decreased with increase in period of storage. Maximum vitamin C (163.10) quantity was observed on 3rd day of storage and minimum (143.13) vitamin C was observed on day 6.
- The total soluble solids (˚Brix), the maximum value of TSS was observed in T_0 (11.49) and minimum value in T_{12} (10.23) followed by T_{10} (10.29), T_{11} (10.37), T_1 (10.56) and T_2 (10.56). Generally with the increasing storage period TSS of guava increased up to a certain period and then decreased. Maximum TSS (11.95) was observed on 6^{th} day of storage and minimum (10.84) was recorded on 3^{rd} day of storage.
- Titratable acidity (%), Maximum value of acidity among treatments was observed in T_{12} (0.54) followed by T_{11} (0.52), T_1 (0.52), T_2 (0.51), and T_{10} (0.51), while minimum in T0 (0.43). In general, acidity of guava decreased with increasing period of storage. On day 3 acidity recorded was maximum i.e. 0.50 and least (0.44) on day 6.
- The TSS/acid ratio, maximum value (24.76) was observed in T_0 and minimum in T_{12} (18.45) followed by T_{11} (19.08), T_{10} (19.26), T_1 (19.41) and T_2 (19.70). In general, TSS/acid ratio of guava increased with increase in storage period up to 6^{th} day but in certain treatments it has been following descending trend. Highest

TSS/acid ratio (26.99) was witnessed on day 6 and lowest TSS/acid ratio (21.66) on day 3.

Experiment – 2(A) Effect of various coating materials on guava *cv*. Allahabad Safeda under cold conditions (7°C) The summary is given as below:

- The physiological loss in weight (%), maximum PLW was observed in T_0 (15.20%) and minimum in T_5 (11.19%). PLW increased with duration of storage showing maximum PLW of weight on 21st DAS (24.05%) and minimum on 3rd DAS (3.68%).
- Vitamin C (mg/100g pulp), maximum value (182.38) was observed in T_5 followed by T_4 (179.18) and minimum value in T_0 (170.93). Generally, vitamin C of guava decreased with increase in storage period. Maximum vitamin C (198.30) quantity was observed on 3rd day of storage and minimum (141.98) vitamin C was observed on 21st day.
- The total soluble solids (˚Brix), the maximum value (10.04) was observed in T_0 and minimum value in T_4 (9.90). In general, TSS of guava increased with increasing storage period up to 15th days but after that the total soluble solids quantity decreased continuously in all treatments with increase in storage period. On 15th days of storage, maximum value of total soluble solids (10.92) was observed and minimum (9.46) TSS was observed on 21st day of storage.
- Titratable acidity (%), maximum value (0.47) was observed in T_5 followed by T_4 (0.46), and T_3 (0.46).while minimum in T_0 (0.40). In general, acidity of guava fruits decreased with increase in storage period regardless of coating materials used. The maximum value of acidity (0.53) was recorded on 3rd day and least acidity (0.33) on 21st day.
- The total sugars (%), highest value (13.40) was observed in T_0 and minimum value in T_4 (12.59) followed by T_5 (12.65). In general, total sugars of guava increased with increases storage period up to 15th days but after that the total sugars quantity decreased continuously in all treatments with increase in storage

period regardless of coating material used. Maximum total sugars (14.97) were observed on 15th DAS and least (11.85) on 3rd day.

- Reducing sugars (%), highest value (7.92) was observed in T_0 and minimum value in T_5 (7.60) followed by T_4 (7.63). In general, reducing sugars of guava increased up to 15th days of storage and thereafter, the reducing sugars quantity decreased continuously in all treatments with increase in storage period regardless of coating material used. Maximum reducing sugars (8.94) was observed on 15th day and minimum value (6.46) was observed on 21st day.
- The Non-reducing sugars (%), highest value (5.08) was observed in T_0 and minimum value in T_5 (4.79) followed by T_4 (4.83). In general, non-reducing sugars of guava increased up to 15th day of storage and thereafter, the non-reducing sugars quantity decreased continuously in all treatments with an increase in storage period regardless of the coating material used. Highest non-reducing sugars (6.31) were observed on 21st DAS and lowest non-reducing sugar (4.11) was observed on 3rd day.
- Sugar/acid ratio, maximum value (35.94) was observed in T_0 and minimum value in T_5 (27.50). In general, sugar/acid ratio of guava increased up to 15th day of storage and thereafter, the sugar/acid ratio decreased continuously in all treatments with an increase in storage period regardless of the coating material used. Highest sugar/acid ratio (39.03) was observed on 15th days of storage and minimum sugar/acid ratio (22.46) was observed on 3rd day.
- The TSS/acid ratio, the maximum value (27.16) was observed in T_0 and minimum value in T_5 (21.51). In general, TSS/acid ratio of guava increased up to 21st day of storage but in certain treatments it has been following descending trend. Maximum TSS/acid ratio (29.51) was observed on 21st day of storage and minimum TSS/acid ratio (18.01) was observed on 3rd day.

Experiment - 2 (B) Effect of various edible coating on guava fruit *cv*. Allahabad Safeda under ambient conditions. The summary is given as below:

- The physiological loss in weight (%), maximum PLW was observed in T_0 (20.61%) and minimum in T_5 (16.42%). PLW increase with duration of storage showing highest PLW of weight on day 6 (23.09%) and lowest on day 3 (13.10%).
- Vitamin C (mg/100g pulp), maximum value (187.22) was observed in T_5 followed by T_4 (185.47) and minimum value in T_0 (172.64). Generally, vitamin C of guava decreased with increase in storage period. Maximum vitamin C (180.59) quantity was observed on 3rd day of storage and minimum (156.53) vitamin C was observed on day 6.
- The total soluble solids (˚Brix), the maximum value (11.50) was observed in T_0 and minimum value in T_5 (10.45). In general, TSS of guava increased with increase in storage period. Maximum total soluble solids (12.45) were observed on 6th days of storage and minimum (10.69) were exhibited on 3rd day.
- Titratable acidity (%), maximum value (0.52) was observed in T_4 followed by T_5 (0.51).while minimum in T_0 (0.47). In general, acidity of guava fruits decreased with increase in storage period regardless of coating materials used. The highest acidity (0.50) was recorded on 3rd DAS and lowest acidity (0.42) on 6th day.
- The total sugars (%), highest value (13.31) was observed in T_0 and minimum value in T_5 (12.25) followed by T_4 (12.34). In general, total sugars of guava increased with increases storage period up to 6th day but after that the total sugars quantity decreased continuously in all the treatments with increase in storage period regardless of coating material used. Maximum total sugars (13.30) were observed on 16th days and lowest (12.22) was observed on 3rd day.
- Reducing sugars (%), highest value (7.59) was observed in T_0 and minimum value in T_5 (7.17) followed by T_4 (7.21).In general, reducing sugars of guava increased with increasing period of storage up to 6th days. Highest reducing sugars (7.90) were observed on day 6 and lowest (7.33) was observed on day 3.
- The Non-reducing sugars (%), highest value (4.83) was observed in T_3 and minimum value in T_5 (4.48) followed by T_4 (4.5). In general, non-reducing sugars

of guava increased with increase storage period up to 6th day. Highest non-reducing sugars (5.13) were observed on day 6 and lowest non-reducing sugars (4.64) was observed on 3rd day.

- Sugar/acid ratio, maximum value (27.88) was observed in T_0 and minimum value in T_5 (23.77). In general, sugar/acid ratio of guava increased up to 6th day. Maximum sugar/acid ratio (32.12) was observed on 6th days of storage and minimum sugar/acid ratio (24.68) was observed on 3rd day.
- The TSS/acid ratio, the maximum value (25.73) was observed in T_0 and minimum value in T_4 (20.83). In general, TSS/acid ratio of guava increased up to 6th day. Maximum TSS/acid ratio (30.09) was observed on 6th days of storage and minimum TSS/acid ratio (21.60) was observed on 3rd day.

Experiment - 3 (A) Effect of various edible coating & packaging on guava fruit *cv*. Allahabad Safeda under cold conditions (7°C). The summary is given as below:

- The physiological loss in weight (%), maximum PLW was observed in T_0 (6.57%) and minimum in T_5 (0.68%). PLW increased with increasing duration of storage showing maximum PLW of weight on 30th day of storage (3.37%) and minimum on 3rd day of storage (0.31%).
- Vitamin C (mg/100g pulp), maximum value (169.95) was observed in T_5 followed by T_4 (166.63) and minimum value in T_0 (157.85). Generally, vitamin C of guava decreased with increase in storage period. Maximum vitamin C (201.77) quantity was observed on 3rd day of storage and minimum (115.15) vitamin C was observed on 30th day.
- The total soluble solids (˚Brix), the maximum value (10.02) was observed in T_0 and minimum value in T_4 (9.84) followed by T_5 (9.85). In general, TSS of guava increased up to 18th day but after that the TSS quantity decreased continuously with increase in storage period, irrespective of coating & packaging material used. Maximum total soluble solids (11.37) were observed on 18th days of storage and minimum (8.95) TSS was exhibited on 3rd day.

- Titratable acidity (%), maximum value (0.50) was observed in T_5 followed by T_4 (0.48), and T_3 (0.47).while minimum in T_0 (0.43). In general, acidity of guava decreased with increasing period of storage irrespective of coating & packaging materials used. Maximum acidity (0.61) was recorded on day 3 and lowest acidity (0.27) on day 30.
- The total sugars (%), the highest value (12.05) was observed in T_0 and minimum value in T_3 (11.80) followed by T_5 (11.81). In general, total sugars of guava increased up to 18^{th} days but after that the total sugars quantity decreased continuously with increasing storage period irrespective of packaging & coating material used. Maximum total sugars (13.82) were observed on 18^{th} day and lowest (13.75) on 30^{th} day.
- Reducing sugars (%), the highest value (7.12) was observed in T_0 and minimum value in T_5 (6.72) followed by T_3 (6.77). In general, reducing sugars of guava increased up to 18^{th} days but after that the reducing sugars quantity decreased continuously in all the treatments with increase in storage period irrespective of coating & packaging material used. Maximum reducing sugars (8.40) was observed on 18^{th} days of storage and minimum reducing sugars (4.65) was observed on 30^{th} day.
- The Non-reducing sugars (%), the highest value (5.09) was observed in T_5 and minimum value in T_1 (4.92). Highest non-reducing sugars (6.11) were observed on 30^{th} days and lowest non-reducing sugars (4.31) was observed on day 6.
- Sugar/acid ratio, the maximum value (31.11) was observed in T_0 and minimum value in T_5 (24.82) In general, sugar/acid ratio of guava increased with increasing storage period irrespective of coating and packaging material used. Maximum sugar/acid ratio (40.53) was observed on 30^{th} days of storage and minimum sugar/acid ratio (17.79) was observed on 3^{rd} day.
- The TSS/acid ratio, the maximum value (26.09) was observed in T_0 and minimum value in T_5 (20.70). In general, TSS/acid ratio of guava increased with increasing period of storage up to 30^{th} days but in certain treatments it has been following

descending trend. Maximum TSS/acid ratio (35.16) was observed on 30th DAS and least TSS/acid ratio (14.62) was recorded on 3rd day.

- Phenol (mg TAE g-1 DW), the maximum value (25.34) was observed in T_5 followed by T_4 (25.06) and minimum value in T_0 (23.59). In general, phenol content of guava decreased with increase of storage period up to 30th days, irrespective of coating and packaging material used. Maximum phenol value (27.68) was observed on 3rd day of storage and minimum phenol value (18.07) was observed on 30th day.
- DPPH (%), the maximum value (3.78) was observed in T_5 followed by T_4 (3.69) and minimum value in T_0 (3.29). In general, DPPH content of guava decreased with increase in storage period up to 30th days, irrespective of coating and packaging material used. Maximum DPPH value (4.70) was observed on 3rd day of storage and minimum DPPH value (1.77) was observed on 30th day.

Experiment - 3 (B) Effect of various edible coating & packaging on guava fruit *cv*. Allahabad Safeda under ambient conditions. The summary is given as below:

- The physiological loss in weight (%), maximum PLW was observed in T_0 (5.96%) and minimum in T_5 (1.10%). PLW increased with increasing duration of storage showing maximum PLW on day 21 (5.37%) and minimum on day 3 (0.35%).
- Vitamin C (mg/100g pulp), maximum value (181.51) was observed in T_5 followed by T_4 (179.83) and minimum value in T_0 (165.46). In general, vitamin C of guava decreased with increasing period of storage. Maximum vitamin C (201.59) quantity was observed on 3rd day of storage and minimum (134.46) vitamin C was observed on 21st day.
- The total soluble solids (˚Brix), the maximum value (10.10) was observed in T_0 and minimum value in T_4 & T_5 (9.66). In general, TSS of guava increased up to 15th day but after that the TSS quantity decreased continuously with increasing storage period, irrespective of packaging & coating material used. Maximum total

soluble solids (11.24) were observed on 15th days of storage and minimum (9.06) TSS was exhibited on 3rd day.

- Titratable acidity (%), maximum value (0.49) was observed in T_5 followed by T_4 (0.46), and T_3 (0.45).while minimum in T_0 (0.38). In general, acidity of guava decreased with increasing period of storage irrespective of coating & packaging materials used. Maximum acidity (0.55) was recorded on day 3 and lowest acidity (0.26) was observed on 21st day.
- The total sugars (%), the highest value (12.54) was observed in T_0 and minimum value in T_5 (12.34) followed by T_3 (12.40). In general, total sugars of guava increased up to 15th day but after that the total sugars quantity decreased continuously with increase in storage period. Highest total sugars (14.36) were observed on 15th day and lowest (11.25) was observed on 3rd day.
- Reducing sugars (%), the highest value (7.19) was observed in T_0 and minimum value in T_5 (6.79) followed by T_3 (6.90). In general, reducing sugars of guava increased up to 15th day but after that the reducing sugars quantity decreased continuously with increasing storage period irrespective of packaging & coating material used. Maximum reducing sugars (8.77) was observed on 15th days of storage and minimum reducing sugars (4.93) were observed on 21st day.
- The Non-reducing sugars (%), the highest value (5.58) was recorded in T_0 followed by T_1 (5.40) and lowest value in T_4 (5.27). Highest non-reducing sugars (7.42) were observed on 21st day and lowest non-reducing sugars (4.46) were observed on 3rd day.
- Sugar/acid ratio, the maximum value (34.43) was observed in T_0 and minimum value in T_5 (25.64) In general, sugar/acid ratio of guava increased with increase in storage period irrespective of coating and packaging material used. Maximum sugar/acid ratio (44.56) was observed on 21st days of storage and minimum sugar/acid ratio (18.78) was observed on 3rd day.
- The TSS/acid ratio, the maximum value (27.79) was observed in T_0 and minimum value in T_5 (20.19). In general, TSS/acid ratio of guava increased up to 21st days.

Maximum TSS/acid ratio (36.25) was observed on 21st days of storage and minimum TSS/acid ratio (15.13) was observed on 3rd day.

- Phenol (mg TAE g-1 DW), the maximum value (24.89) was observed in T_5 followed by T_3 (24.84) and minimum value in T_0 (23.44). In general, phenol content of guava decreased with increase in storage period up to 21st days, irrespective of coating and packaging material used. Maximum phenol value (27.24) was observed on 3rd day of storage and minimum phenol value (19.16) was observed on 21st day.
- DPPH (%), the maximum value (4.00) was observed in T_5 followed by T_2 (3.83) and minimum value in T_0 (3.15). In general, DPPH content of guava decreased with increase in storage period up to 21st days, irrespective of coating and packaging material used. Maximum DPPH value (4.59) was observed on 3rd day and lowest DPPH value (2.25) was reported on 21st day.

On the basis of the present investigation which was conducted in three trials including storage studies of guava having 39 combinations of coating treatments and six packaging materials, it is concluded that the storage life of guava *cv*. Allahabad Safeda was found to be maximum when chitosan (0.3%) is used along with LDPE (100μ) under ambient conditions and cold conditions (7°C).

ANNEXURE-I

Meteorological weather data during Experiment 1 at Lovely Professional University, Phagwara. (www.timeanddate.com)

Date	Temperature (^{o}C)		Relative Humidity (%)	
	Max.	Min.	Max.	Min.
08 August (2018)	32	25	92	72
09 August (2018)	33	27	88	68
10 August (2018)	34	27	89	65
11 August (2018)	34	28	89	73
12 August (2018)	34	27	85	65
13 August (2018)	32	28	92	64
14 August (2018)	32	24	93	59
15 August (2018)	33	26	89	58

Meteorological weather data during Experiment 2 at Lovely Professional University, Phagwara (www.timeanddate.com)

Date	Temperature (^{o}C)		Relative Humidity (%)	
	Max.	Min.	Max.	Min.
1 September (2018)	35	28	84	47
2 September (2018)	34	27	90	66
3 September (2018)	32	26	91	70
4 September (2018)	33	26	92	64
5 September (2018)	36	26	88	58
6 September (2018)	35	28	86	60
7 September (2018)	34	26	87	60
8 September (2018)	33	24	96	54

Meteorological weather data during Experiment 3 at Lovely Professional University, Phagwara (www.timeanddate.com)

Date	Temperature (^{o}C)		Relative Humidity (%)	
	Max.	Min.	Max.	Min.
02 February (2019)	19	06	100	51
03 February (2019)	21	07	100	47
04 February (2019)	20	06	100	53
05 February (2019)	22	10	100	46
06 February (2019)	19	10	100	70
07 February (2019)	15	10	98	93
08 February (2019)	16	08	100	57
09 February (2019)	19	06	100	48
10 February (2019)	19	06	100	42
11 February (2019)	20	09	94	46
12 February (2019)	20	10	98	55
13 February (2019)	21	10	100	58
14 February (2019)	15	11	100	96
15 February (2019)	18	10	100	80
16 February (2019)	20	10	100	61
17 February (2019)	17	09	100	63
18 February (2019)	20	11	99	59
19 February (2019)	20	07	100	54
20 February (2019)	20	12	100	69
21 February (2019)	20	13	100	75
22 February (2019)	19	08	100	50
23 February (2019)	20	07	97	42

ANNEXURE II

Analysis of Variance Table

Experiment 1- Effect of various edible coatings on guava fruit *cv.* Allahabad Safeda under ambient conditions

Physiological loss in weight (%)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	39	71.354	1.830	2.113	0.00242
	Error	80	69.267	0.866		
	Total	119	140.621			
6	Treatment	39	321.031	8.232	4.973	0.00000
	Error	80	132.418	1.655		
	Total	119	453.449			

Vitamin C (mg/100gm)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	39	5,772.760	148.019	142.355	0.00000
	Error	80	83.183	1.040		
	Total	119	5,855.943			
6	Treatment	39	6,163.405	158.036	155.840	0.00000
	Error	80	81.128	1.014		
	Total	119	6244.533			

Acidity (%)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	39	0.081	0.002	2.338	0.00068
	Error	80	0.071	0.001		
	Total	119	0.152			
6	Treatment	39	0.069	0.002	1.874	0.00908
	Error	80	0.076	0.001		
	Total	119	0.145			

Total Soluble Solids (ºBrix)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	39	9.995	0.256	72.578	0.00000
	Error	80	0.282	0.004		
	Total	119	10.278			
6	Treatment	39	26.693	0.684	169.872	0.00000
	Error	80	0.322	0.004		
	Total	119	27.016			

TSS/Acid ratio

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	39	252.897	6.485	3.717	0.00000
	Error	80	139.559	1.744		
	Total	119	392.455			
6	Treatment	39	608.666	15.607	4.570	0.00000
	Error	80	273.222	3.415		
	Total	119	881.889			

Experiment – 2(A) Effect of various coating materials on guava *cv.* Allahabad Safeda under cold conditions (7°C)

Physiological loss in weight (%)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	3.665	0.733	3.881	0.02522
	Error	12	2.267	0.189		
	Total	17	5.932			
6	Treatment	5	6.327	1.265	3.429	0.03728
	Error	12	4.429	0.369		
	Total	17	10.755			
9	Treatment	5	18.436	3.687	2.702	0.07349
	Error	12	16.375	1.365		
	Total	17	34.811			
12	Treatment	5	34.609	6.922	3.496	0.03512
	Error	12	23.758	1.980		
	Total	17	58.367			
15	Treatment	5	45.682	9.136	2.308	0.10920
	Error	12	47.500	3.958		
	Total	17	93.182			
18	Treatment	5	71.186	14.237	2.244	0.11664
	Error	12	76.120	6.343		
	Total	17	147.306			
21	Treatment	5	172.287	34.457	2.785	0.06778
	Error	12	148.458	12.372		
	Total	17	320.745			

Vitamin C (mg/100gm)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	3.665	0.733	3.881	0.02522
	Error	12	2.267	0.189		
	Total	17	5.932			
6	Treatment	5	6.327	1.265	3.429	0.03728
	Error	12	4.429	0.369		
	Total	17	10.755			
9	Treatment	5	18.436	3.687	2.702	0.07349
	Error	12	16.375	1.365		
	Total	17	34.811			
12	Treatment	5	34.609	6.922	3.496	0.03512
	Error	12	23.758	1.980		
	Total	17	58.367			
15	Treatment	5	45.682	9.136	2.308	0.10920
	Error	12	47.500	3.958		
	Total	17	93.182			
18	Treatment	5	71.186	14.237	2.244	0.11664
	Error	12	76.120	6.343		
	Total	17	147.306			
21	Treatment	5	172.287	34.457	2.785	0.06778
	Error	12	148.458	12.372		
	Total	17	320.745			

Total soluble solids (ºBrix)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	0.071	0.014	8.060	0.00154
	Error	12	0.021	0.002		
	Total	17	0.092			
6	Treatment	5	0.235	0.047	24.523	0.00001
	Error	12	0.023	0.002		
	Total	17	0.258			
9	Treatment	5	0.354	0.071	21.987	0.00001
	Error	12	0.039	0.003		
	Total	17	0.393			
12	Treatment	5	0.603	0.121	45.181	0.00000
	Error	12	0.032	0.003		
	Total	17	0.635			
15	Treatment	5	1.393	0.279	76.926	0.00000
	Error	12	0.043	0.004		
	Total	17	1.437			
18	Treatment	5	1.266	0.253	84.425	0.00000
	Error	12	0.036	0.003		
	Total	17	1.302			
21	Treatment	5	0.760	0.152	73.844	0.00000
	Error	12	0.025	0.002		
	Total	17	0.785			

Acidity (%)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	0.002	0.000	4.098	0.02107
	Error	12	0.001	0.000		
	Total	17	0.003			
6	Treatment	5	0.005	0.001	4.023	0.02240
	Error	12	0.003	0.000		
	Total	17	0.008			
9	Treatment	5	0.008	0.002	6.515	0.00377
	Error	12	0.003	0.000		
	Total	17	0.010			
12	Treatment	5	0.016	0.003	11.246	0.00034
	Error	12	0.003	0.000		
	Total	17	0.020			
15	Treatment	5	0.019	0.004	12.253	0.00023
	Error	12	0.004	0.000		
	Total	17	0.023			
18	Treatment	5	0.030	0.006	18.821	0.00003
	Error	12	0.004	0.000		
	Total	17	0.034			
21	Treatment	5	0.035	0.007	17.625	0.00004
	Error	12	0.005	0.000		
	Total	17	0.040			

Total Sugars (%)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	0.292	0.058	17.619	0.00004
	Error	12	0.040	0.003		
	Total	17	0.332			
6	Treatment	5	0.933	0.187	37.394	0.00000
	Error	12	0.060	0.005		
	Total	17	0.993			
9	Treatment	5	2.395	0.479	71.554	0.00000
	Error	12	0.080	0.007		
	Total	17	2.476			
12	Treatment	5	4.637	0.927	116.926	0.00000
	Error	12	0.095	0.008		
	Total	17	4.732			
15	Treatment	5	4.167	0.833	63.712	0.00000
	Error	12	0.157	0.013		
	Total	17	4.324			
18	Treatment	5	6.687	1.337	87.164	0.00000
	Error	12	0.184	0.015		
	Total	17	6.871			
21	Treatment	5	2.580	0.516	50.579	0.00000
	Error	12	0.122	0.010		
	Total	17	2.702			

Reducing Sugars (%)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	0.187	0.037	4.338	0.01737
	Error	12	0.104	0.009		
	Total	17	0.291			
6	Treatment	5	1.334	0.267	37.743	0.00000
	Error	12	0.085	0.007		
	Total	17	1.419			
9	Treatment	5	1.297	0.259	31.407	0.00000
	Error	12	0.099	0.008		
	Total	17	1.396			
12	Treatment	5	1.694	0.339	47.480	0.00000
	Error	12	0.086	0.007		
	Total	17	1.779			
15	Treatment	5	1.158	0.232	28.465	0.00000
	Error	12	0.098	0.008		
	Total	17	1.255			
18	Treatment	5	1.845	0.369	42.689	0.00000
	Error	12	0.104	0.009		
	Total	17	1.949			
21	Treatment	5	2.141	0.428	53.124	0.00000
	Error	12	0.097	0.008		
	Total	17	2.238			

Non-Reducing Sugar (%)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	0.027	0.005	0.815	0.56163
	Error	12	0.079	0.007		
	Total	17	0.105			
6	Treatment	5	0.039	0.008	18.886	0.00003
	Error	12	0.005	0.000		
	Total	17	0.044			
9	Treatment	5	0.179	0.036	3.471	0.03592
	Error	12	0.124	0.010		
	Total	17	0.303			
12	Treatment	5	0.758	0.152	29.105	0.00000
	Error	12	0.063	0.005		
	Total	17	0.821			
15	Treatment	5	1.057	0.211	26.184	0.00000
	Error	12	0.097	0.008		
	Total	17	1.154			
18	Treatment	5	1.400	0.280	33.146	0.00000
	Error	12	0.101	0.008		
	Total	17	1.501			
21	Treatment	5	0.067	0.013	2.002	0.15060
	Error	12	0.081	0.007		
	Total	17	0.148			

TSS/Acid ratio

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	3.291	0.658	5.258	0.00870
	Error	12	1.502	0.125		
	Total	17	4.793			
6	Treatment	5	9.515	1.903	4.796	0.01220
	Error	12	4.762	0.397		
	Total	17	14.277			
9	Treatment	5	26.670	5.334	9.004	0.00095
	Error	12	7.109	0.592		
	Total	17	33.778			
12	Treatment	5	90.875	18.175	21.871	0.00001
	Error	12	9.972	0.831		
	Total	17	100.847			
15	Treatment	5	183.435	36.687	21.077	0.00001
	Error	12	20.887	1.741		
	Total	17	204.322			
18	Treatment	5	352.621	70.524	28.568	0.00000
	Error	12	29.624	2.469		
	Total	17	382.245			
21	Treatment	5	532.599	106.520	22.958	0.00001
	Error	12	55.676	4.640		
	Total	17	55.676			

Sugar/Acid ratio

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	7.710	1.542	8.407	0.00128
	Error	12	2.201	0.183		
	Total	17	9.911			
6	Treatment	5	27.764	5.553	14.193	0.00011
	Error	12	4.695	0.391		
	Total	17	32.458			
9	Treatment	5	80.073	16.015	17.371	0.00004
	Error	12	11.063	0.922		
	Total	17	91.136			
12	Treatment	5	242.636	48.527	31.314	0.00000
	Error	12	18.596	1.550		
	Total	17	261.233			
15	Treatment	5	379.211	75.842	25.020	0.00001
	Error	12	36.375	3.031		
	Total	17	415.586			
18	Treatment	5	802.566	160.513	40.659	0.00000
	Error	12	47.373	3.948		
	Total	17	849.939			
21	Treatment	5	1,007.239	201.448	31.567	0.00000
	Error	12	76.578	6.382		
	Total	17	1083.817			

Experiment 2 (B) Effect of various edible coating on guava fruit *cv.* Allahabad Safeda under ambient conditions

Physiological loss in weight (%)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	24.121	4.824	4.824	0.01194
	Error	12	12.000	1.000		
	Total	17	36.121			
6	Treatment	5	47.418	9.484	31.867	0.00000
	Error	12	3.571	0.298		
	Total	17	50.989			

Vitamin C (mg/100gm)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	690.976	138.195	164.983	0.00000
	Error	12	10.052	0.838		
	Total	17	701.028			
6	Treatment	5	1,117.654	223.531	264.911	0.00000
	Error	12	10.126	0.844		
	Total	17	1127.779			

Total soluble solids (ºBrix)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	2.385	0.477	194.321	0.00000
	Error	12	0.029	0.002		
	Total	17	2.415			
6	Treatment	5	8.347	1.669	356.414	0.00000
	Error	12	0.056	0.005		
	Total	17	8.404			

Acidity (%)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	0.009	0.002	4.221	0.01906
	Error	12	0.005	0.000		
	Total	17	0.014			
6	Treatment	5	0.012	0.002	3.843	0.02603
	Error	12	0.007	0.001		
	Total	17	0.019			

Total Sugars (%)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	2.540	0.508	60.618	0.00000
	Error	12	0.101	0.008		
	Total	17	2.641			
6	Treatment	5	4.136	0.827	67.035	0.00000
	Error	12	0.148	0.012		
	Total	17	4.284			

Reducing Sugars (%)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	0.780	0.156	30.000	0.00000
	Error	12	0.062	0.005		
	Total	17	0.842			
6	Treatment	5	1.026	0.205	35.373	0.00000
	Error	12	0.070	0.006		
	Total	17	1.096			

Non-Reducing Sugar (%)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	1.789	0.358	585.821	0.00000
	Error	12	0.007	0.001		
	Total	17	1.796			
6	Treatment	5	1.041	0.208	132.891	0.00000
	Error	12	0.019	0.002		
	Total	17	1.059			

TSS/Acid Ratio

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	53.941	10.788	15.934	0.00006
	Error	12	8.125	0.677		
	Total	17	62.065			
6	Treatment	5	197.579	39.516	14.873	0.00009
	Error	12	31.882	2.657		
	Total	17	229.461			

Sugar/Acid Ratio

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	48.631	9.726	13.713	0.00013
	Error	12	8.511	0.709		
	Total	17	57.142			
6	Treatment	5	180.735	36.147	11.851	0.00026
	Error	12	36.602	3.050		
	Total	17	217.337			

Experiment 3 (A) Effect of various edible coating & packaging on guava fruit *cv.* Allahabad Safeda under cold conditions (7°C)

Physiological loss in weight (%)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	2.489	0.498	1,066.845	0.00000
	Error	12	0.006	0.000		
	Total	17	2.495			
6	Treatment	5	8.833	1.767	228.282	0.00000
	Error	12	0.093	0.008		
	Total	17	8.926			
9	Treatment	5	17.154	3.431	469.259	0.00000
	Error	12	0.088	0.007		
	Total	17	17.242			
12	Treatment	5	33.265	6.653	397.050	0.00000
	Error	12	0.201	0.017		
	Total	17	33.466			
15	Treatment	5	63.989	12.798	1,039.566	0.00000
	Error	12	0.148	0.012		
	Total	17	64.136			
18	Treatment	5	93.081	18.616	469.182	0.00000
	Error	12	0.476	0.040		
	Total	17	93.557			
21	Treatment	5	150.346	30.069	628.386	0.00000
	Error	12	0.574	0.048		
	Total	17	150.920			
24	Treatment	5	195.223	39.045	620.248	0.00000
	Error	12	0.755	0.063		
	Total	17	195.978			
27	Treatment	5	239.833	47.967	967.030	0.00000
	Error	12	0.595	0.050		
	Total	17	240.428			
30	Treatment	5	297.329	59.466	737.520	0.00000
	Error	12	0.968	0.081		
	Total	17	298.297			

Vitamin C (mg/100gm)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	95.788	19.158	16.774	0.00005
	Error	12	13.705	1.142		
	Total	17	109.493			
6	Treatment	5	123.950	24.790	22.324	0.00001
	Error	12	13.325	1.110		
	Total	17	137.275			
9	Treatment	5	304.667	60.933	60.826	0.00000
	Error	12	12.021	1.002		
	Total	17	316.688			
12	Treatment	5	383.699	76.740	70.942	0.00000
	Error	12	12.981	1.082		
	Total	17	396.680			
15	Treatment	5	584.571	116.914	109.212	0.00000
	Error	12	12.846	1.071		
	Total	17	597.417			
18	Treatment	5	666.598	133.320	141.996	0.00000
	Error	12	11.267	0.939		
	Total	17	677.864			
21	Treatment	5	673.170	134.634	131.089	0.00000
	Error	12	12.324	1.027		
	Total	17	685.494			
24	Treatment	5	308.127	61.625	75.150	0.00000
	Error	12	9.840	0.820		
	Total	17	317.968			
27	Treatment	5	195.988	39.198	41.870	0.00000
	Error	12	11.234	0.936		
	Total	17	207.222			
30	Treatment	5	367.712	73.542	70.270	0.00000
	Error	12	12.559	1.047		
	Total	17	380.271			

Total soluble solids (ºBrix)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	0.096	0.019	8.381	0.00130
	Error	12	0.028	0.002		
	Total	17	0.124			
6	Treatment	5	0.240	0.048	18.910	0.00003
	Error	12	0.030	0.003		
	Total	17	0.271			
9	Treatment	5	0.404	0.081	31.324	0.00000
	Error	12	0.031	0.003		
	Total	17	0.435			
12	Treatment	5	0.445	0.089	42.661	0.00000
	Error	12	0.025	0.002		
	Total	17	0.470			
15	Treatment	5	0.528	0.106	43.167	0.00000
	Error	12	0.029	0.002		
	Total	17	0.557			
18	Treatment	5	1.509	0.302	102.268	0.00000
	Error	12	0.035	0.003		
	Total	17	1.544			
21	Treatment	5	0.869	0.174	67.585	0.00000
	Error	12	0.031	0.003		
	Total	17	0.899			
24	Treatment	5	0.751	0.150	56.814	0.00000
	Error	12	0.032	0.003		
	Total	17	0.782			
27	Treatment	5	0.262	0.052	21.395	0.00001
	Error	12	0.029	0.002		
	Total	17	0.291			
30	Treatment	5	0.494	0.099	40.415	0.00000
	Error	12	0.029	0.002		
	Total	17	0.523			

Acidity (%)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	0.004	0.001	7.997	0.00159
	Error	12	0.001	0.000		
	Total	17	0.005			
6	Treatment	5	0.006	0.001	4.046	0.02199
	Error	12	0.003	0.000		
	Total	17	0.009			
9	Treatment	5	0.014	0.003	8.842	0.00103
	Error	12	0.004	0.000		
	Total	17	0.018			
12	Treatment	5	0.018	0.004	7.877	0.00170
	Error	12	0.006	0.000		
	Total	17	0.024			
15	Treatment	5	0.022	0.004	6.407	0.00403
	Error	12	0.008	0.001		
	Total	17	0.030			
18	Treatment	5	0.021	0.004	7.013	0.00278
	Error	12	0.007	0.001		
	Total	17	0.028			
21	Treatment	5	0.024	0.005	3.633	0.03117
	Error	12	0.016	0.001		
	Total	17	0.039			
24	Treatment	5	0.022	0.004	3.801	0.02698
	Error	12	0.014	0.001		
	Total	17	0.035			
27	Treatment	5	0.018	0.004	3.623	0.03143
	Error	12	0.012	0.001		
	Total	17	0.029			
30	Treatment	5	0.031	0.006	6.016	0.00518
	Error	12	0.012	0.001		
	Total	17	0.043			

Total Sugars (%)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	0.042	0.008	11.473	0.00031
	Error	12	0.009	0.001		
	Total	17	0.050			
6	Treatment	5	0.111	0.022	3.287	0.04233
	Error	12	0.081	0.007		
	Total	17	0.193			
9	Treatment	5	2.082	0.416	80.004	0.00000
	Error	12	0.062	0.005		
	Total	17	2.145			
12	Treatment	5	2.848	0.570	87.262	0.00000
	Error	12	0.078	0.007		
	Total	17	2.927			
15	Treatment	5	1.899	0.380	69.438	0.00000
	Error	12	0.066	0.005		
	Total	17	1.964			
18	Treatment	5	2.582	0.516	66.904	0.00000
	Error	12	0.093	0.008		
	Total	17	2.675			
21	Treatment	5	2.867	0.573	66.734	0.00000
	Error	12	0.103	0.009		
	Total	17	2.970			
24	Treatment	5	0.950	0.190	32.208	0.00000
	Error	12	0.071	0.006		
	Total	17	1.020			
27	Treatment	5	2.266	0.453	70.229	0.00000
	Error	12	0.077	0.006		
	Total	17	2.343			
30	Treatment	5	0.678	0.136	18.165	0.00003
	Error	12	0.090	0.007		
	Total	17	0.768			

Reducing Sugar (%)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	0.284	0.057	14.469	0.00010
	Error	12	0.047	0.004		
	Total	17	0.331			
6	Treatment	5	0.906	0.181	44.022	0.00000
	Error	12	0.049	0.004		
	Total	17	0.955			
9	Treatment	5	2.338	0.468	97.325	0.00000
	Error	12	0.058	0.005		
	Total	17	2.396			
12	Treatment	5	3.125	0.625	139.523	0.00000
	Error	12	0.054	0.004		
	Total	17	3.179			
15	Treatment	5	3.558	0.712	147.073	0.00000
	Error	12	0.058	0.005		
	Total	17	3.616			
18	Treatment	5	2.321	0.464	98.583	0.00000
	Error	12	0.056	0.005		
	Total	17	2.377			
21	Treatment	5	1.489	0.298	66.178	0.00000
	Error	12	0.054	0.004		
	Total	17	1.543			
24	Treatment	5	0.975	0.195	36.715	0.00000
	Error	12	0.064	0.005		
	Total	17	1.039			
27	Treatment	5	3.313	0.663	130.337	0.00000
	Error	12	0.061	0.005		
	Total	17	3.374			
30	Treatment	5	5.392	1.078	224.173	0.00000
	Error	12	0.058	0.005		
	Total	17	5.450			

Non-Reducing Sugar (%)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	0.196	0.039	32.444	0.00000
	Error	12	0.015	0.001		
	Total	17	0.211			
6	Treatment	5	0.981	0.196	54.187	0.00000
	Error	12	0.043	0.004		
	Total	17	1.025			
9	Treatment	5	2.464	0.493	1,453.023	0.00000
	Error	12	0.004	0.000		
	Total	17	2.468			
12	Treatment	5	1.693	0.339	56.747	0.00000
	Error	12	0.072	0.006		
	Total	17	1.765			
15	Treatment	5	0.275	0.055	14.490	0.00010
	Error	12	0.045	0.004		
	Total	17	0.320			
18	Treatment	5	0.145	0.029	3.621	0.03147
	Error	12	0.096	0.008		
	Total	17	0.241			
21	Treatment	5	0.387	0.077	11.320	0.00033
	Error	12	0.082	0.007		
	Total	17	0.470			
24	Treatment	5	0.315	0.063	17.210	0.00004
	Error	12	0.044	0.004		
	Total	17	0.359			
27	Treatment	5	1.937	0.387	29.344	0.00000
	Error	12	0.158	0.013		
	Total	17	2.096			
30	Treatment	5	2.153	0.431	805.141	0.00000
	Error	12	0.006	0.001		
	Total	17	2.159			

TSS/Acid ratio

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	3.368	0.674	10.535	0.00046
	Error	12	0.767	0.064		
	Total	17	4.136			
6	Treatment	5	8.058	1.612	7.485	0.00212
	Error	12	2.584	0.215		
	Total	17	10.642			
9	Treatment	5	27.320	5.464	15.054	0.00008
	Error	12	4.355	0.363		
	Total	17	31.676			
12	Treatment	5	47.642	9.528	13.564	0.00014
	Error	12	8.430	0.702		
	Total	17	56.072			
15	Treatment	5	80.342	16.068	8.919	0.00099
	Error	12	21.620	1.802		
	Total	17	101.962			
18	Treatment	5	138.916	27.783	11.154	0.00035
	Error	12	29.891	2.491		
	Total	17	168.807			
21	Treatment	5	166.442	33.288	4.462	0.01575
	Error	12	89.525	7.460		
	Total	17	255.968			
24	Treatment	5	203.346	40.669	4.449	0.01591
	Error	12	109.698	9.142		
	Total	17	313.044			
27	Treatment	5	208.464	41.693	3.857	0.02572
	Error	12	129.699	10.808		
	Total	17	338.163			
30	Treatment	5	620.931	124.186	6.283	0.00436
	Error	12	237.181	19.765		
	Total	17	858.112			

Sugar/Acid ratio

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	3.722	0.744	12.181	0.00023
	Error	12	0.733	0.061		
	Total	17	4.456			
6	Treatment	5	6.075	1.215	4.991	0.01055
	Error	12	2.921	0.243		
	Total	17	8.996			
9	Treatment	5	56.310	11.262	26.101	0.00000
	Error	12	5.178	0.431		
	Total	17	61.487			
12	Treatment	5	98.982	19.796	19.838	0.00002
	Error	12	11.975	0.998		
	Total	17	110.957			
15	Treatment	5	143.952	28.790	13.275	0.00015
	Error	12	26.024	2.169		
	Total	17	169.976			
18	Treatment	5	210.105	42.021	14.124	0.00011
	Error	12	35.701	2.975		
	Total	17	245.806			
21	Treatment	5	301.294	60.259	6.092	0.00493
	Error	12	118.699	9.892		
	Total	17	419.993			
24	Treatment	5	291.434	58.287	5.246	0.00877
	Error	12	133.333	11.111		
	Total	17	424.767			
27	Treatment	5	383.426	76.685	5.633	0.00670
	Error	12	163.364	13.614		
	Total	17	546.790			
30	Treatment	5	806.690	161.338	6.586	0.00361
	Error	12	293.982	24.499		
	Total	17	1100.672			

Phenol (mg TAE g-1 DW)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Signficance
3	Treatment	5	0.279	0.056	3.136	0.04863
	Error	12	0.214	0.018		
	Total	17	0.493			
6	Treatment	5	0.318	0.064	3.128	0.04899
	Error	12	0.244	0.020		
	Total	17	0.563			
9	Treatment	5	0.169	0.034	3.627	0.03132
	Error	12	0.112	0.009		
	Total	17	0.280			
12	Treatment	5	3.433	0.687	64.631	0.00000
	Error	12	0.127	0.011		
	Total	17	3.560			
15	Treatment	5	5.648	1.130	100.623	0.00000
	Error	12	0.135	0.011		
	Total	17	5.783			
18	Treatment	5	12.137	2.427	185.523	0.00000
	Error	12	0.157	0.013		
	Total	17	12.295			
21	Treatment	5	9.978	1.996	128.588	0.00000
	Error	12	0.186	0.016		
	Total	17	10.165			
24	Treatment	5	19.110	3.822	311.341	0.00000
	Error	12	0.147	0.012		
	Total	17	19.258			
27	Treatment	5	25.633	5.127	318.153	0.00000
	Error	12	0.193	0.016		
	Total	17	25.826			
30	Treatment	5	30.916	6.183	486.024	0.00000
	Error	12	0.153	0.013		
	Total	17	31.069			

DPPH (%)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	0.090	0.018	6.864	0.00304
	Error	12	0.032	0.003		
	Total	17	0.122			
6	Treatment	5	0.192	0.038	7.902	0.00168
	Error	12	0.058	0.005		
	Total	17	0.250			
9	Treatment	5	0.251	0.050	17.681	0.00004
	Error	12	0.034	0.003		
	Total	17	0.285			
12	Treatment	5	0.261	0.052	17.551	0.00004
	Error	12	0.036	0.003		
	Total	17	0.296			
15	Treatment	5	0.559	0.112	34.427	0.00000
	Error	12	0.039	0.003		
	Total	17	0.597			
18	Treatment	5	0.720	0.144	54.024	0.00000
	Error	12	0.032	0.003		
	Total	17	0.752			
21	Treatment	5	0.661	0.132	43.760	0.00000
	Error	12	0.036	0.003		
	Total	17	0.698			
24	Treatment	5	1.080	0.216	58.474	0.00000
	Error	12	0.044	0.004		
	Total	17	1.124			
27	Treatment	5	1.570	0.314	77.621	0.00000
	Error	12	0.049	0.004		
	Total	17	1.618			
30	Treatment	5	1.666	0.333	85.443	0.00000
	Error	12	0.047	0.004		
	Total	17	1.713			

Experiment 3 (B) Effect of various edible coating & packaging on guava fruit *cv.* Allahabad Safeda under ambient conditions

Physiological loss in weight (%)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	0.949	0.190	2.946	0.05812
	Error	12	0.773	0.064		
	Total	17	1.722			
6	Treatment	5	5.577	1.115	4.446	0.01595
	Error	12	3.011	0.251		
	Total	17	8.587			
9	Treatment	5	16.757	3.351	7.881	0.00170
	Error	12	5.103	0.425		
	Total	17	21.860			
12	Treatment	5	49.523	9.905	15.743	0.00007
	Error	12	7.550	0.629		
	Total	17	57.073			
15	Treatment	5	81.243	16.249	58.849	0.00000
	Error	12	3.313	0.276		
	Total	17	84.556			
18	Treatment	5	109.505	21.901	892.704	0.00000
	Error	12	0.045	0.004		
	Total	17	109.549			
21	Treatment	5	112.256	27.885	906.825	0.00000
	Error	12	0.452	0.002		
	Total	17	112.708			

Vitamin C (mg/100gm)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	121.546	24.309	23.124	0.00001
	Error	12	12.615	1.051		
	Total	17	134.161			
6	Treatment	5	267.528	53.506	56.404	0.00000
	Error	12	11.383	0.949		
	Total	17	278.911			
9	Treatment	5	407.820	81.564	81.227	0.00000
	Error	12	12.050	1.004		
	Total	17	419.870			
12	Treatment	5	677.841	135.568	128.867	0.00000
	Error	12	12.624	1.052		
	Total	17	690.465			
15	Treatment	5	946.546	189.309	191.506	0.00000
	Error	12	11.862	0.989		
	Total	17	958.408			
18	Treatment	5	1,244.141	248.828	229.379	0.00000
	Error	12	13.017	1.085		
	Total	17	1,257.158			
21	Treatment	5	1,718.597	343.719	343.116	0.00000
	Error	12	12.021	1.002		
	Total	17	1730.618			

Total soluble solids of (ºBrix)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	0.259	0.052	22.571	0.00001
	Error	12	0.028	0.002		
	Total	17	0.287			
6	Treatment	5	1.634	0.327	123.903	0.00000
	Error	12	0.032	0.003		
	Total	17	1.666			
9	Treatment	5	2.696	0.539	156.677	0.00000
	Error	12	0.041	0.003		
	Total	17	2.737			
12	Treatment	5	4.364	0.873	231.370	0.00000
	Error	12	0.045	0.004		
	Total	17	4.409			
15	Treatment	5	4.589	0.918	15.472	0.00007
	Error	12	0.712	0.059		
	Total	17	5.301			
18	Treatment	5	3.291	0.658	236.494	0.00000
	Error	12	0.033	0.003		
	Total	17	3.324			
21	Treatment	5	2.968	0.594	190.473	0.00000
	Error	12	0.037	0.003		
	Total	17	3.005			

Acidity (%)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	0.006	0.001	4.045	0.02199
	Error	12	0.003	0.000		
	Total	17	0.009			
6	Treatment	5	0.011	0.002	7.554	0.00204
	Error	12	0.003	0.000		
	Total	17	0.014			
9	Treatment	5	0.032	0.006	10.445	0.00048
	Error	12	0.007	0.001		
	Total	17	0.039			
12	Treatment	5	0.026	0.005	8.165	0.00146
	Error	12	0.008	0.001		
	Total	17	0.033			
15	Treatment	5	0.038	0.008	9.494	0.00074
	Error	12	0.010	0.001		
	Total	17	0.047			
18	Treatment	5	0.033	0.007	7.751	0.00182
	Error	12	0.010	0.001		
	Total	17	0.043			
21	Treatment	5	0.030	0.006	7.441	0.00217
	Error	12	0.010	0.001		
	Total	17	0.040			

TSS/Acid ratio

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	7.635	1.527	9.142	0.00088
	Error	12	2.004	0.167		
	Total	17	9.639			
6	Treatment	5	31.138	6.228	27.123	0.00000
	Error	12	2.755	0.230		
	Total	17	33.894			
9	Treatment	5	114.473	22.895	25.864	0.00000
	Error	12	10.622	0.885		
	Total	17	125.095			
12	Treatment	5	181.436	36.287	21.048	0.00001
	Error	12	20.689	1.724		
	Total	17	202.125			
15	Treatment	5	464.838	92.968	20.245	0.00002
	Error	12	55.106	4.592		
	Total	17	519.944			
18	Treatment	5	593.102	118.620	15.987	0.00006
	Error	12	89.039	7.420		
	Total	17	682.141			
21	Treatment	5	957.756	191.551	12.938	0.00017
	Error	12	177.666	14.806		
	Total	17	1135.422			

Sugar/Acid ratio

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	10.611	2.122	11.226	0.00034
	Error	12	2.268	0.189		
	Total	17	12.879			
6	Treatment	5	39.970	7.994	26.699	0.00000
	Error	12	3.593	0.299		
	Total	17	43.563			
9	Treatment	5	131.760	26.352	19.314	0.00002
	Error	12	16.372	1.364		
	Total	17	148.132			
12	Treatment	5	172.099	34.420	14.895	0.00009
	Error	12	27.730	2.311		
	Total	17	199.829			
15	Treatment	5	697.076	139.415	18.891	0.00003
	Error	12	88.558	7.380		
	Total	17	785.634			
18	Treatment	5	749.525	149.905	14.007	0.00012
	Error	12	128.422	10.702		
	Total	17	877.947			
21	Treatment	5	1,305.915	261.183	12.969	0.00017
	Error	12	241.675	20.140		
	Total	17	1547.590			

Total Sugars (%)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	0.289	0.058	8.567	0.00118
	Error	12	0.081	0.007		
	Total	17	0.370			
6	Treatment	5	1.284	0.257	34.804	0.00000
	Error	12	0.089	0.007		
	Total	17	1.372			
9	Treatment	5	0.953	0.191	22.204	0.00001
	Error	12	0.103	0.009		
	Total	17	1.056			
12	Treatment	5	1.212	0.242	24.963	0.00001
	Error	12	0.117	0.010		
	Total	17	1.328			
15	Treatment	5	6.984	1.397	135.877	0.00000
	Error	12	0.123	0.010		
	Total	17	7.107			
18	Treatment	5	1.952	0.390	57.106	0.00000
	Error	12	0.082	0.007		
	Total	17	2.035			
21	Treatment	5	3.709	0.742	119.640	0.00000
	Error	12	0.074	0.006		
	Total	17	3.783			

Reducing Sugars (%)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	0.197	0.039	8.361	0.00131
	Error	12	0.056	0.005		
	Total	17	0.253			
6	Treatment	5	0.235	0.047	8.550	0.00119
	Error	12	0.066	0.005		
	Total	17	0.301			
9	Treatment	5	0.943	0.189	36.247	0.00000
	Error	12	0.062	0.005		
	Total	17	1.005			
12	Treatment	5	0.517	0.103	19.495	0.00002
	Error	12	0.064	0.005		
	Total	17	0.581			
15	Treatment	5	0.911	0.182	32.723	0.00000
	Error	12	0.067	0.006		
	Total	17	0.977			
18	Treatment	5	1.362	0.272	52.341	0.00000
	Error	12	0.062	0.005		
	Total	17	1.424			
21	Treatment	5	1.181	0.236	44.281	0.00000
	Error	12	0.064	0.005		
	Total	17	1.245			

Non-Reducing Sugar (%)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	0.018	0.004	2.276	0.11287
	Error	12	0.019	0.002		
	Total	17	0.036			
6	Treatment	5	0.438	0.088	16.419	0.00005
	Error	12	0.064	0.005		
	Total	17	0.502			
9	Treatment	5	0.105	0.021	22.006	0.00001
	Error	12	0.011	0.001		
	Total	17	0.117			
12	Treatment	5	0.333	0.067	13.841	0.00012
	Error	12	0.058	0.005		
	Total	17	0.391			
15	Treatment	5	3.911	0.782	114.006	0.00000
	Error	12	0.082	0.007		
	Total	17	3.994			
18	Treatment	5	0.180	0.036	82.905	0.00000
	Error	12	0.005	0.000		
	Total	17	0.185			
21	Treatment	5	0.755	0.151	33.648	0.00000
	Error	12	0.054	0.004		
	Total	17	0.809			

Phenol (mg TAE g-1 DW)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	1.675	0.335	6.219	0.00454
	Error	12	0.646	0.054		
	Total	17	2.321			
6	Treatment	5	2.540	0.508	35.525	0.00000
	Error	12	0.172	0.014		
	Total	17	2.711			
9	Treatment	5	2.740	0.548	36.992	0.00000
	Error	12	0.178	0.015		
	Total	17	2.918			
12	Treatment	5	8.999	1.800	122.121	0.00000
	Error	12	0.177	0.015		
	Total	17	9.176			
15	Treatment	5	9.043	1.809	117.555	0.00000
	Error	12	0.185	0.015		
	Total	17	9.228			
18	Treatment	5	16.365	3.273	186.813	0.00000
	Error	12	0.210	0.018		
	Total	17	16.576			
21	Treatment	5	14.856	2.971	154.358	0.00000
	Error	12	0.231	0.019		
	Total	17	15.087			

DPPH (%)

Storage Days	Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
3	Treatment	5	0.110	0.022	5.970	0.00534
	Error	12	0.044	0.004		
	Total	17	0.155			
6	Treatment	5	0.551	0.110	26.221	0.00000
	Error	12	0.050	0.004		
	Total	17	0.601			
9	Treatment	5	1.038	0.208	38.503	0.00000
	Error	12	0.065	0.005		
	Total	17	1.103			
12	Treatment	5	1.620	0.324	41.413	0.00000
	Error	12	0.094	0.008		
	Total	17	1.714			
15	Treatment	5	3.450	0.690	81.067	0.00000
	Error	12	0.102	0.009		
	Total	17	3.552			
18	Treatment	5	3.243	0.649	97.443	0.00000
	Error	12	0.080	0.007		
	Total	17	3.323			
21	Treatment	5	5.889	1.178	140.404	0.00000
	Error	12	0.101	0.008		
	Total	17	5.990			

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